

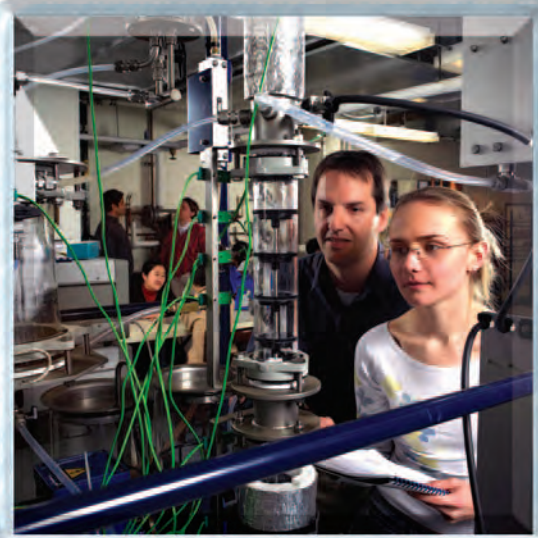


POLYTECHNIC UNIVERSITY 2005-2007

Catalog

UNDERGRADUATE AND
GRADUATE PROGRAMS

NEW YORK'S PREMIER UNIVERSITY FOR TECHNOLOGY-FOCUSED EDUCATION



POLYTECHNIC UNIVERSITY

UNDERGRADUATE AND GRADUATE CATALOG 2005



Brooklyn Campus
Six MetroTech Center
Brooklyn, NY 11201
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Fax: 718-260-3446
Web: www.poly.edu/admissions
E-mail: admitme@poly.edu

Long Island Graduate Center

105 Maxess Road
Melville, NY 11747
Phone: 631-755-4300
Fax: 631-755-4404
E-mail: ligc@poly.edu



Westchester Graduate Center

40 Saw Mill River Road
Hawthorne, NY 10532
Phone: 914-323-2000
Fax: 914-323-2010
E-mail: westinfo@west.poly.edu

**Manhattan Location
Institute for Technology and Enterprise**

55 Broad Street, Suite 13-B
New York, NY 10004
Phone: 718-260-4014
Fax: 212-547-7029
E-mail: ite@poly.edu



Visit our website: www.poly.edu

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POLYTECHNIC UNIVERSITY MISSION STATEMENT

To produce and support the leaders of tomorrow, we will provide excellence in research and education in engineering, computing, science and related fields for the New York region and the world.

PART 1

GENERAL 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 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 published well in advance of its effective date; therefore some course descriptions 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.

ADMINISTRATIVE OFFICES

LEGEND

LC – Dibner/CATT Bldg.
JAB – Jacobs Academic Bldg.
JB – Jacobs Bldg.
ORH – Othmer Residence Hall
RH – Rogers Hall
WH – Wunsch Hall

EXECUTIVE OFFICES

Office of the President

Office: JB 555
Tel: 718-260-3500
Fax: 718-260-3755
E-mail: hultin@poly.edu

Office of the Provost and Academic Affairs

Office: RH 321
Tel: 718-260-3550
Fax: 718-260-3063
E-mail: griffis@poly.edu

Office of the Chancellor

Office: JB 555
Tel: 718-260-3553
Fax: 718-260-3755
E-mail: chang@poly.edu

Office of Development and University Relations

Office: JB 555
Tel: 718-260-3880
Fax: 718-260-3755
E-mail: rthorsen@poly.edu

Office of Finance and Administration

Office: JB 555
Tel: 718-260-3026
Fax: 718-260-3755
E-mail: westcott@poly.edu

Office of Student Affairs

Office: JB 153
Tel: 718-260-3137
Fax: 718-260-3924
E-mail: mhutmake@poly.edu

ACADEMIC ADVISEMENT CENTER

www.advisement.poly.edu
Office: JB 356
Tel: 718-260-3716
Fax: 718-260-3941
E-mail: advisement@poly.edu
Hours: Monday–Friday, 9AM–6PM

ACADEMIC ASSESSMENT AND INSTITUTIONAL RESEARCH

survey.poly.edu
Office: RH 404A
Tel: 718-260-3060
Fax: 718-260-3431
E-mail: assess@poly.edu
Hours: Monday–Friday, 9AM–5PM

ACADEMIC SUCCESS

www.das.poly.edu
Office: JB 356
Tel: 718-260-3014
Fax: 718-260-3136
E-mail: academicsuccess@poly.edu
Hours: Monday–Friday, 9AM–5PM

ADMISSIONS–GRADUATE

www.poly.edu/admissions/graduate
Office: RH 102
Tel: 718-260-3182
Tel: 914-323-2023 (Westchester)
Fax: 718-260-3642
E-mail: gradinfo@poly.edu
Hours: Monday – Friday, 9AM–5PM

ADMISSIONS–UNDERGRADUATE

www.poly.edu/admit
Office: WH, 2nd Floor
Tel: 800-POLYTECH or 718-260-3589
Fax: 718-260-3446
E-mail: admitme@poly.edu
Hours: Monday–Friday, 9AM–5PM

ALUMNI RELATIONS

www.poly.edu/alumni
Office: JB 468
Tel: 800-FON-POLY or 718-260-3561
Fax: 718-260-3114
E-mail: alumni@poly.edu
Hours: Monday–Friday, 9AM–5PM

ATHLETICS

www.poly.edu/athletics
Office: RH 220
Tel: 718-260-3453
Fax: 718-260-3474
E-mail: athletics@poly.edu
Hours: Monday–Friday, 10AM–7PM
Gymnasium/Fitness Center:
Monday–Friday, 11AM–9:30PM
Saturday & Sunday, 12–7PM

BERN DIBNER LIBRARY OF SCIENCE AND TECHNOLOGY

library.poly.edu
LC, 3rd Floor
Tel: 718-260-3530
Fax: 718-260-3756
E-mail: blibrary@poly.edu
Hours: Monday–Friday, 9AM–10PM
Saturday–Sunday, 12PM–8PM

BOOKSTORE

www.poly.bkstr.com
Office: RH, 1st Floor
Tel: 718-260-3882
Fax: 718-260-3778
E-mail: poly@bkstr.com
Hours: Monday–Friday, 9AM–5PM

CAFETERIA

See Jasper H. Kane Dining Hall

CAREER SERVICES AND COOPERATIVE EDUCATION

www.poly.edu/special/careerservices
Office: JB 359
Tel: 718-260-3650
Fax: 718-260-3325
E-mail: careerservices@poly.edu
Hours: Monday–Friday, 9AM–5PM

CENTER FOR YOUTH IN ENGINEERING AND SCIENCE (YES CENTER)

www.poly.edu/yes
Office: WH 117
Tel: 718-637-5944
Fax: 718-260-3446
E-mail: yes@poly.edu
Hours: Monday–Friday, 9AM–5PM

COMMUNICATIONS AND MEDIA RELATIONS

www.poly.edu/communications
 Office: JB 551
 Tel: 718-260-3400
 Fax: 718-260-3084
 E-mail: media@poly.edu
 Hours: Monday–Friday, 9AM–5PM

CONTRACT AND GRANTS

www.poly.edu/cng
 Office: RH 321
 Tel: 718-260-3036
 Fax: 718-260-3063
 E-mail: contractandgrants@poly.edu
 Hours: Monday–Friday, 9AM–5PM

COUNSELING CENTER

www.counseling.poly.edu
 Office: JB 358
 Tel: 718-260-3456
 Tel: 718-260-3207 (for emergencies)
 E-mail: counseling@poly.edu
 Hours: Monday–Friday, 9AM–5PM
 Walk-in hours: Monday–Friday, 1–2PM

DAVID PACKARD CENTER FOR TECHNOLOGY AND EDUCATIONAL ALLIANCES

www.poly.edu/edu/packard
 Office: JB 452
 Tel: 718-260-3524
 Fax: 718-260-3733
 E-mail: packardcenter@poly.edu
 Hours: Monday–Friday, 9AM–5PM

DEVELOPMENT

Office: JB 458
 Tel: 800-765-9929 or 718-260-3636
 Fax: 718-260-3449
 E-mail: tdaly@poly.edu
 Hours: Monday–Friday, 9AM–5PM

DIBNER LIBRARY

See Bern Dibner Library of Science and Technology

FACILITIES

Office: JB 152
 Tel: 718-260-3020
 Fax: 718-260-3753
 E-mail: acarino@poly.edu or facility@poly.edu
 Hours: Monday–Friday, 9AM–5PM

FINANCIAL AID

www.poly.edu/finaid
 Office: JB 256
 Tel: 718-260-3300
 Fax: 718-260-3052
 E-mail: finaidb@poly.edu
 Hours: Monday & Thursday, 10AM–6PM
 Tuesday & Wednesday, 10AM–5PM
 Friday, 10AM–3PM

FINANCIAL OPERATIONS

Office: JB 454
 Tel: 718-260-3869
 Fax: 718-260-3752
 E-mail: financialoperations@poly.edu
 Hours: Monday–Friday, 9AM–5PM

GENERAL STUDIES PROGRAM

www.gs.poly.edu
 Office: JB 453
 Tel: 718-260-3391
 E-mail: mparham@poly.edu
 Hours: Monday–Friday, 9AM–5PM

HIGHER EDUCATION OPPORTUNITY PROGRAM (HEOP)

www.poly.edu/heop
 Office: JB 355
 Tel: 718-260-3370
 Fax: 718-260-4135
 E-mail: heop@poly.edu
 Hours: Monday–Friday, 9AM–5PM

HUMAN RESOURCES

www.poly.edu/hr
 Office: JB 258
 Tel: 718-260-3840
 Fax: 718-260-3981
 E-mail: askhr@poly.edu
 Hours: Monday–Friday, 9AM–5PM

INFORMATION SYSTEMS

insight.poly.edu
 Office: RH 337
 Tel: 718-260-3123
 Fax: 718-260-3680
 E-mail: help@poly.edu
 Hours: Monday–Friday, 9AM–5PM

INTERNATIONAL STUDENTS AND SCHOLARS

www.poly.edu/oiss
 Office: JB 352
 Tel: 718-260-3445
 Fax: 718-260-3710
 E-mail: international@poly.edu
 Hours: Monday–Friday, 9AM–5PM

JASPER H. KANE DINING HALL

www.poly.edu/lackman
 Lackmann Culinary Services
 Office: RH, 1st Floor
 Tel: 718-260-3786
 Fax: 718-875-0309
 E-mail: dining@poly.edu
 Hours: Monday–Friday, 7:30AM–8:30PM
 Saturday, Sunday, 11AM–6PM

LONG ISLAND GRADUATE CENTER

www.poly.edu/li
 105 Maxess Road, Suite N201, Melville
 Tel: 631-755-4300
 Fax: 631-755-4404
 E-mail: ligc@poly.edu
 Hours: Monday–Thursday, 9AM–6PM
 Friday, 9AM–12PM

MAILROOM

Office: JB 151
 Tel: 718-260-3396
 Fax: 718-260-3136
 E-mail: mailroom@poly.edu
 Hours: Monday–Friday, 8AM–5PM

ADMINISTRATIVE OFFICES

LEGEND

LC – Dibner/CATT Bldg.
JAB – Jacobs Academic Bldg.
JB – Jacobs Bldg.
ORH – Othmer Residence Hall
RH – Rogers Hall
WH – Wunsch Hall

MANHATTAN LOCATION

www.poly.edu/aboutpoly/directionsMnh.cfm

New York Information Technology Center, 55 Broad Street, Suite 13B
Tel: 212-547-7030
Fax: 212-547-7029
E-mail: ite@poly.edu
Hours: Monday–Friday, 10AM–6PM

PACKARD CENTER

See David Packard Center for Technology and Education Alliances

POLYTECHNIC TUTORING CENTER

www.tutoring.poly.edu
Office: JAB 373
Tel: 718-260-3425
E-mail: tutoring@poly.edu
Hours: Monday–Thursday, 11AM–5PM
Friday, 10AM–3PM

PRINTING SERVICES

Office: JB 150
Tel: 718-260-3396
Fax: 718-260-3136
E-mail: printing@poly.edu
Hours: Monday–Friday, 8AM–5PM

REGISTRAR

www.poly.edu/registrar
Office: JB 256
Tel: 718-260-3486
Fax: 718-260-3052
E-mail: registrar@poly.edu
Hours: Monday & Thursday, 10AM–6PM
Tuesday & Wednesday, 10AM–5PM
Friday, 10AM–3PM

RESIDENCE LIFE

www.poly.edu/reslife
Office: ORH 103
Tel: 718-260-4160
Fax: 718-260-4195
E-mail: reslife@poly.edu
Hours: Monday–Friday, 9AM–6PM

SECURITY

Tel: 718-260-3727 LC Entrance
Tel: 718-260-3537 JAB Front Entrance
Tel: 718-260-3213 RH Rear Entrance
Tel: 718-260-4170 ORH Entrance

SPECIAL SERVICES

www.poly.edu/specialservices/SpecialServices.html
Office: JB 341
Tel: 718-260-3560
Fax: 718-260-3945
E-mail: specserv@poly.edu
Hours: Monday–Friday, 9AM–5PM

STUDENT ACCOUNTS

www.poly.edu/administration/stuaccounts.cfm
Office: JB 256
Tel: 718-260-3700
Fax: 718-260-3052
Email: stuacct@poly.edu
Hours: Monday & Thursday, 10AM–6PM
Tuesday & Wednesday, 10AM–5PM
Friday, 10AM–3PM

STUDENT AFFAIRS

www.poly.edu/student-affairs
Office: JB 158
Tel: 718-260-3137
Fax: 718-260-3924
E-mail: studentaffairs@poly.edu
Hours: Monday–Friday, 9AM–5PM

STUDENT DEVELOPMENT

www.poly.edu/student_development
Office: JB 158
Tel: 718-260-3800
Fax: 718-260-3197
E-mail: studentdevelopment@poly.edu
Hours: Monday–Friday, 9AM–5PM

STUDENT NOTEBOOK COMPUTER HELP DESK

www.poly.edu/notebook
Office: RH 339
Tel: 718-260-3368
Fax: 718-260-3188
E-mail: notebook@poly.edu
Hours: Monday–Friday, 8AM–6PM

TUTORING CENTER

See Polytechnic Tutoring Center

WEB SERVICES

www.poly.edu/webmaster
Office: LC 300
Tel: 718-260-3109
Fax: 718-260-3756
E-mail: webmaster@poly.edu
Hours: Monday–Friday, 9AM–5PM

WESTCHESTER GRADUATE CENTER

www.poly.edu/west/?loc=west
40 Saw Mill River Road, Hawthorne
Tel: 914-323-2000
Fax: 914-323-2010
E-mail: westinfo@west.poly.edu
Hours: Monday–Friday, 9AM–5PM

YES CENTER

See Center for Youth in Engineering and Science



2005-2007 ACADEMIC CALENDAR

FALL 2005

Monday, September 1
Classes begin

Monday, September 5
NO CLASSES – Labor Day

Thursday, September 8
Monday classes meet

Thursday, September 29
NO CLASSES – Poly 150th
Convocation Day

Monday, October 3
No classes after 2PM

Tuesday, October 4
NO CLASSES

Monday, October 10
Thursday classes meet
No Monday classes

Wednesday, October 12
No classes after 2PM

Thursday, October 13
NO CLASSES

Wednesday, November 9
Last day to withdraw from
course with a W grade

Wednesday, November 23
Thursday classes meet
No Wednesday classes

Thursday-Friday, November 24-25
SCHOOL CLOSED—
Thanksgiving recess

Thursday, December 8
Classes end

Friday-Tuesday, December 9-13
Reading days

Monday, December 12
Monday evening classes meet
(make-up for October 3)

Tuesday, December 13
Wednesday evening classes meet
(make-up for October 12)

Wednesday-Thursday
December 14-22
Final exams

Friday-Monday
December 23- January 2
Winter Recess

Tuesday-Tuesday, January 3-17
Winter mini-session

SPRING 2006

Monday, January 16
SCHOOL CLOSED—
Martin Luther King Jr. Day

Wednesday, January 18
Classes begin

Monday, February 20
NO CLASSES—President's Day

Monday-Friday, March 13-17
NO CLASSES—Spring Break

Tuesday, April 4
Last day to withdraw from
course with a W grade

Wednesday – Friday, April 12-14
NO CLASSES

Monday, May 1
Classes end

Tuesday-Wednesday, May 2-3
Reading days

Thursday-Friday, May 4-12
Final exams

Monday-Friday, May 15-26
Summer mini-session

SUMMER 2006

Monday, May 29
SCHOOL CLOSED—
Memorial Day

Thursday, June 1
Classes Begin for X and Z Sessions

Wednesday, June 28
Last day to withdraw from X
session course with a W grade

Tuesday, July 4
SCHOOL CLOSED—
Independence Day

Thursday, July 6
Tuesday classes meet
No Thursday classes
(make-up for Independence Day)

Thursday, July 13
Classes end for X session

Monday, July 17
Classes begin for Y session

Wednesday, July 26
Last day to withdraw from Z session
course with a W grade

Friday, August 11
Last day to withdraw from Y
session course with a W grade

Friday, August 25
Classes end for Y and Z sessions

FALL 2006

Monday, September 4
SCHOOL CLOSED – Labor Day

Tuesday, September 5
Classes begin

Monday, October 2
NO CLASSES

Tuesday, October 3
Monday classes meet
No Tuesday classes

Monday, October 9
NO CLASSES – Columbus Day

Monday, November 13
Last day to withdraw from
course with a W grade

Wednesday-Friday,
November 22-24
SCHOOL CLOSED—
Thanksgiving Recess

Monday, December 11
Classes end

Tuesday- Wednesday,
December 12 -13
Reading days

Thursday-Friday, December 14-22
Final exams

Monday-Monday,
December 25 – January 1
Winter recess

Tuesday-Tuesday, January 2-16
Winter mini-session

SPRING 2007

Monday, January 15
SCHOOL CLOSED—
Martin Luther King, Jr. Day

Monday, January 22
Classes begin

Monday, February 19
NO CLASSES—President's Day

Friday, March 30
Last day to withdraw from
course with a W grade

Monday-Friday, April 2-6
NO CLASSES—Spring Break

Monday, April 30
Classes end

Tuesday-Wednesday, May 1-2
Reading days

Thursday-Friday, May 3-11
Final exams

Monday-Friday, May 14-25
Summer mini-session

SUMMER 2007

Monday, May 28
SCHOOL CLOSED—
Memorial Day

Thursday, May 31
Classes begin for X and Z sessions

Wednesday, June 27
Last day to withdraw from X
session courses with a W grade

Wednesday, July 4
SCHOOL CLOSED—
Independence Day

Thursday, July 5
Wednesday classes meet
No Thursday classes
(make-up for Independence Day)

Thursday, July 12
Classes end for X session

Monday, July 16
Classes begin for Y session

Thursday, July 26
Last day to withdraw from Z
session course with a W grade

Friday, August 10
Last day to withdraw from Y
session course with a W grade

Friday, August 24
Classes end for Y and Z sessions



POLYTECHNIC UNIVERSITY PROFILE

INTRODUCTION

Polytechnic is a coeducational, independent, private university accredited by the Middle States Association. Undergraduate programs in 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). The undergraduate chemistry program is approved by the American Chemical Society. Degree and certificate programs listed in this catalog are registered by the New York State Education Department.

The student body includes more than 1,500 undergraduates and nearly 1,300 graduate students. The majority of its students live in the New York metropolitan area, but many students come from throughout the United States and the world as well to study at Polytechnic. Twenty percent of the undergraduate population is women; 9 percent are black, 6 percent Hispanic and 25 percent Asian. Polytechnic is among the leading private universities in the nation in awarding engineering degrees to underrepresented 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 enjoys a high national ranking in the percentage of its graduates who go on to receive a doctorate in engineering or science, and has an excellent placement record for 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 out-

standing reputation with both public and private employers, and many have achieved remarkable success. Approximately one of every 30 Polytechnic graduates is a company president or high-level executive. Seven Polytechnic alumni are currently the presidents of prestigious universities in the United States 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 University is the second oldest private institution of science and engineering in the United States. Founded in 1854 as the Brooklyn Collegiate and Polytechnic Institute, the school originally educated young men, ages 9 to 22, and was located on Livingston Street in downtown Brooklyn. In 1889, the collegiate and preparatory departments were separated, with the collegiate division adopting the name Polytechnic Institute of Brooklyn. The preparatory department was renamed and moved off campus in 1901.

The Institute, historically referred to as “Brooklyn Poly,” moved its campus to Jay Street in 1957. In 1961, it opened a Long Island campus in Farmingdale as a graduate and research center.

In 1973, Polytechnic merged with the New York University School of Engineering and Science and was renamed the Polytechnic Institute of New York. The Institute began offering undergraduate programs at its Long Island campus in 1974 and, in 1975, opened the Westchester Graduate Center in White Plains. The center later moved to its current location in Hawthorne in 1987.

In 1985, the institution was granted university status by the New York State Board of Regents and officially renamed Polytechnic University.

The next 15 years saw a period of great activity as the University undertook the creation of MetroTech Center, a 16-acre, \$1-billion university-corporate park,

which was built around Polytechnic’s existing buildings and renewed an area that once had been a site of urban decay. Polytechnic updated its facilities, renovated its student center building and built a new home for its library and for the Center for Advanced Technology in Telecommunications. It also began offering several management of technology programs in the heart of Manhattan’s high-technology and financial district.

During this time, the University launched the Campaign for Polytechnic—*Fulfilling the American Dream* to raise \$275 million to transform itself into one of the nation’s premier technological universities. In 1998, Polytechnic received a \$175 million bequest from the estates of Donald F. Othmer, a longtime Polytechnic professor, and his wife, Mildred, at the time the largest single cash gift ever made to a private American university. In 1999, Polytechnic received its second largest contribution from alumnus Joseph J. Jacobs, who gave \$20 million. The campaign successfully concluded on June 30, 2001.

The new millennium promises more significant changes. In 2002, Polytechnic opened two new buildings on the MetroTech campus: the Joseph J. and Violet J. Jacobs Building, an eight-story academic and athletic facility with state-of-the-art classrooms and laboratories and a full gymnasium; and the 20-story, 400-bed Donald F. and Mildred Topp Othmer Residence Hall, Polytechnic’s first on-campus residence hall in Brooklyn. In addition, the main academic building, Rogers Hall, underwent a complete renovation to create several new instructional facilities and upgrade instructional equipment in existing facilities. An expanded cafeteria, seating 300, opened in 2002, and a new student lounge opened in 2003.

The University has also redirected its education programs, phasing out undergraduate programs at the Long Island campus and consolidating them at MetroTech. In June 2002, the University opened the Long Island Graduate Center in Melville, N.Y.

ACADEMIC PROGRAMS

Polytechnic offers the degree Bachelor of Science in 14 disciplines, covering computer science, engineering, the physical sciences, mathematics and liberal arts. The degree Master of Science is offered in 32 disciplinary specialties. The degree Master of Engineering in Interdisciplinary Studies in Engineering is offered with different concentrations, including Wireless Innovation. The degree Doctor of Philosophy is offered in eight 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 PhD study. The PhD is the terminal research degree for those seeking careers in industrial or academic research. It requires an independent research dissertation that advances the state-of-the-art in the discipline of study. Details of academic degree requirements and detailed program descriptions are given in Part 3 of this catalog.

ACADEMIC DEPARTMENTS

University Faculty is grouped into academic departments for administrative purposes. Each degree program is planned and administered by the faculty of a department (or in some cases by faculty from collaborating departments). Instructional laboratories and some research laboratories are also managed by academic departments.

Part 2 of this catalog contains descriptions of the faculty and facilities of the following nine academic departments, as well as identification of the degrees that each department supervises.

- Chemical and Biological Sciences and Engineering
- Civil Engineering
- Computer and Information Science
- Electrical and Computer Engineering
- Humanities and Social Sciences
- Introductory Design and Science
- Management
- Mathematics
- Mechanical, Aerospace and Manufacturing Engineering

RESEARCH PROGRAMS AND CENTERS

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

In 2005, Polytechnic University conducted over \$12 million of sponsored research under contracts and grants, of which 64 percent were funded by the federal and state governments and 36 percent by private industry. Over 75 faculty members were involved in these efforts, which also provided support for over 80 research fellows. Research at Polytechnic is conducted either through academic department structures, or through one of the major interdisciplinary research centers.

Many of these research centers sponsor education efforts in areas related to their research mission. CATT developed two executive-format MS programs offered jointly by the Departments of Management, Electrical and Computer Engineering and Computer and Information Science. The Polymer Research Institute and the Transportation Research Institute sponsor colloquia and/or continuing education programs as well. Significant research efforts also occur outside these centers within academic departments. The Department of Civil Engineering has developed a strong base in infrastructure research and the Othmer Department of Chemical and Biological Sciences and Engineering has a number of efforts not related to polymers that are administered in the department.

CENTER FOR ADVANCED TECHNOLOGY IN TELECOMMUNICATIONS (CATT)

The Center for Advanced Technology in Telecommunications (CATT) was created in 1983 as one of New York State's four original Centers for Advanced Technology. CATT focuses on research and technology transfer in the areas of telecommunications and distributed information systems.

CATT houses 30 experts, who work in cooperation with telecommunication-provider and telecommunication-user businesses in the areas of networking, distributed information systems, imaging and wireless communications. More information on CATT is available at <http://catt.poly.edu>.

CENTER FOR CONSTRUCTION MANAGEMENT TECHNOLOGY (CCMT)

The primary mission of the Center for Construction Management Technology (CCMT) is to develop teaching and research to further develop world-class expertise in Fully-Integrated and Automated Project Process (FIAPP), and to promote the applications of FIAPP to building, process and infrastructure construction projects in the New York region and beyond. This mission is one which fully aligns both with Polytechnic's past—as a technological University which has been providing engineering education for nearly 150 years, and with its future—as an institution with a new strategic plan that calls for greater interdependence with industry. Real-world construction projects are central components of both education and research at the CCMT. For both undergraduate and graduate courses, actual New York City construction projects will serve as a test bed, with students engaged in case studies that allow them to plan for the production, scheduling and managing of the projects. Research, too, will focus closely on actual New York area projects, the overall aim being to solve integration and automation problems in particular practical contexts. The full integration of actual construction projects into the work of the CCMT serves two purposes: it provides a richer learning and research environment, and it accelerates industry adoption of FIAPP by demonstrating its effectiveness in real contexts.

A MS in Construction Management draws part-time and full-time students, nationally and internationally. A summer-semester Construction Executive Institute consists of a two-week intensive course in international construction management. There are currently about a half-dozen PhD candidates affiliated with the CCMT.

Research centers on a cluster of projects relating to FIAPP, three-dimensional Computer Aided Design (CAD) and four-dimensional CAD (3D + time).

CENTER FOR FINANCE AND TECHNOLOGY (CFT)

The Center for Finance and Technology (CFT), under the auspices of the Department of Management, is a unique resource, addressing the evolving financial—and technology-enabled—innovation needs of the financial services industry. CFT is a research hub as well as a laboratory for generating new ideas and tools for the industry. CFT also undertakes collaborative research projects to provide ideas, methods and tools with scholarly and practical applications. For more information, contact Fred Novomestky at 718-260-3436 or fnovomes@poly.edu, or visit www.cft.poly.edu.

CENTER FOR THE HISTORY AND PHILOSOPHY OF TECHNOLOGY AND SCIENCE STUDIES

The Center for the History and Philosophy of Technology and Science Studies was established to encourage discussion among philosophers, engineers, computer scientists and other practitioners from the scientific and technological professions on the ethical, political and general cultural connotations of contemporary technological activity, as well as straightforward research in the traditional philosophical questions concerning technology. The center also fosters various types of interdisciplinary education. By bringing the humanities, communications and social science disciplines closer together and reaching out to other academic departments in the University, the center helps facilitate the exploration of intellectual common ground. For more information, e-mail philtech@poly.edu.

CENTER FOR TECHNOLOGY IN SUPPLY CHAINS AND MERCHANDISING

The Center for Technology in Supply Chains and Merchandising emphasizes technology in the engineering and management of supply chains, retailing and merchandising. The Center's emphasis on the technical side differentiates it from other academic programs that are primarily focused on marketing in the retail and merchandising field. The center draws on Polytechnic's diverse student body and its existing programs in telecommunications, transportation, information systems, technology management and financial engineering.

The center's mission is threefold: to encourage engineering and computer-science majors to enter the retail and mer-

chandising industries, to provide advance training to the managers and technical professionals of these industries, and to foster research and the creation of intellectual capital in the development and application of technology and technology management in distribution and retail.

The center offers internships in the retail and supply-chain industry to undergraduate students, and to high school students who plan to enter Polytechnic and have an interest in the industry. The center also supports a tract in the Management of Technology and Innovation in Retailing (MOTIR) as part of the executive Management of Technology (MOT) Program offered by Polytechnic's Department of Management.

INSTITUTE FOR TECHNOLOGY AND ENTERPRISE (ITE)

The Institute for Technology and Enterprise (ITE) is supported by the Department of Management at Polytechnic University and located at 55 Broad Street in Manhattan. ITE is New York City's research and education hub for the management of technology and innovation and modern e-business, telecommunications and networking decision making. Located in the heart of high-technology New York City, ITE is a focal point and R&D engine for building managerial knowledge and developing learning programs suited particularly to technology-intensive and "hybrid"—i.e., digital and physical—settings. ITE's emphasis is on the creation of new value through innovation. Hence, ITE's emphasis is often on such sectors as media, entertainment, financial and professional services, bio-medical and healthcare and other industries comprising much of the New York City economy.

ITE is also a gathering place for a unique, diverse and interdisciplinary community, comprising faculty members from the Department of Management and other Polytechnic departments, industry leaders, and participating professionals in ITE's executive master's programs. These highly committed professionals and scholars take part in ITE round tables and workshops in New York City and around the world, and, working together, develop relevant research and learning materials that are used in learning programs and other international events.

ITE activities include:

- Round tables and executive workshops on such subjects as wireless innovation, media management, e-business decision making and new business mod-

els, managerial challenges in the biotechnology industry in Israel, innovation in the post-NASDAQ-crash, post-9/11 world, homeland security and U.S. innovation and new dimensions in global innovation.

- Research and curriculum development on modern innovation management, the transformation of the print media industry, value creation in financial services, global innovation strategy, and the emerging homeland security sector's impact on U.S. technology decision making in firms.

ITE is closely aligned with the activities of the Department of Management; in particular, ITE has a strong and mutually reinforcing relationship with Polytechnic's executive master's programs in the Management of Technology (MOT) and Telecommunications and Information Management (TIM), which are also held at 55 Broad Street in Manhattan.

For more information, call 718-260-3610, fax: 212-547-7029, e-mail ite@poly.edu, or visit www.ite.poly.edu.

INTEGRATED DIGITAL MEDIA INSTITUTE

The Integrated Digital Media Institute (IDMI) was founded in 2001 by the Department of Humanities and Social Sciences to develop programs and research spanning the traditionally separate areas of media creation, criticism and technology development. IDMI's mandate includes graduate and undergraduate strategic curriculum development, conferences and joint research projects with scholars, institutions and media organizations worldwide. The founding principles of the IDMI are the threefold: (1) There can be no such thing as "read-only" media literacy; therefore, media theory must always include elements of practice and practical engagement to be viable. (2) The separation of technological and creative disciplines in higher education has driven many young polymaths to a false choice of one over the other, which has made it difficult for either sector to recruit or prepare students for the complex challenges they will face as media professionals. (3) The technological, creative and analytical dimensions of digital media are in a constant state of mutual mutation; it is therefore necessary to think and practice them as an integrated field. For more information on IDMI, contact: Director Carl Skelton at cskelton@poly.edu.

**NATIONAL SCIENCE
FOUNDATION INDUSTRY/
UNIVERSITY COOPERATIVE
RESEARCH CENTER FOR
BIOCATALYSIS AND
BIOPROCESSING OF
MACROMOLECULES (NSF-BBM)**

NSF-BBM was established in 2000 to fill a need expressed by industry to provide a mechanism to assess the potential impact that biocatalysis and bioprocessing might have on its future businesses. NSF-BBM is organized to provide its industrial members with critical cutting edge research on enzyme transformations related to polymer technology. The resulting knowledge base and the resources of NSF-BBM are made available on a proprietary basis to its members. The objective is to allow industrial members to make informed decisions as to how new developments in biocatalysis and bioprocessing can specifically be directed toward their core-business needs.

**OTHMER INSTITUTE FOR
INTERDISCIPLINARY STUDIES**

The Othmer Institute for Interdisciplinary Studies was launched in 2002 to enhance Polytechnic's position as a significant contributor to a knowledge-based society. The institute was founded with a \$25-million endowment from a bequest from Donald F. Othmer, a longtime Polytechnic professor, and his wife, Mildred.

Underlying the creation of the institute is the insight that extraordinary innovations often take place at the intersection of completely different fields. Being relatively small but committed to knowledge creation in the technology arena, Polytechnic is well situated for undertaking interdisciplinary breakthroughs. By sponsoring unique research and educational initiatives, creative outreach efforts and groundbreaking diverse spin-offs, the institute aims to act as a unique catalyst for such progress and as an agent of potentially transformational change at the University.

Major activities of the institute include the Othmer Institute Major Project Initiative, which provides large-scale funding for innovative, high-risk, high-impact interdisciplinary research, programmatic and curriculum development and teaching; the Othmer Visiting Fellows Initiative, which brings visiting faculty and other leaders to Polytechnic to share and infuse ideas, to interact and collaborate with Polytechnic faculty and students, to give public lectures and ultimately to further significant interdisciplinary work at the University; the Othmer Short-Term Faculty

Seed Grant Initiative for Polytechnic faculty, which acts as a catalyst for early-stage and potentially significant research and educational endeavors of a strongly interdisciplinary nature and which provides seed funding for subsequent more intensive and deeper interdisciplinary work; Large-Scale Symposia, which bring together scholars and practitioners from a variety of fields to share interdisciplinary research and insights; the Othmer Institute Distinguished Seminar Series, which hosts seminars by Polytechnic faculty and external speakers that focus on the interdisciplinary innovations; and Spin-offs and Economic Development Activities, which seeks to create a vibrant hub for high-technology innovation in New York City and beyond by actively and aggressively encouraging wise spin-offs and economic development based on interdisciplinary work sponsored by the institute.

The Othmer Institute has, as another aspect of its mission, a commitment to educational innovation. The institute took the lead in designing the Honors College at Polytechnic University. The Honors College continues to operate under the aegis of the Othmer Institute.

For more information, call 718-260-3556, fax 718-260-3896, e-mail ois@poly.edu, or visit www.othmerinstitute.poly.edu.

**HERMAN F. MARK
POLYMER RESEARCH
INSTITUTE (PRI)**

The Herman F. Mark Polymer Research Institute (PRI) was founded in 1943 by Dr. Mark, internationally recognized as the "father of polymer science." Today it continues to be a leader in the synthesis, characterization, structure, processing, properties and applications of polymeric materials. In addition to its role in fostering interdisciplinary interest and work in polymers, PRI sponsors symposia, conferences and professional educational programs. The institute provides a focal point for the research of over 15 faculty members in chemistry, chemical engineering and physics. PRI is actively involved with industry in regard to outsourcing, problem solving and education. In addition to the traditional chemical-related areas, PRI has recently expanded its interests in macromolecular technology to health-related areas.

**TRANSPORTATION RESEARCH
INSTITUTE (TRI)**

Created in 1975, the Transportation Research Institute (TRI) uses research and educational programs to develop and transfer the knowledge base in transportation systems and policy to improve the mobility and safety of persons, freight and services in metropolitan areas. TRI has conducted various landmark studies on capacity analysis of freeways and signalized intersections and led the development of the 1985 Highway Capacity Manual, which is used throughout the world as a design and analysis standard. TRI oversees the Intelligent Transportation Systems (ITS) research on technical, institutional and private-public issues and on its education and training. Through the Urban ITS Center, TRI assists New York City and New York State's Departments of Transportation in facilitating the deployment of ITS technologies in the New York metropolitan area. Other areas of TRI research include travel demand management, policy studies, transportation models, operational analysis, highway construction materials and pavement management. TRI comprises faculty from civil engineering, computer science, mechanical engineering, chemical engineering, the social sciences and transportation engineering.

**URBAN INFRASTRUCTURE
INSTITUTE**

The Urban Infrastructure Institute is a federation of research centers providing an integrated framework for cross-disciplinary research with urban infrastructure agencies, electrical, gas and water utilities and the construction industry. The Institute is a member of the City Construction Consortium, established in 1993. Its executive director is Polytechnic faculty member Dr. Ilan Juran.

The Institute currently involves the following four centers:

- Urban ITS Center (UITSC); Director: John C. Falcocchio (<http://media.poly.edu/tri/itsdocs/home.htm>)
- Urban Utility Center (UUC); Director: Ilan Juran (www.uuc.poly.edu)
- The Center for Construction Management Technology (CCMT); Director: Fletcher H. (Bud) Griffis (www.poly.edu/cee)
- Rudin Center for Transportation Policy and Management (CTPM), in partnership with New York University, Polytechnic University and the Institute

of Public Administration; Director: Lee Sander, formerly NYC Transportation Commissioner (www.nyu.edu/wagner/transportation/)

The Urban Infrastructure Institute is also affiliated with the Institute for Civil Infrastructure Systems (ICIS) at New York University, in which Polytechnic is a partnering institution (www.nyu.edu/icis). Its principal investigator in that partnership is John C. Falcocchio.

URBAN SECURITY INITIATIVE

Security concerns in the United States that have arisen since 9/11 are disproportionately urban security concerns. Today, more than 220 million Americans—some 80 percent of the population—live in and around cities. Over 160 million live in major metropolitan areas with populations exceeding one million. A city is a powerful, complex hub of interdependent infrastructure elements, including utility systems, which provide water, electricity and fuel; digital and voice communications systems; and the dense networks of buildings, streets, highways, bridges, tunnels and waterways. This concentration of interdependent elements makes a city especially vulnerable to terrorist attack as well as natural disasters.

In response to the need to address these urban security concerns, Polytechnic has established a University-wide interdisciplinary Urban Security Initiative (USI) to address pressing urban security problems through the engineering, scientific, management and educational capabilities of the University and collaborating institutions, industries and public entities. Educationally, USI seeks to create a skilled workforce of urban-security specialists through graduate and undergraduate courses and certificate programs.

USI's initial concentration is in four areas. The first, First Responder/Fire and Emergency Operations, is an initiative with Polytechnic's Center for Advanced Technology in Telecommunications to study fire-ground communications, tracking and information management (CTIM), which was discovered to be one of the critical vulnerabilities in responding to the disaster at the World Trade Center. The second area, BioSensors/BioTerrorism, is a project undertaken by Polytechnic's Polymer Research Institute to develop biopolymers to detect *Bacillus Anthracis* and to develop technology to provide fast and safe alerting systems. In the third area, CyberSecurity/Information Assurance, the

National Security Agency recently designated Polytechnic as a Center of Excellence in Information Assurance Education, enabling the University to expand its research activity in biometrics, steganography, information assurance and digital watermarking. The fourth area, Urban Infrastructure, involves Polytechnic's Urban Infrastructure Institute, which—in partnership with industry and cities such as Boston and Paris—is researching advanced technologies to rehabilitate and securely manage water mains and critical underground networks.

In addition, USI capitalizes on the University's advanced information infrastructure and its Bern Dibner Library of Science and Technology.

WEBER WIRELESS RESEARCH INSTITUTE (W²RI)

Founded as the Microwave Research Center, the Weber Wireless Research Institute (W²RI) was renamed in 1985 in honor of its founder, Dr. Ernst Weber. The institute played a key role in World War II in the development of electromagnetic defense and communications systems. In 2000, the second "W" was added to the title to reflect its current mission to advance the science and technology of wireless communications. W²RI conducts research in wave propagation, advanced antennas, communication system design and simulation, signal processing, radio resource management and technologies that promote the quality and efficiency of the wireless Internet. Faculty and students in the Department of Electrical and Computer Engineering and the Department of Computer and Information Science conduct the research.

WIRELESS INTERNET CENTER FOR ADVANCED TECHNOLOGY (WICAT)

The Wireless Internet Center for Advanced Technology (WICAT) was founded in 2001, with funding from the New York State Office for Science, Technology and Academic Research, under its Enhanced Center of Advanced Technology Program. WICAT houses researchers from the University's Departments of Management, Electrical and Computer Engineering and Computer and Information Science, as well as Columbia University's Departments of Electrical Engineering and Computer Science. WICAT researchers perform systems-oriented research aimed at making the wireless Internet a reality. For more information, visit <http://wicat.poly.edu>.

FACULTY

The heart of Polytechnic is its distinguished teaching and research faculty. There are more than 470 full-time and adjunct faculty; teaching and research fellows; research assistants, associates and scientists; and postdoctoral and special fellows. The number of full-time teaching faculty alone is over 130. 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 relationships 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 members maintain regular office hours for consultation with individual students. Because many faculty members are actively involved in on-campus research, they are easily accessible outside the classroom. All formal academic advising after the first year is done by the faculty.

The Polytechnic faculty is one of the most distinguished in the world. Polytechnic faculty members 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 members of the National Academy of Engineering and numerous fellows of the various professional disciplinary organizations. Polytechnic faculty members have authored numerous undergraduate and graduate textbooks used throughout the United States and abroad and edit leading professional journals. They are frequently honored with prestigious awards.

ALUMNI

The POLYTECHNIC ALUMNI, the University's alumni association, provides a range of on and off campus educational, social, cultural and other programs for the benefit of alumni. The association is governed by an elected Executive Council and an International Board of Directors. Polytechnic alumni can be found in all 50 states and at least 64 countries.

The POLYTECHNIC ALUMNI supports regional and special-interest chapters estab-

lished by alumni to provide opportunities for alumni gatherings and to represent Polytechnic in the community. Alumni organize reunions, by class year, discipline or other criteria.

Each year, the POLYTECHNIC ALUMNI recognizes alumni accomplishments through different awards programs, including the Distinguished Alumni Awards and Dedicated Alumni Awards. In addition, it funds annual scholarships for selected students and presents annual awards to outstanding graduating seniors and outstanding athletes from Polytechnic sports teams.

The university provides alumni with the opportunity to audit Polytechnic courses at reduced tuition and use the Bern Dibner Library of Science and Technology. Alumni may open a free Polytechnic e-mail account and have lifetime access to many of the services offered by the Office of Career Services.

Cable, the alumni magazine, is published quarterly to provide current news and information on the activities of the alumni and Polytechnic. Every five years, the POLYTECHNIC ALUMNI publishes a directory containing pertinent information on all known alumni.

Alumni are invited to participate in varied events and activities throughout the year. These include Leadership Seminars, Alumni-Student Mixers, Alumni Leadership Breakfasts and the annual Golden Jubilee and Silver Jubilee, celebrating 50th and 25th class anniversaries, respectively. The polytechnic alumni also sponsors trips and tours of interest to alumni. Most important, through its numerous activities, the polytechnic alumni provides opportunities for alumni to maintain ties to each other and the University.

Information regarding the organization's programs can be found in *Cable* or at www.poly.edu/alumni.

The Office of Alumni Relations works with the POLYTECHNIC ALUMNI to organize many of its programs, provides administrative and communication support and assists academic and administrative offices in keeping in touch with the more than 38,000 living alumni.

CAMPUSES

Brooklyn Campus
Six MetroTech Center
Brooklyn, NY 11201
Tel: 718-260-3600
Fax: 718-260-3136
E-mail: admitme@poly.edu

Polytechnic's main campus is located in the center of downtown Brooklyn, a vibrant residential and business community, surrounded by cultural institutions such as the Brooklyn Botanic Garden, the Brooklyn Historical Society, the Brooklyn Museum and the Brooklyn Academy of Music (BAM). The cultural richness of Manhattan is easily accessible via public transportation. The Brooklyn campus forms the nucleus of MetroTech Center, the largest urban university-corporate park in the United States. Developed in the early 1990s, the 16-acre, \$1-billion complex features a tree-lined commons and pedestrian walkways and is home to several technology-dependent companies that have fostered research and employment relationships with the University. They include the following:

- **Securities Industry Automation Corporation (SIAC)** operates the computer information networks of the New York and American Stock Exchanges and oversees their transaction-clearing operations. SIAC built its 533,000-square-foot office and data-processing complex in MetroTech in 1990.
- **KeySpan Energy** (formerly Brooklyn Union Gas Company) has its headquarters in MetroTech in an 845,000-square-foot office facility. Bear Stearns, a major brokerage house, became a tenant of the building in 1992.
- **JPMorgan Chase** opened two major office facilities totaling approximately 1.5-million square feet in 1992. The buildings house the bank's U.S. technology and operations functions.
- **New York Marriott Brooklyn Hotel** is Brooklyn's first large hotel to be built in half a century. The 376-room hotel opened in 1998 and is attached to a 32-story office tower, the Brooklyn Renaissance Plaza.
- **Empire Blue Cross Blue Shield**, New York's largest health-insurance company, occupies nine floors in MetroTech's latest building, a 19-story

facility completed in 2003. Nearly 1,500 Empire employees are located in 322,220 square feet in the new building.

- **Other MetroTech companies** include the headquarters for the New York City Fire Department and the New York City Police Department's 911 Answering Center.

The Brooklyn campus is easily accessible from all parts of New York City, Long Island, New Jersey and Connecticut. It is served by New York City's major subway lines and is easily accessible by car from the Brooklyn or Manhattan Bridges or the Brooklyn-Queens Expressway. The University is a member of New York City's "college town," included on a list of colleges and universities that are within either a 10-minute walk or 15-minute subway ride from the heart of the city. All commercial MetroTech buildings have parking facilities.

The Brooklyn campus is contained within three acres in MetroTech and comprises the following six buildings:

- **Rogers Hall** is the main academic building and named after the late Harry S. Rogers, Polytechnic's fifth president (1933-57). The building houses faculty and department offices, classrooms, research and teaching laboratories, cafeteria, dining hall, student lounge and bookstore. The lower level houses offices for student clubs and the Polytechnic incubator Brooklyn Enterprise on Science and Technology (BEST). Starting in 1999, it underwent significant improvements and renovations. Three new facilities opened in 2000: a 9,000-square-foot interdisciplinary laboratory for undergraduate students in civil, chemical and mechanical engineering; an undergraduate computer lab center; and a new facility for Polytechnic's computing infrastructure, containing all of the University's central servers and system monitoring software.
- **Bern Dibner Library of Science and Technology/Center for Advanced Technology in Telecommunications (CATT) Building** opened in 1992 and provides 128,000 square feet of academic space. The building houses several key elements of the University: a state-of-the-art library, named after the late Bern Dibner '21 H'59, a Polytechnic alumnus, trustee and benefactor; the prestigious New York State-funded

research center, CATT; computer laboratories; and administrative offices for the Departments of Management, Electrical and Computer Engineering, and Computer and Information Science.

- **Joseph J. and Violet J. Jacobs Building** opened in 2002 and is named after the late Dr. Jacobs '37 '39 '42 H'86, former chairman of the Polytechnic Board of Trustees, and his wife. The eight-story building, the main entrance to the University, contains lecture halls; laboratories for chemistry, biology and environmental engineering; "smart" classrooms wired for the latest Internet and multi-media technologies. The building also includes a full multi-purpose gymnasium, including a fitness center and basketball court.
- **Donald F. and Mildred Topp Othmer Residence Hall** opened in 2002 and is named after the late Dr. Othmer, a long-time Polytechnic professor of chemical engineering (1932-76), and his wife. The 20-story building houses over 400 students in two-bedroom suites and two-bedroom apartments with kitchenettes and data, voice and cable television ports for every student. The building includes student lounges, study rooms, laundry facilities, health offices and storage space. The housing staff—comprising two full-time professional staff members, graduate and undergraduate student resident assistants and security personnel—supervise the students and building 24 hours a day.
- **Joseph W. and Samuel Wunsch Hall** is housed in a historic landmark. Built in 1846, the Greek Revival building was the home of the African Wesleyan Methodist Church, the first black congregation in Brooklyn, and reputed to be a stop on the Underground Railroad. Polytechnic bought the property in 1968 and closed it for renovation in 1990. It was authentically restored through the generosity of the Wunsch family, in memory of brothers and Polytechnic alumni Joseph '17 and Samuel Wunsch '29, and reopened in 1996. The building houses the Office of Undergraduate Admissions.
- **Joseph J. Jacobs Administration Building** was dedicated in Dr. Jacobs honor in 1986. The building contains offices for administration—including the president, vice presidents and chan-

cellor—and for student organizations. Most student service offices are also located in Jacobs, including registration, student accounts, financial aid, student development and career services. Other administrative offices include development, alumni relations, university relations and communications and media relations.

**Long Island Graduate Center
Melville Corporate Center**

**105 Maxess Road
Melville, NY 11747**

Tel: 631-755-4300

Fax: 631-755-4404

E-mail: ligc@poly.edu

In 2002, Polytechnic opened a new state-of-the-art, fully wired graduate center near the Huntington Quadrangle on Long Island. The mission of the center is to help Long Island industry grow by producing skilled graduates needed by Long Island companies and, therefore, serve as an important resource for Long Island's engineering and technology community.

This modern facility includes six classrooms with wireless computing capability, faculty and administrative offices, engineering laboratories in wireless communications, local area networks, and VHDL, an Internet lounge and a distance-learning facility. Students enrolled at the Long Island Graduate Center can choose to pursue a 36-unit master's degree program or a 15-unit graduate certificate program, or enroll in selected courses. Classes are offered in the evening, Monday through Thursday, and during the day on Saturday to accommodate the schedules of working professionals.

Programs available include:

Evening Master's Degree Programs:

Computer Engineering
Computer Science
Electrical Engineering
Electrophysics
Management
RF/Microwaves
Systems Engineering
Systems Integration
Telecommunication Networks
Wireless Innovation

Evening Graduate Certificate Programs

Computer Engineering
Software Engineering
Telecommunication Network Management
Wireless Communications

A corporate Advisory Council of noted Long Island business leaders advises Polytechnic University on the continuing

education needs of Long Island industry. Polytechnic is active in organizations dedicated to the high-tech future of Long Island, including the Long Island Association (LIA) and the Long Island Forum for Technology (LIFT), founded by Polytechnic. From its Long Island Graduate Center, Polytechnic interacts with Long Island industry through its Center for Advanced Technology in Telecommunications (CATT) and other research efforts.

Westchester Graduate Center

**40 Saw Mill River Road
Hawthorne, NY 10532**

Tel: 914-323-2000

Fax: 914-323-2010

E-mail: westinfo@west.poly.edu

The Westchester Graduate Center has served the Hudson Valley area for near 30 years and is the area's premier center for graduate and continuing technical and managerial education. The center draws students from every sector of the tri-state region, ranging from information, telecommunications and chemical companies to the banking, finance, heavy industry and high technology areas. Students come from major corporations, small companies, not-for-profit agencies and the public sector. Since its creation in 1976, several thousand scientists, engineers, chemists, managers, teachers and other professionals have earned master's degrees at the center.

The Graduate Center offers part-time master's degree programs in management, chemistry, chemical engineering, computer science and telecommunication networks (with concentrations in e-business management, entrepreneurship, information management, technology management and operations management). Courses are scheduled in the evening and on Saturdays.

The Graduate Center is home to Polytechnic's MS in Information Systems Engineering, offered in the executive degree program format. A modern facility, the Graduate Center is equipped with wired classrooms, an advanced computer laboratory with high-speed Internet connection and ample free parking.

**Manhattan Location
Institute for Technology
and Enterprise (ITE)
55 Broad Street, Suite 13-B
New York, NY 10004**

Tel: 718-260-4014

Fax: 212-547-7029

E-mail: ite@poly.edu

Polytechnic's Manhattan location is situated

in the heart of New York City's high-technology and financial services districts and serves a burgeoning population of modern professionals. At this location, the Department of Management offers the Management of Technology (MOT) and Telecommunications and Information Management (TIM) executive master's programs and the Financial Engineering (FE) Master's Program. MOT and TIM courses are offered in executive format with classes meeting on Thursday evenings and all-day Saturday on alternate weeks over four consecutive semesters. MOT and TIM students complete their degree in 16 months. FE courses are offered in the evenings, Monday through Thursday. MOT, TIM and FE courses are offered exclusively at the Manhattan location. This location is also home for the Department of Management's Institute for Technology and Enterprise (ITE).

BERN DIBNER LIBRARY OF SCIENCE AND TECHNOLOGY

The Bern Dibner Library of Science and Technology opened in 1992 and serves as Polytechnic University's information hub, where wireless networks allow users with laptop computers to access the library's electronic services both from within the library and from other campus locations. Network jacks are also available throughout the library for users to connect their notebook computers by Ethernet cable. Wireless printing is available.

The library offers electronic access 24 hours a day, seven days a week. Its resources can be accessed through the main Polytechnic University Web site (www.poly.edu) or directly through the library's site (<http://library.poly.edu>). The library's Web site offers up-to-date information on both traditional and electronic services. Users can access books and journals, many of them in full text, as well as imaged course materials and online courses. Subject-related Internet links created by professional staff facilitate further study and research.

In-house library services are augmented by participation in regional and national cooperatives. The University library is an active member of the Academic Libraries of Brooklyn (seven participating libraries) the New York Metropolitan Reference and Research Library Agency (currently 270 member institutions representing 1,200

libraries) and the Long Island Library Resource Council (over 200 participating libraries). The library is also a member of the Online Computer Library Center, which maintains an international database compiled and maintained by over 9,000 participating libraries.

Skilled information professionals provide support through the following products and services:

- One-on-one assistance using online catalog, electronic databases and other services. Tutorials on effective research methods are offered in conjunction with various academic departments.
- An in-house collection of more than 190,000 books and journals provides basic support for undergraduate and graduate programs in engineering, the sciences, management and other fields.
- A document delivery service, which supplies, on request, books, journal articles and reports not available in Polytechnic's in-house collections or online databases.

CENTRAL COMPUTING FACILITIES

The computing facilities were designed to be aligned with the Polytechnic's course offerings in computer science and engineering and the University's role in educating and training knowledge workers of the future.

Polytechnic requires every student to have a laptop computer; mobile technology is integrated into the curriculum, using tools such as AutoCAD, LabVIEW, Common Space, MathLab, Visual Studio and the Microsoft Professional office suite. Mobile technology and timely, pervasive access to information are also integrated throughout the Poly campus with a full wired and wireless network infrastructure.

The University provides electronic access through state-of-the-art, standards-based, broadband wired and wireless network, which allows students to roam seamlessly around campus while staying connected to the Internet and all educational support and information resources. The combination of student laptops, a ubiquitous broadband network, online information and learning support tools, promotes "congregate learning" and links the Poly community into an electronic

learning community.

Several departments and laboratories have their own sub-networks that are part of the overall University network. These include the Electrical Engineering Wireless Communications Labs, the Mechanical Engineering Controls and Robotics Labs, the Computer Engineering Microprocessor Design Labs, the Computer Science Distributed Systems Labs, and the Freshman Engineering Labs.

The University also provides access to a multitude of central computing laboratories in support of various discipline-specific fields. These labs consist of a collection of top-end Intel-based desktops and Unix-based workstations. These resources access a multitude of server operating systems and applications, giving students exposure to a highly heterogeneous technology environment, which reflects the mostly widely used tools used in the engineering and technology professions.

The software provided in the central computing labs include Accolade; Adobe Acrobat, Illustrator and PageMaker; AutoCAD and Borland C++ Builder; CircuitMaker; Microsoft Office 2003, Visual Studio and Net; Object Ada; Primavera Project Planner; and Statistical Package for the Social Sciences (SPSS).

Since many of the learning and information support systems are web enabled, students can access these resources off campus as easily as on campus. Students living in the Othmer Residence Hall have state-of-the-art voice, data and cable connections in their rooms and throughout the building.

Through the Internet portal My Poly, students are able to examine their course information, keep track of tuition and financial aid records and monitor their degree progress. Faculty members use My Poly as a preferred method to enhance their courses by uploading syllabi and related documents and to communicate with students. Students are encouraged to interact with their instructors using electronic means, allowing students to have access to guidance, support, mentoring and advisement anytime, anywhere.

The University provides computer support and assistance 24 hours/7 days/365 days a year through a central helpdesk service (718-260-3123 or help@poly.edu) and on-site support services during general working hours.

ACADEMIC DEPARTMENTS AND DEGREES

OTHER DEPARTMENT OF CHEMICAL AND BIOLOGICAL SCIENCES AND ENGINEERING

BS Biomolecular Science²
BS Chemical & Biological Engineering
MS Bioinformatics
MS Biomedical Engineering
MS Chemical Engineering
MS Chemistry
PhD Chemical Engineering
PhD Materials Chemistry
Advanced Certificates: Bioinstrumentation, Biomedical Materials

DEPARTMENT OF CIVIL ENGINEERING

BS Civil Engineering
BS Construction Management
MS Civil Engineering
MS Construction Management
MS Environmental Engineering
MS Environmental Science
MS Transportation Management
MS Transportation Planning and Engineering
MS Urban Systems Engineering and Management
PhD Civil Engineering
PhD Transportation Planning and Engineering
Advanced Certificates: Construction Management¹, Executive Construction Management (Exec21), Hazardous Waste Management, Traffic Engineering, Transportation Management and Economics, Transportation Planning

DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE

BS Computer Engineering¹
BS Computer Science
MS Computer Science
MS Information Systems Engineering
MS Telecommunication Networks²
PhD Computer Science
Advanced Certificate: Computer Engineering¹, Cyber Security, Information Security Professional, Information Systems Administration, Software Engineering

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

BS Computer Engineering¹
BS Electrical Engineering
MS Computer Engineering¹
MS Electrical Engineering
MS Electrophysics
MS System Engineering
MS Telecommunication Networks¹
PhD Electrical Engineering
Advanced Certificates: Computer Engineering¹, Image Processing, Telecommunication Network Management, Wireless Communications

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCE

BS Liberal Studies
BS Technical Communication
MS Environment–Behavior Studies
MS History of Science
MS Integrated Digital Media²
MS Specialized Journalism
Advanced Certificates: Environment–Behavior Studies, Technical Communication

DEPARTMENT OF MANAGEMENT

BS Business and Technology Management
MS Financial Engineering
MS Management
MS Management of Technology
MS Organizational Behavior
MS Telecommunications and Information Management
PhD Technology Management
Advanced Certificates: Construction Management, Electronic Business Management, Entrepreneurship, Financial Engineering, Financial Technology Management, Human Resource Management, Information Management, Operations Management, Organizational Behavior, Risk Management, Technology Management, Telecommunications Management

DEPARTMENT OF MATHEMATICS

BS Mathematics
MS Mathematics
PhD Mathematics

DEPARTMENT OF MECHANICAL, AEROSPACE AND MANUFACTURING ENGINEERING

BS Mechanical Engineering
MS Industrial Engineering
MS Mechanical Engineering
MS Manufacturing Engineering
MS Materials Science
PhD Mechanical Engineering
Advanced Certificates: Achieving World Class Quality, Industrial Engineering, Manufacturing Engineering and Production Science, Manufacturing Excellence by Design: Holistic Approach

DEGREES OFFERED OUTSIDE DEPARTMENTS

BS Physics
ME Interdisciplinary Studies in Engineering

1. Offered by the Department of Electrical and Computer Engineering and the Department of Computer and Information Science.
2. Pending approval by New York State.

DEGREES OFFERED AT POLYTECHNIC

Polytechnic offers a wide range of degree programs leading to award of the degrees Bachelor of Science, Master of Science, Master of Engineering and Doctor of Philosophy. These programs are offered at four University locations: Brooklyn, Long Island, Manhattan and Westchester. In addition, the MS in Management and in Organizational Behavior are offered in Israel. The table below indicates the degrees registered at each campus. Please check with each department to confirm that a program is currently available at the locations indicated below.

Graduate courses taken at any campus are applicable toward MS and PhD degree programs officially offered at another campus. Most graduate courses are offered in the evening or late afternoon. While PhD seminars, qualifying exams, etc., are available only on the Brooklyn campus, dissertation research may be at another campus where the faculty adviser is resident.

Program Title	HEGIS code ¹	Brooklyn	Long Island	Westchester	Manhattan ³	Israel
Bioinformatics	1999.20	MS				
Biomedical Engineering	0905	MS	MS			
Biomolecular Science ⁶	0499	BS				
Business & Technology Management	0599	BS				
Chemical & Biological Engineering	0906	BS				
Chemical Engineering	0906	MS, PhD				
Chemistry	1905	MS, PhD ⁵		MS		
Civil Engineering	0908	BS, MS, PhD				
Computer Engineering	0909	BS, MS	MS			
Computer Science	0701	BS, MS, PhD	MS	MS		
Construction Management	0599	BS, MS				
Electrical Engineering	0909	BS, MS, PhD	MS	MS		
Electrophysics	0919	MS	MS			
Environment–Behavior Studies	2201	MS				
Environmental Engineering	0922	MS				
Environmental Science	0922	MS				
Financial Engineering	0599	MS			MS	
History of Science	2205	MS				
Industrial Engineering	0913	MS				
Information Systems Engineering	0990			MS		
Integrated Digital Media	-----	MS ⁶				
Interdisciplinary Studies in Engineering	0999	ME	ME	ME		
Liberal Studies	4901	BS				
Management	0506	MS	MS	MS		MS ⁴
Management of Technology ⁷	0599				MS ²	
Manufacturing Engineering	0913	MS				
Materials Chemistry	1905	PhD				
Materials Science	0915	MS				
Mathematics	1701	BS, MS, PhD				
Mechanical Engineering	0910	BS, MS, PhD				
Organizational Behavior	0514	MS				MS ⁴
Physics	1902	BS				
Specialized Journalism	0602	MS				
Systems Engineering	0901		MS			
Technical Communication	0602	BS				
Technology Management	0599	PhD				
Telecommunication Networks	0799	MS	MS	MS		
Telecommunications & Information Management	0599				MS ²	
Transportation Management	0510	MS				
Transportation Planning & Engineering	0908	MS, PhD				
Urban Systems Engineering & Management	0999	MS				

1. Higher Education General Inventory System.

2. Executive format degree program.

3. Offered at 55 Broad Street, Manhattan, pending New York State approval.

4. More information is given in Department of Management section of this catalog.

5. See PhD program in Materials Chemistry.

6. Pending New York State approval.

7. Includes Accelerated Management of Technology (AMOT) Program.

CERTIFICATES OFFERED AT POLYTECHNIC

Program Title	HEGIS code¹	Academic Department	Campus
Achieving World Class Quality	0913	Mechanical, Aerospace & Manufacturing Engineering	Brooklyn
Bioinstrumentation	0905	Chemical & Biological Sciences & Engineering	Brooklyn
Biomedical Materials	0905	Chemical & Biological Sciences & Engineering	Brooklyn
Computer Engineering	0909	Computer & Information Science/ Electrical & Computer Engineering	Brooklyn Long Island
Construction Management	0599	Civil Engineering/Management	Brooklyn
Cyber Security	-----	Computer & Information Science	Brooklyn
Electronic Business Management	0599	Management	Brooklyn Westchester Long Island
Entrepreneurship	0506	Management	Brooklyn Westchester Long Island
Environment-Behavior Studies	2201	Humanities & Social Sciences	Brooklyn
Executive Construction Management (Exec21)	0599	Civil Engineering	Manhattan ²
Financial Engineering	0599	Management	Manhattan
Financial Technology Management	0599	Management	Manhattan
Hazard Waste Management	0420	Civil Engineering	Brooklyn
Human Resource Management	0515	Management	Brooklyn
Image Processing	0999	Electrical & Computer Engineering	Brooklyn
Industrial Engineering	0913	Mechanical, Aerospace & Manufacturing Engineering	Brooklyn
Information Management	0702	Management	Brooklyn Westchester Long Island
Information Security Professional	-----	Computer & Information Science	Brooklyn
Information Systems Administration	-----	Computer & Information Science	Brooklyn
Manufacturing Engineering & Production Science	0913	Mechanical, Aerospace & Manufacturing Engineering	Brooklyn
Manufacturing Excellence by Design: Holistic Approach	0913	Mechanical, Aerospace & Manufacturing Engineering	Brooklyn
Operations Management	0506	Management	Brooklyn Westchester Long Island
Organizational Behavior	0515	Management	Brooklyn
Risk Management	0504	Management	Manhattan
Software Engineering	0799	Computer & Information Science	Brooklyn
Technical Communication	0699	Humanities & Social Sciences	Brooklyn
Technology Management	0599	Management	Brooklyn Westchester Long Island
Telecommunication Network Management	0799	Electrical & Computer Engineering	Brooklyn, Long Island
Telecommunications Management	0599	Management	Brooklyn Long Island
Traffic Engineering	0908	Civil Engineering	Brooklyn
Transportation Management & Economics	0908	Civil Engineering	Brooklyn
Transportation Planning	0908	Civil Engineering	Brooklyn
Wireless Communications	0909	Electrical & Computer Engineering	Brooklyn Long Island

1. Higher Education General Inventory System.

2. Offered at 2 Broadway in Manhattan.

ACADEMIC POLICIES AND DEGREE REQUIREMENTS

PROGRAM AREAS

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

- Computer and Information Science
- Engineering
- Liberal Studies
- Management
- The Sciences and Mathematics

COMPUTER AND INFORMATION SCIENCE

Computer and information science has become an important and expanding field as today's society moves into the Information Age. Computer and information science includes the design of systems (computer hardware and software) and the development of principles for applying computers to new uses. It requires a high level of theory and practice and often involves the development and/or integration of complex software.

A multidisciplinary focus is required for computer and information science, since computers are everywhere in society. Computer and information science is a major element in modern information technology, allowing information to be used in analyzing and solving problems in diverse fields, such as telemedicine, health care, finance, entertainment, manufacturing, telecommunications, transportation and biomedicine.

The curriculum is an integrated program of basic science, computer science, mathematics, humanities and social sciences. Students take electives in technical and non-technical subjects to give them flexibility and breadth in their studies at Polytechnic.

The current faculty works in such state-of-the-art fields as high-speed imaging classification, software virus protection, high-speed graphics, text and data mining, fault tolerant computing, database management systems, software engineering, data compression, data security, parallel and distributed computation, scheduling theory, computer vision and Internet and Web technologies. This faculty experience,

combined with a strong curriculum, integrating theory and practice, allows Polytechnic graduates to be well positioned for the 21st century.

ENGINEERING

Engineering is perhaps best described as the creation of devices and implements that can control or manipulate nature to produce a desired effect. It is the application of science to build the infrastructure, devices, tools and other implements needed by society to improve quality of life and environment.

The modern engineer must have a firm background in the sciences and mathematics. Science provides fundamental knowledge about the natural world; mathematics is the language most often used to describe it, and through which engineers manipulate it. A background in the liberal arts provides a fundamental understanding of society, its structures, needs and desires. No one can hope to improve society without such understanding. Engineers must also have a deep appreciation for the role they play in society, particularly their professional ethics and responsibilities. Finally, engineers must have excellent communications skills to work effectively with other engineers, other professionals, decision-makers and the public.

Polytechnic's engineering programs build on a firm foundation of mathematics and science to develop the analysis and design skills required of a practicing professional. State-of-the-art laboratories introduce students to devices and systems currently used in their fields as well as develop their skills in using computer-aided design packages. Undergraduate programs prepare students equally for entry into the profession and for continued education at the graduate level.

Above all, Polytechnic prepares engineering graduates for a lifetime of education and growing knowledge in the rapidly developing field of technology. By giving 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 varied fields—such as telecommunications, microwaves, space electronics, imaging sciences, quantum electronics, pulse power, materials, aerospace, geotechnology, software engineering and earthquake performance of structures—Polytechnic students are being equipped to carry this tradition forward to the next generation of technological breakthroughs.

LIBERAL STUDIES

Through the study of the liberal arts students learn to understand human society and its development, needs, desires and the means through which it makes these known. No one can adequately address technology or its creation and development without understanding the needs of the society with 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.

Liberal studies majors at Polytechnic study traditional programs in social sciences and humanities as well as a curriculum specifically addressing the interactions between society and technology.

MANAGEMENT

Polytechnic's Department of Management is the premier learning, research and development hub in the New York City/tri-state region, explicitly devoted to the critical arenas of innovation, information and technology management.

The department has achieved this pre-eminent position with a continuous stream of high-quality and relevant research, development and pacesetting learning programs. Its faculty contributes to theory and practice in an increasingly knowledge-intensive age.

The research and development conducted within the Department of Management is varied, including scholarly books and articles in the respected journals and timely case studies. Some of this material forms part of the content in educational programs, helping to keep programs up-to-date and distinctive. The department's Institute for Technology and Enterprise functions as an "engine" for

high-level research and development for the whole department and for relevant firms and fields at large.

The department is also committed to integrating technology into all educational programs to enhance learning. Because all managers must now understand how technology and innovation are essential for delivering value to organizations and the market, the department offers a portfolio of educational programs dealing with the broad spectrum of innovation, information and technology management in the modern economy.

In addition to its academic programs, the Department of Management offers short-term, nondegree programs, including programs tailored to the needs of specific firms and industries that are related in some fashion to the broadly defined technology and information management field.

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, engineers look to apply them to developing new technology. Without the physical sciences and mathematics, engineers would have no tools with which to invent the technology of tomorrow.

Polytechnic's undergraduate science and mathematics programs give students unique opportunities to study basic theory, while at the same time interacting with design disciplines. The structure of undergraduate programs in these areas encourages students to select concentrations of elective courses in technology areas.

Students use modern laboratories and interact with faculty who are world-class researchers. Many junior and senior classes are small, allowing students to develop one-on-one relationships with faculty and work with them in their appropriate research areas.

The future of technology critically depends on the 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 through which they can extend and apply that which they discern. Polytechnic programs prepare scientists and mathematicians for this vital role, enabling them to lead society to a better future.

GENERAL POLICIES

TRANSCRIPTS

The issuance of transcripts and generally the release of any information about a student are subject to the provisions of Public Law 93-380, the Family Educational Rights and Privacy Act of 1974 as amended.

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 a school or other properly authorized parties. There is a \$5 fee for an official transcript.

Unofficial transcripts are available to students 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 a 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 Office of the Registrar before the record is sealed.

INTELLECTUAL PROPERTY

The University has a written policy on intellectual property, which governs faculty and student project work, in terms of rights, benefits and releases. The policy is available from the Office of Academic Affairs.

UNDERGRADUATE DEGREE REQUIREMENTS AND ACADEMIC POLICIES

This section details the general University-wide degree requirements that apply to all Polytechnic undergraduate degrees. Academic departments may place additional requirements on individual degrees. Such additional requirements are explained in the programs section of this catalog. In no case may a department specify requirements less stringent than those indicated here.

BASIC DEGREE REQUIREMENTS AND DEFINITION OF CREDITS

Programs for the degree Bachelor of Science require 120 to 131 credits, depending upon the major as described in the programs section of this catalog. Undergraduate semester credits are based upon the number of 55-minute periods scheduled each week during one semester.

Normally, 1 credit signifies a minimum of either one 55-minute period of class work, or three periods 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.

Students may attend on a part-time or full-time basis, and all degrees may be completed in four years of full-time study. To earn the degree Bachelor of Science from Polytechnic, students must take a minimum of 32 credits of junior- and senior-level courses at Polytechnic in the student's major field in order to fulfill residency requirements. Nearly 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.

To earn a bachelor's degree, students must have a cumulative GPA of 2.0 or better in all courses taken at Polytechnic. (See the section on academic standing and probation.) Some programs have additional requirements for grades involving specified courses or groups of courses. Most undergraduate engineering curricula require students to participate in team projects, including participation in interdisciplinary sequence courses and group design project exercises. Students are required to participate in outcomes assessment, as described on the next page.

Undergraduate students admitted to Polytechnic are encouraged to declare their major immediately, although incoming freshmen may initially enter as "undeclared" majors. Freshmen who wish to consider several program options are encouraged to use the first semester to explore major fields in consultation with departmental advisers. Polytechnic's freshman year is uniform for all engineering majors and very similar for other majors. Thus, students who choose to delay selecting their major until the end of the freshman year must select courses in consultation with advisers from the Office of Academic Success.

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. Students entering Polytechnic with an undeclared major must declare any currently offered undergraduate major by the end of their first year. Changes in major may involve some loss of credit if done later than the end of the first year. Students wishing to change majors should work with an adviser to min-

ACADEMIC POLICIES AND DEGREE REQUIREMENTS

imize credit loss and disruption to their educational program.

SELECTION OF A MINOR

A minor is an approved coherent concentration of academic study within a single discipline. In specified programs, undergraduate students may select a minor in a field distinct from or related to their major, with approval of advisers in both the major and minor fields. With the consent of a student's major department, some of the courses used to satisfy the minor requirements may also satisfy the required or electives course requirements in the student's major program. The names and associated requirements for minors are listed in the sections of this catalog devoted to related major programs.

COURSE PLACEMENT EVALUATION

Polytechnic gives all incoming freshmen placement and diagnostic examinations in writing and mathematics, as well as an entrance questionnaire concerning computer background. Transfer students are evaluated using some of these placement tools, in consultation with departmental advisers.

Polytechnic's placement evaluations are intended to ensure that each student receives the most appropriate instruction in basic areas needed to successfully complete the degree program they have chosen. Placement evaluations may supersede the results of Advanced Placement examinations and/or acceptable transfer credits from another institution of higher education, by the designated adviser and the department offering the course.

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 or her own field but with professionals in other technical and non-technical fields, with private and public decision-makers and the general public.

Polytechnic's degree programs involve frequent writing and speaking assignments across all areas of the curriculum; it is essential that all students have appropriate background skills before enrolling in upper-division courses related to their professional studies.

All incoming freshmen and most transfer students are 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:

EN 1014 Writing & the Humanities I 4 credits
or
EN 1090 Introductory Composition 0 credits [4 credits*]

Students with an ESL background will be placed in either:

EN 1034 Writing & the Humanities I (ESL) 4 credits
or
EN 1080 Reading & Writing (ESL) 0 credits [4 credits*]

** EN 1080 and EN 1090 do not carry credits toward a degree. However, they do contribute to the full-time credit load during the semester in which they are taken.*

Students completing EN 1014 or EN 1034 continue with EN 1204 Writing and the Humanities II. Students completing EN 1090 continue with EN 1014, while those completing EN 1080 go on to take EN 1034. Students placed in EN 1080 or EN 1090 are encouraged to take these courses over the summer preceding their freshman year. The courses are made available at a significantly reduced cost for students who take them in the summer. Students unable to take a course over the summer may take EN 1080 or EN 1090 during their first regular semester. Typical schedules can be rearranged to accommodate this. University guidelines do not permit undergraduate students placed into EN 1080 or EN 1090 to progress to more advanced humanities courses until they receive a passing grade in these courses.

Mathematics Diagnostic Examination

The Mathematics Diagnostic Examination is an extensive test designed to provide a profile of students' knowledge and skills in basic and advanced mathematics. The department uses the scores on various components of this examination to recommend students' assignments to an appropriate mathematics courses. Based on results of the mathematics diagnostic test, students may be placed in the normal sequence, beginning with MA 1024 Calculus I, MA 1324 Integrated Calculus I or MA 1054 Calculus I with Precalculus in the first freshman semester. They may also be placed in MA 914 Precalculus when the test

indicates a need for strengthening students' mathematical background.

MA 914 does not count toward degree requirements. Students must complete MA 914 before starting the calculus program.

Computer Placement Questionnaire

All freshmen take CS 1114 Introduction to Programming and Problem Solving during their first year of study. Sections of this course, however, are designated for students who have had significant hands-on experience with computers previously while other sections are for those who have had very little experience. 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.

Transfer students with prior college coursework in C++ may (1) receive transfer credit, (2) place out of CS 1114 or (3) register for credit by exam. Students needing more information should meet with an adviser in the Department of Computer and Information Science.

WRITING AND SPEAKING ACROSS THE CURRICULUM

Polytechnic has adopted a Writing and Speaking Across the Curriculum program to ensure graduates develop adequate communications skills. The program ensures that significant writing and speaking assignments are included in designated courses throughout students' undergraduate program, and that the course grades are influenced by the quality of presentation in addition to mastery of content.

To support this program, the Polytechnic Tutoring Center offers the writing center for students, staffed by instructors and qualified tutors. Students are encouraged to make an appointment to improve their writing and/or speaking skills.

Core courses such as EN 1014, EN 1034, EN 1204, HI 2104, EG 1004, all HU/SS electives and all senior design projects are writing- and speaking- intensive courses. Each disciplinary curriculum identifies other courses that fit into this category as well.

FRESHMAN SEMINAR AND ACADEMIC SKILLS SEMINAR

All incoming freshmen, including transfer students with less than 6 credits, are required to take SL 1010 Freshman Seminar. This course is noncredit and includes weekly discussions and presentations on time management, study and test-taking skills, available support services at

Polytechnic and many other subjects of importance to new students. Students must submit a short paper on their selection of a major during the 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 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.

All first-year, first-time probationary students are required to register for and pass SL 1020 Academic Skills Seminar. The course consists of eight one-hour sessions, which meet once per week and is taught on a pass/fail basis. The seminar helps students learn to become more academically successful. The Academic Probation section in this part of the catalog contains more information.

OUTCOMES ASSESSMENT

Polytechnic conducts outcomes assessment activities to monitor student academic achievement, effective teaching methods and continuous improvement of the University, as well as to facilitate compliance with accreditation standards. To obtain periodic measurements of student perceptions and intellectual growth, undergraduates are required to participate in surveys, focus groups, interviews or related activities. While individual input is collected, the data resulting from these assessments are published only in aggregate form. Effective fall 2000, undergraduate students are required to complete online course surveys for all courses in which they are registered each semester (except guided studies and courses in which the enrollment is less than six students). Graduating seniors are required to complete exit surveys online. Any additions to or exceptions to this requirement will be disseminated to the University each semester by the Office of Assessment. Student compliance with outcomes assessment activities generally is a precondition for receipt of semester grade reports, transcripts and degrees.

CURRICULUM 2000

Effective fall 2000, Polytechnic began phasing in a new undergraduate curriculum. The freshman, sophomore and junior curricula in all departments are now based on 4-credit courses. Many of these courses feature a close integration of laboratory, recitation and lecture components. While

most senior-year courses also carry 4 credits, some programs include 3-credit senior electives or 2-credit, half-semester courses.

CURRICULUM 2000 CORE REQUIREMENTS 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 programs section 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 ensure 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 ensure a breadth of knowledge of fundamental engineering principles and an appreciation and understanding of all engineering disciplines.

The four components to the core curriculum are the following:

(1) Liberal Arts Core

Every engineering student must take a minimum of 24 credits in the humanities and social sciences. These courses have two objectives: to develop students' communications skills and expose them to an appropriate balance of study in the liberal arts. Both areas are critically important and contribute to the general literacy of engineering undergraduates as they deal with the world and societal issues that set the context for the practice of their professions.

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

EN 1014 Writing and the Humanities I	4 credits
EN 1204 Writing and the Humanities II	4 credits
HI 2104 Contemporary World History	4 credits

Students placed in EN 1080 Reading and Writing (ESL) or EN 1090 Introductory Composition must successfully complete these courses before beginning EN 1034 Writing and the Humanities I (ESL) or EN 1014, respectively. EN 1034, if required, must be completed before registering for HI 2104; EN 1204 is a desirable co-requisite.

The 12 credits of required HU/SS coursework include 6 credits of content in the area of humanities and social sciences and 6 credits of writing and speaking skills development. To complete the requirements of the liberal arts core, students must take three additional 4-credit elective courses

as (1) two Level 2 electives in two different disciplines and (2) one Level 3 elective.

A Level 2 elective is a course that has EN 1204 and or HI 2104 as a prerequisite. Consult the Liberal Studies Program section in this catalog for course descriptions and further detail. Electives are available in the following humanities disciplines: literature, philosophy, music and fine arts. Electives are also available in the following social science disciplines: history, history of science, economics, psychology and sociology/anthropology.

Courses with the following prefixes do not count as humanities or social sciences electives: DM Digital Media, LA Liberal Arts, LW Law and TC Technical Communication.

(2) Mathematics Core

Every engineering student must take a minimum of 16 credits of study in mathematics beginning with 8 credits of calculus.

Each engineering discipline specifies 8 to 12 additional credits of mathematics from the list below. Consult the programs section of this catalog for information on specific requirements and preferred sequencing for each discipline. Students with AP credit or transfer credit for Calculus I and II are required to take the 2-credit bridge course MA 1132 Numerical Methods for Calculus before registering for higher-level mathematics courses. Transfer students who score 60 percent or better on the mathematics diagnostic examination will receive transfer credit for MA 1122 and be exempt from MA 1132.

MA 2012 Elements of Linear Algebra I	2 credits
MA 2112 Multivariable Calculus I	2 credits
MA 2122 Multivariable Calculus II	2 credits
MA 2132 Ordinary Differential Equations	2 credits
MA 2212 Data Analysis I	2 credits
MA 2222 Data Analysis II	2 credits
MA 2312 Discrete Mathematics I	2 credits
MA 2322 Discrete Mathematics II	2 credits
MA 3012 Probability I	2 credits
MA 3122 Complex Variables I	2 credits

Students placed in MA 914 Precalculus must successfully complete this course before beginning the required sequence described above.

(3) Basic Science Core

The basic science core consists of 12 credits of study in the critical areas of chemistry and physics. The following courses are required of all engineering majors:

CM 1004 General Chemistry for Engineers	4 credits
PH 1004 Introductory Physics I	4 credits
PH 2004 Introductory Physics II	4 credits

Some departments may require an additional 4 credits of science. See the program section of this catalog for details.

(4) Engineering and Computer Science Core

The centerpiece of the core curriculum for engineering majors is the engineering and computer science core. This portion of the curriculum is intended to ensure 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 is the freshman engineering course, 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 many of these fundamental areas.

All engineering students are required to take EG 1004 Introduction to Engineering and CS* Senior Design Project.

** Actual course code depends on department.*

Transfer students may replace EG 1004 Introduction to Engineering with an advanced technical course if they enroll in the University at a sophomore or higher level, subject to adviser approval.

EG 1004 focuses on hands-on experiential learning and the process of engineering design as the single most unique professional function of the engineer. Each major defines its own capstone senior design projects, but every engineering student must complete one.

SEQUENCES

Students are required to complete a two-course, interdisciplinary 8-credit sequence. These sequences are normally taken in the last half of the junior year and the first half of the senior year. Many of these sequences are being offered beginning spring 2002. Catalog supplements will be issued to describe the availability and content of approved sequences as they are developed and implemented.

HONORS COLLEGE

The Honors College, under the auspices of the Othmer Institute for Interdisciplinary Studies, emphasizes an enriched intellectual and social experience for undergraduates with superior academic records and ability. The essence of the Honors College encompasses close relationships with outstanding faculty mentors, high-level individualized attention and support, the opportunity to earn dual BS/MS degrees in as few as four years, incorporation of a global learning experience by encouraging study abroad, specialized course sections and interdisciplinary seminars, a Senior Honors Thesis, reduced class size, advanced placement, an accelerated pace of study and special Honors College events and activities.

The Honors College at Polytechnic was established in 2003. It is managed by the Othmer Institute and is overseen by an Honors College Faculty Governing Board, comprising representatives from all academic departments.

Students selected for the Honors College must have superior academic records in high school and participate in an interview with a member of the Honors College Faculty Governing Board. For more information, e-mail honorscollege@poly.edu, visit www.honorscollege.poly.edu, or call 718-260 3587.

ENGINEERING COMPETENCIES

All Polytechnic undergraduate engineering programs are accredited by ABET. That agency identifies the following core competencies that every engineering program should address: (a) an ability to apply knowledge of mathematics, science and engineering; (b) an ability to design and conduct experiments, as well as to analyze and interpret data; (c) an ability to design a system, component or process to meet desired needs; (d) an ability to function on multidisciplinary teams, (e) an ability to identify, formulate and solve engineering problems; (f) an understanding of professional and ethical responsibility; (g) an ability to communicate effectively; (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context; (i) a recognition of the need for, and an ability to engage, in lifelong learning; (j) a knowledge of contemporary issues; (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Some of the course descriptions list the ABET competencies that they address.

MODIFICATIONS TO CURRICULA

Course Substitutions

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," and available from the Office of the Registrar. Each substitution must be documented on the form and be approved by the student's major faculty adviser and by the Office of Academic Affairs. If a graduation checklist has already been issued at the time of the substitution, the change should be formally entered on the checklist and approved by the major adviser and the Office of Academic Affairs.

Interruption of Study

Polytechnic graduates must fulfill degree requirements using courses that are current and meet the current standards in the field. Accordingly, students have up to eight years to complete the degree requirements in effect when they first enrolled in a Polytechnic undergraduate degree program. This time limit is irrespective of any leave of absence that may be granted during the eight-year period. As courses continuously evolve, the University may replace some courses in the original degree requirements with comparable ones with updated contents. Should the University institute a new set of degree requirements for new students, continuing students may choose to satisfy the new requirements. In such cases, the University will decide which portion of the new requirements may be satisfied by the courses students have already completed, and modification, if any, of the original eight-year time limit.

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.

Current participating societies at Polytechnic:

- Chi Epsilon, civil engineering
- Eta Kappa Nu, electrical engineering
- Omega Chi Epsilon, chemical engineering
- Pi Mu Epsilon, mathematics
- Pi Tau Sigma, mechanical engineering
- Sigma Gamma Tau, aerospace engineering
- Sigma Xi, research
- Tau Beta Pi, engineering
- Upsilon Pi Epsilon, computing sciences

GRADUATION CHECKLIST

Undergraduates nearing completion of their degree requirements receive a graduation checklist, which lists completed courses, assignment to required areas of study and courses remaining to be completed for the degree.

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 GPAs:

BS Cum Laude	3.40 - 3.59
BS Magna Cum Laude	3.60 - 3.69
BS Summa Cum Laude	3.70 or better

Transfer students are eligible to graduate with honors, including being selected as valedictorian, after they complete a minimum of 60 credits toward their degree requirements at Polytechnic.

Senior Honors Students

Each spring, the Department of Electrical and Computer Engineering selects senior honors students with high GPAs 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. Transfer students are eligible for this designation after they complete half of the credits needed to satisfy degree requirements at Polytechnic (e.g., 64 of 128 total credits).

BS/MS ACCELERATED HONORS PROGRAM

Undergraduates with outstanding academic records in certain programs may apply for admission to the BS/MS Accelerated Honors Program, which leads to simultaneous award of a bachelor's and master's degree. This program allows students to make accelerated progress towards completing the two degrees through combinations of AP credits, summer course work and additional credits each semester.

The courses required for the two degrees in this program include all courses required for the individual BS and MS degrees, but the total number of credits may be less than the sum of the credits required for the individual degrees. Specific combinations of BS and MS majors that are available in this accelerated format are described in the programs section of this catalog. Additional information can be obtained from departmental faculty adviser. International Students in F-1 or J-1 status must obtain prior permission and an appropriate I-20/DS-2019 from the Office of International Students and Scholars before enrollment in the combined BS/MS program.

UNDERGRADUATE THESIS

The undergraduate thesis allows students to apply knowledge gained in their major field of interest and use it to plan, conduct and report original research. The thesis may be a discourse upon a subject included in students' 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.

The undergraduate thesis is optional and is not offered by all departments. 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. Department heads approve requests and appoint a thesis adviser. Students should contact their thesis adviser immediately and register for a thesis during the next registration period. Thereafter, the student must register for the thesis every fall and spring semester until it is completed and accepted and the final grade is entered into the student's permanent record.

All theses and results obtained become the property of Polytechnic University. Regulations covering thesis registration and thesis format are available in the Office of Academic Affairs.

APPLICATION PROCESS FOR THE BACHELOR OF SCIENCE

Students must file a formal application for the award of the degree Bachelor of Science from Polytechnic. Applications are available in the Office of the Registrar. 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 graduation date. Upon graduation, no transfer of courses among degree programs is allowed.

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.

UNDERGRADUATE CREDITS

Residency

To satisfy residency requirements for the BS degree at Polytechnic University, students must complete a minimum number of 32 credits at the University in approved junior and senior subjects at the time they are admitted to the University.

Transfer Credits from Other Undergraduate Institutions

Students who have completed some undergraduate courses at other colleges or universities before beginning studies at Polytechnic are encouraged to transfer credits into Polytechnic programs. Polytechnic will award transfer credit for appropriate courses satisfactorily completed at other accredited institutions. Students transferring to Polytechnic from other universities must have transcripts of their courses examined by the Office of Academic Affairs 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 students' records are complete. All evaluations of transfer credits must be completed by the end of students' first semester of registration at Polytechnic. Some programs may choose to delay approval of transfer credits until the students have demonstrated satisfactory progress for a semester at Polytechnic.

Undergraduate transfer credit is not given for any course in which a grade less than C has been earned. In addition, students

completing a course at Polytechnic for which transfer credit has already been given automatically forfeit the transfer credit for that course.

The contents and standards of courses vary from school to school. Thus, some transfer students find after a semester's work at Polytechnic that they will be better prepared for advanced courses if they re-enroll in a course at Polytechnic for which they have been given transfer credit. Students may be required to do this after consulting with their 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 students will be permitted to submit a more advanced course to satisfy degree requirements. This differs from "credit by examination," described below.

Grades of courses for which transfer credit is given are not included in the computation of students' cumulative or current semester GPA.

Articulation Agreements

Agreements have been established with liberal arts and two-year institutions to assist in the transfer process for students seeking entry into Polytechnic's undergraduate programs. These agreements match requirements at other institutions with those at Polytechnic and assist students in planning for transfer into individual programs. Students who meet the course and minimum admission requirements outlined in the agreements are guaranteed admission to the University. Information regarding individual agreements can be found on the Office of Admissions' website, under Transfer Students. Questions regarding articulation agreements should be addressed to the Office of Academic Affairs.

Transfer Credits While in Residence

Undergraduates enrolled at Polytechnic are expected to take all course work at the University. Exceptions are rarely made in cases where Polytechnic does not offer timely courses of importance to the attainment of students' academic goals.

To obtain credit/units for courses taken elsewhere while enrolled at Polytechnic, students must obtain written permission from the major academic adviser, the department head of the course for which transfer credit is requested and the Office of Academic Affairs. 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.
- Pass/fail courses are not acceptable under any conditions.
- Only credits will be granted; grades are not included in the computation of cumulative or current semester GPAs.

Undergraduate Validation Credits

When it is unclear whether a course taken outside Polytechnic is suitable for transfer credit, students 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 at the time of application to Polytechnic. 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 Polytechnic. A grade of C or better is required to validate course credits for undergraduate students. An examination may not be taken more than once. Students who register for or attend the course at Polytechnic forfeit the right to take a validation examination.

Advanced Placement Credits

Polytechnic will grant students credit for appropriate Advanced Placement courses taken in high school, given acceptable performance on AP examinations. Students must request evaluation of AP credits by no later than the end of their first semester of matriculation. 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 advanced placement or college preview courses are not included in the computation of the cumulative or current semester GPAs.

Credit by Examination

Undergraduate students with an outstanding record or with specialized competence may establish a maximum of 16 credits toward the baccalaureate degree by passing comprehensive examinations. Each department determines the courses in which such an examination is available and the examination format. Students must obtain the approval of the department giving the

course, the department of major study and the Office of Academic Affairs.

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. The examination cannot be taken more than once.

Students pay a specified fee to the Office of Student Accounts in advance of each examination. The course and credits are posted on a student's permanent record without a grade and do not count toward the minimum residence requirement for the bachelor's degree or for a degree with honors or toward the GPA.

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:

Freshman	1 - 27 credits
Sophomore	28 - 61 credits
Junior	62 - 94 credits
Senior	95 or more credits

UNDERGRADUATE REGISTRATION STATUS AND MAXIMUM CREDITS PERMITTED

Academic Year Full Time

Undergraduate students registered for 12 or more credits are categorized as full time*. The usual course load for full-time undergraduate students is normally 16 credits.

**For certain types of attendance and enrollment certifications, some students who are registered for less than 12 (undergraduate) credits may be certified as full time; specifically, undergraduates who are pursuing University-authorized full-time, full-semester co-op work assignments; a form to establish full-time equivalency is available from the Office of the Registrar.*

Academic Year Part Time

Students registered for less than 12 credits per semester (except summer) are categorized as part time. 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 8 credits during each six-week summer term, and for no more than 16 credits for the combined 12-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 following semester or summer session for the purposes of student records and credit.

UNDERGRADUATE INTERNATIONAL STUDENTS

Full-Time Status, Program and Degree Changes

To maintain non-immigrant student status, international students must enroll full-time, taking 12 credits on the undergraduate level for each fall and spring semester. Students may take less than a full course of study if fewer credits are needed during the last semester to graduate, or for valid academic and medical reasons. All reasons for exceptions must be approved in writing by the Office of International Students and Scholars (OISS) prior to the last day of late registration each semester so that courses can be added to students' schedule if necessary.

Students in F-1 and J-1 status must obtain written permission from the OISS to withdraw from classes, if the withdrawal will result in less than a full course load, or to take a leave of absence. They must also obtain written permission and an appropriate I-20/DS-2019 form the OISS before enrolling a new degree program. The process of withdrawing from a course, changing degree level, or taking a leave of absence through the Office of the Registrar keeps a non-immigrant student in good standing only with the University, but not with the U.S. Immigration and Citizenship Services (USCIS).

Failure to comply with the immigration requirements regarding full time status, course withdrawals, degree changes or leave of absence violate the non-immigrant student status and make a student ineligible for any of the benefits of that status. According to USCIS, lack of compliance may also result in deportation.

POLICIES ON UNDERGRADUATE GRADING AND GRADES

Computing the Grade-Point Average
The Office of the Registrar determines the weighted GPA of undergraduate students 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
AUD		Audit
NR		Not Received*
P		Passing**
MR		Must Repeat***

* Grade not received by Office of the Registrar in time to report it.

** Only used in SL 1010 and SL 1020.

*** Applies only to Freshmen.

In computing GPAs, Polytechnic does not consider or count courses graded W, I, S or U towards the total credits passed or earned. GPA's are computed by multiplying the numerical grade in each course, adding these products for the courses taken and then dividing this sum by total number of credits represented by courses considered.

The W and I grades are described in greater detail in subsequent sections. Grades 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 or grades of D or AUDIT.

The MR grade is used for pre-college level courses to replace grades of D, D+ or F, and is not counted in the GPA computation once received in the first two semesters of the student's studies at Polytechnic. Any course taken after the first two semesters, including any courses then being repeated, are subject to the existing grading system. Students receiving an MR grade are ineligible for the Dean's List for the semester the MR grade was received.

Repeating Courses

If undergraduate students take a course two or more times, only the second and subsequent grades will count toward their GPA. 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.

No undergraduate course may be repeated more than twice, for a total of three attempts. If a student earns an F grade after the last permitted attempt in a course that serves as a prerequisite or a degree requirement, the student is then academically disqualified and is not eligible for readmission to any program with that requirement. If the last permitted attempt occurs after the first two semesters of a

freshman's time at Polytechnic, then the assigned grade can only be the standard letter grades (opposed to a grade of MR).

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 six-, nine- 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 5PM of the day indicated in the current Schedule of Classes. In the case of a two-week course, withdrawal must be filed by 5PM of the seventh class day. Students who file a course withdrawal form with the Office of the Registrar by the scheduled deadline automatically receive a W grade. Once entered on the student's record, a W cannot be changed to any other grade. An F grade is recorded for any student who ceases to attend a course without formally withdrawing in the required fashion by the required deadline.

Incomplete Grades

If a student is unable to complete the course work at the usual time due to valid reasons, such as illness or other critical emergency, the instructor may give a grade of incomplete I. The date for completion is 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 ensure 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. An I grade signifies that upon successful completion of the work, a passing grade will be issued.

An I grade lapses into an F if students fail to complete the course work within the specified completion date. If students reregister 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.

UNDERGRADUATE ACADEMIC STANDING AND PROBATION

Dean’s List

Undergraduate students who achieve a semester GPA of 3.4 or better, with no grades of F, I, MR or U for the semester, and are otherwise in good academic standing, are commended by the Department of Academic Success and placed on the Dean’s List. The list is posted following the fall and spring semesters for full-time students and following the spring semester for part-time students. Only those who complete 12 or more credits during the fall or spring semester (or fall and spring semesters combined for part-time students) are eligible. Students who include project courses in their 12-or-more-credit 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. Students who include graduate courses in their 12-or-more-credit-programs are eligible. Non-degree credit courses EN 1080 and EN 1090 may count towards the 12 credit requirements as 4 credits. The Dean’s List notation appears on the student’s permanent record. Students who convert a grade of I to a regular letter grade or receive a change of grade after a given semester that would then qualify them for the Dean’s List may retroactively receive Dean’s List honors by bringing the change to the attention of the Department of Academic Success; such grade changes must occur within one year of the end of the semester in question for Dean’s List eligibility to be maintained. Students who repeat a course in a subsequent semester, causing a grade to be no longer used in GPA calculation (see the earlier section on Repeating Courses), do not gain eligibility for the Dean’s List should the revised semester’s GPA rise to 3.4 or above.

General Academic Standing

To remain in good standing, undergraduate students must maintain term and cumulative GPAs of 2.0 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 point at which 12 or more credits are undertaken. Thus, the first semester of study ends when 12 credits are accumulated; the second semester is calculated from that time onward until 24 credits are accumulated. According to these semester equivalents, grade-point requirements for part-time stu-

dents 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 appears below in Table 1.

6	1.88
7	1.95
8	2.00
9	2.00
10	2.00

Table 1: Minimum Credits to Be Earned by Semester of Full-Time Study

SEMESTER	Minimum Credits Successfully Completed
1	8
2	16
3	28
4	40
5	56
6	68
7	84
8	96
9	112
10	128

In calculating the number of successfully completed credits:

1. Courses with F grades do not count toward the criteria of Table 1.
2. Credits bearing an F grade 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 they are repeated.
3. Credits with an I grade will be counted toward enrollment for one year. At the end of that time, any I grade that has not been changed by the instructor on record will automatically lapse to an F grade.
4. Credits assigned a W grade do not appear in the calculation of credits undertaken, earned or successfully completed.
5. Transfer students enter the standard as calculated from the point at which transfer credits place them.

A second requisite for enrollment is the maintenance of a 2.0 GPA or better or performance approaching 2.0 in a steady and realistic fashion. Table 2 contains the absolute minimum cumulative GPA 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 of Full-Time Study

SEMESTER	Minimum Cumulative GPA
1	1.30
2	1.40
3	1.50
4	1.67
5	1.78

The Office of Academic Success provides regular academic monitoring of all undergraduate students to review each student’s academic record after each semester and inform the student’s academic adviser or other representatives from the student’s major department of the results of that review. Students who are identified as being in academic difficulty may not register for more than 12 credits per semester unless otherwise approved by their adviser. Students in academic difficulty will be placed on academic probation following the steps and actions described below.

Academic Warning

Students whose midterm grades show they are in danger of failing receive letters of academic warning. Letters and e-mails 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 their academic adviser.

Academic Probation

Students are placed on academic probation when (1) their semester and/or cumulative GPAs fall below 2.0, but remain above the minimum standards of Table 2 or (2) their number of successfully completed credits falls below the minimum standards of Table 1. Students falling into these categories are notified by letter and are directed to meet with their advisers.

All first-year, first-time probationary students must take SL 1020 Academic Skills Seminar. The seminar consists of eight one-hour sessions, meeting once a week and taken on a pass/fail basis. SL 1020 helps students develop and enhance an awareness of their individual learning styles, study skills and time management techniques so they may become more successful students and return to good academic standing. Topics include establishing a mindset for success, discussing career opportunities, setting goals, managing time, overcoming procrastination, learning study and test-taking skills and self assessing. SL 1020 is structured in small, interactive group sessions designed to support students as they develop strategies for academic success.

Final Probation

Students whose academic records indicate an unacceptable level of academic progress may be placed on final probation. Notified by e-mail and letter of their standing, these students must meet with their adviser to determine a program of study geared toward improving their performance. Failure to improve their performance results in disqualification. Students on final probation may not register before completing current courses.

Disqualification

The Academic Standing Committee, comprising the Department of Academic Success, the associate provost 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. A disqualified student may not apply for readmission for at least one year.

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 problems (physical or psychological), must be documented and can lead to a waiver of these criteria for one semester. Performance in the subsequent semester must meet minimum standards. Such arrangements must be made together with the head of the major department and the Office of Student Development.

WITHDRAWAL FROM THE UNIVERSITY**Voluntary Withdrawal**

Undergraduates must notify the Office of Academic Affairs if they withdraw completely prior to the deadline listed in the Academic Calendar and during a semester in which they are registered. 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 F grades recorded for courses not completed. To receive W grades for the semester, the withdrawal must be completed by the withdrawal deadline indicated in the Academic Calendar.

Involuntary Withdrawal

Polytechnic is concerned about the health, safety and well being of its students; students judged to be a threat to themselves or to others may be involuntarily withdrawn from Polytechnic. The University seeks, whenever possible, for such students to be allowed to continue as active students if they agree to involve themselves in appropriate care of a professional. Full details concerning this policy are available from the Office of Student Development.

LEAVES OF ABSENCE AND READMISSION**Leave of Absence**

Undergraduates taking a leave of absence must obtain permission from the Office of Academic Affairs. Students who want to re-enter after a period of absence of one year or more must file an application for readmission with the Office of Admissions.

Automatic Withdrawal

Undergraduates who do not formally file a leave of absence and who do not register for two consecutive semesters or two consecutive semesters beyond the authorized leave are automatically withdrawn. Students placed in this category must apply for readmission. If readmission is granted, students will be governed by the catalog and rules in effect at the time of readmission.

GRADUATE DEGREE REQUIREMENTS AND ACADEMIC POLICIES

This section details the general University-wide degree requirements that apply to all Polytechnic graduate degrees. Academic departments may place additional requirements on individual degrees. Such additional requirements are explained in the programs section of this catalog. In no case may a department specify requirements less stringent than those indicated here.

OUTCOMES ASSESSMENT

Polytechnic conducts outcomes assessment activities to monitor student academic achievement, effective teaching methods and continuous improvement of the University, as well as to facilitate compliance with accreditation standards. To obtain periodic measurements of student perceptions and intellectual growth, graduate students are strongly encouraged to

participate in surveys, focus groups, interviews or related activities. While individual input is collected, the data resulting from these assessments will be published only in aggregate form.

DEFINITION OF UNITS

Graduate studies are expressed in terms of units. One 55-minute period of graduate class work for a single semester carries 11.75 graduate units. A standard graduate course meeting for two-and-a-half 55-minute periods per week is 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 two-and-a-half periods each week are assigned units in the appropriate proportion. The final examination period is an integral part of the semester.

GRADUATE DEGREES AND ADVANCED CERTIFICATES**Master of Science**

Admission to Master of Science programs requires a bachelor's degree in an appropriate preparatory discipline from an institution acceptable to Polytechnic. Candidates for the degree Master of Science must complete no less than 36 units of advanced study and/or research beyond the bachelor's degree in the program selected. Specific course requirements for each MS program are detailed in the programs section of this catalog.

In order to obtain any graduate degree or certificate, students must maintain a GPA of 3.0 (equivalent to a B letter grade) or better in all graduate courses taken at Polytechnic, including those not used to fulfill specific program requirements. An average of B or better is also required in all guided studies, including readings, projects, theses and dissertations.

Students may offer no more than 12 units of project, guided studies and/or thesis towards fulfillment of the MS degree requirements. Students must register for at least 3 units of a project and/or thesis every semester until the work is completed and a grade recorded.

Graduates must take a minimum of 27 units of work at Polytechnic. A maximum of 9 units may be accepted as transfer and/or validation credits, the latter not exceeding 6 units. Students must complete all requirements for the MS degree within a period of no more than five years after beginning their graduate studies at Polytechnic. Any extension of this period

ACADEMIC POLICIES AND DEGREE REQUIREMENTS

requires the approval of the Office of Academic Affairs.

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

Master of Engineering

Admission to Master of Engineering programs requires a bachelor's degree in an appropriate preparatory discipline from an institution acceptable to Polytechnic. Candidates for the degree Master of Engineering must complete no less than 36 units of advanced study and/or research beyond the bachelor's degree in the program.

Doctor of Philosophy

Requirements for the degree Doctor of Philosophy 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 a PhD should confer with an adviser in the department of major interest regarding (1) selection of courses, (2) major and minor fields of study, (3) formulation of a guidance committee, (4) qualifying and language examinations and (5) degree candidacy. Students must satisfy the detailed requirements of the degree program selected.

All doctorate candidates must complete a minimum of 90 units of graduate work beyond the bachelor's degree, including a minimum of 24 units of dissertation research (depending on major). They must take a minimum of 30 units, including all dissertation units, at Polytechnic.

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 students have started their dissertation, they must register for at least 3 units every semester until it has been completed and accepted, unless a leave of absence is formally granted.

Students must maintain a 3.0 GPA

(equivalent to a B letter grade) or better for all graduate courses taken at Polytechnic and a B or better average for the dissertation. Some departments have specific course or grade requirements that must be fulfilled.

Full-time students must complete all work for a PhD within six calendar years counted from the time of admission graduate work at Polytechnic. Part-time students must complete within 12 years. Any extension of these periods requires prior approval of the Office of Academic Affairs.

Graduate Advanced Certificate Programs

Polytechnic offers a number of graduate advanced certificate programs in specialized subject areas for students who do not wish to enroll in a full-degree program. Students must officially enroll in a certificate program when they begin graduate study at Polytechnic. Detailed descriptions of the certificate programs are available from the responsible departments. Please see Certificates Offered at Polytechnic in this section of the catalog for a full listing.

Depending on the program, 12 to 15 units must be taken at Polytechnic in order to earn a certificate, and the courses may also be applied to graduate degrees. Applicants must be formally admitted to a certificate program before beginning course work. Admission requirements are the same as those for related MS programs.

Students must have a cumulative GPA of 3.0 in all graduate courses taken at Polytechnic to receive a certificate. No courses applied to one certificate program can be applied to another. Requirements for certificates must be completed within three years.

Students in such a program who subsequently decide to pursue a graduate degree must file a separate application for admission to the regular graduate program.

GRADUATE UNITS AND REQUIREMENTS

Residency

To satisfy residency requirements for a graduate degree at Polytechnic University, students must complete the following minimum number of units at the University:

- Master of Science 27 units
- Master of Engineering 27 units
- Doctor of Philosophy 30 units
(including dissertation)
- Graduate Certificate 12-15 units

Transfer Units

Students may transfer a limited number of units toward meeting the requirements for master's, doctoral or graduate certificate at Polytechnic, if the unit courses are (1) consistent with Polytechnic's residency requirements, (2) completed with honor grades A or B, (3) from accredited institutions (4) acceptable at the transferring institution for similar degree programs and (5) taken after receipt of a bachelor's degree. The student's major academic department evaluates the graduate transfer units.

Graduate courses taken at Polytechnic while a student is pursuing an undergraduate degree may be subsequently applied toward a graduate degree, provided that they earned a B grade or better and did not use this course to fulfill requirements for an undergraduate degree. Such courses are not subject to the 9-unit maximum transfer limitation for the MS degree, and the grades are not figured into the cumulative GPA.

Graduate Validation Units

When it is unclear whether a course taken outside Polytechnic is suitable for transfer credit, students may qualify for transfer credit by passing a validation examination. Permission to take the 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 can it be scheduled more than one calendar year after the student begins study at Polytechnic. A grade of 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 9 units for the MS degree.

Graduate Registration Status and Maximum Units Permitted

Graduate students pay tuition at the per-unit rate.

- Full-time MS students are registered for 9 units or more.*
- Part-time MS students are registered for less than 9 units per semester (except in summer). Part-time students do not qualify for most financial assistance programs.

- Full-time PhD students may register for 6 units per semester upon passing the PhD qualifying examination. Prior to passing the exam, they are registered for 9 units or more.*
- Part-time PhD students register for less than 6 credits per semester upon passing the qualifying examination.

* For certain types of attendance and enrollment certifications some MS students registered for less than 9 graduate units and some PhD students who passed the PhD qualifying examination and are registered for less than 6 units may be certified as full time. This includes graduate students pursuing research projects that their department head certifies in writing to the Office of the Registrar as full time. A form to establish full-time equivalency is available from the Office of the Registrar.

GRADUATE INTERNATIONAL STUDENTS

Full-time Status, Program and Degree Changes

A full course of study for all MS students or graduate students seeking the PhD, and who have not passed the qualifying examination, consists of 9 units on the graduate level for each fall and spring semester. To maintain non-immigrant student status, international students must enroll on a full-time basis. Students may take less than a full course of study if fewer units are needed during the last semester to graduate, or for valid academic and medical reasons. All reasons for exceptions must be approved in writing by the Office of International Students and Scholars (OISS) prior to the last day of late registration each semester so that courses can be added to the student's schedule if necessary.

Students in F-1 and J-1 status must obtain written permission from the OISS to withdraw from classes, if the withdrawal will result in less than a full course load, or to take a leave of absence. They must also obtain written permission and an appropriate I-20/DS-2019 form before enrolling in a new degree program. The process of withdrawing from a course, changing degree level, or taking a leave of absence through the Office of the Registrar keeps a non-immigrant student in good standing only with the University, but not with the U.S. Immigration and Citizenship Services (USCIS).

Failure to comply with the immigration requirements regarding full time status, course withdrawals, degree changes or leave of absence violates the non-immigrant student status and makes a student ineligible for any of the benefits of that sta-

tus. According to USCIS, lack of compliance may also result in deportation.

Maintenance of Studies

- **PhD Students:** PhD students, including international students, who have completed all required course and dissertation credits may register for up to two semesters of "maintenance of studies" for no tuition charge (a University fee will apply). This category of registration officially maintains the degree candidacy of the student and is intended to extend the time needed for completing the writing and defense of the dissertation.
- **MS Students:** Under exceptional and well-documented circumstances, graduate students, including international students, seeking an MS degree in a program that requires a MS thesis or MS project may, with the permission of the thesis or project supervisor, request one semester of maintenance of study to complete the project or thesis. Adequate written justification must be provided to the Office of Academic Affairs for permission to be granted.

POLICIES ON GRADING AND GRADES

Computing the Grade-Point Average for Graduate Students

For the purposes of computing GPAs 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
S		Satisfactory
U		Unsatisfactory
W		Withdrawal
I		Incomplete
AUD		Audit
NR		Not Received

Grades S and U are used to reflect progress on continuing research efforts. Once the dissertation is completed, the appropriate letter grade is entered on the transcript. Noncredit seminar courses are also graded S or U. Grades S, U, I, W and AUD are not included in computing the GPA, which is computed as indicated for undergraduate students.

Repeating Courses

The first time a graduate student repeats a course, the lower grade will not be counted towards the GPA. All subsequent grades in a course repeated more than once will be included in the GPA, 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 six-, nine- 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 5PM of the day indicated in the current Schedule of Classes. In the case of a two-week course, withdrawal must be filed by 5PM 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 W grade. Once entered on the student's record, a W grade may not be changed to any other grade. An F grade 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 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 if they select courses for audit status. Under no circumstances may an audit status be changed to credit status once elected.

Incomplete Grades

If students are unable to complete the course work at the usual time due to valid reasons, such as illness or other critical emergency, the instructor may give an incomplete I grade. The date for completion is inserted next to the I grade on the grade sheet and will be communicated directly to the students by the instructor when possible. Whenever feasible, this date will not extend beyond the intersession, in fairness to stu-

dents who finish course requirements on time and to ensure 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 I grade is used sparingly and only in cases with valid reasons, not merely because students have planned poorly or overloaded themselves. An I signifies that upon successful completion of the work, a passing grade will be issued.

ONLINE LEARNING—EPOLY

Polytechnic’s online programs, ePoly, are designed specifically for working adults who want to remain current and advance in their careers or for graduate students who aspire to a Polytechnic degree but cannot attend classes at any of the University locations. All courses are presently designed and instructed by Polytechnic full-time and adjunct faculty. Some MS degrees, graduate certificates, individual courses and continuing education seminars are available completely online.

An increasing number of Polytechnic’s traditional graduate courses are available online for convenient study. These courses are designated with a four-digit course number: the first three digits indicating the classroom equivalent, and the fourth digit always the number 4. While online courses are considered equivalent to classroom counterparts in terms of similar topics and requirements, online courses introduce supplementary topics or projects that require additional class time and study.

CONTINUATION OF STUDIES BEYOND THE INITIAL MASTER OF SCIENCE

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. Examples are (1) progressing from an MS program to a PhD program or (2) seeking a second MS degree from Polytechnic. In the latter case, students should be aware that New York State regulations prohibit graduate credits applied toward the first degree be applied towards a second MS degree.

ACADEMIC STANDING AND PROBATION

Graduate students are expected to progress in their studies and maintain a 3.0 GPA. Failure to do so results in students being placed on academic probation or disqualified based upon the guidelines set in the table below. For additional information, contact the associate dean for graduate studies in the Office of Academic Affairs.

Grade-Point Average Required to Avoid Disqualification (All Graduate Students)

After “N” Units Taken at Polytechnic	Matriculated or Visiting Status Transfer Units			
	none	3	6	9 or more
N= 6	2.00	2.00	2.50	2.50
12	2.50	2.50	2.50	2.50
18	2.50	2.50	2.66	2.66
24	2.75	2.75	2.87	2.87
30	2.90	2.90	3.00	3.00

N>36, GPA>3.00 required (check every 6 units)

Notes:

1. Students with GPA below the entries in above table are disqualified and, with rare exception, cannot be readmitted.
2. Students with GPA equal to or above the entries in the above table, but less than 3.0, are notified that they are on graduate probation and informed that they will be disqualified if the GPA falls below the entries in the above table.
3. The entries are credits taken, not credits earned. Courses with W grades are excluded from the computation, as are project/thesis grades when assigned an S or U.

At the end of the spring semester grades, graduate students whose cumulative GPA is below 3.0 are notified that they are on academic probation or disqualified. Copies of probation/disqualification notices go to each department, where the accuracy of GPA determinations is checked. Students with GPAs lower than 3.0 are notified in August by the Office of Academic Affairs.

A major department may request that a graduate student be placed on academic probation at any time that it finds a student falling below a 3.0 cumulative GPA. The request is signed by the department head and sent to the Office of Academic Affairs.

A graduate student on academic probation may not register for further courses without written permission of the department head or designated adviser and the concurrence of the Office of Academic Affairs. When a student is permitted to register, the department will provide the stu-

dent 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 Academic Affairs and the major department office. A student may be denied permission to register by an academic department or the Office of Academic Affairs at any time while on academic probation. Students are cautioned that if they fail to maintain a 3.0 cumulative GPA, they may lose regular status and/or be refused permission to register.

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

WITHDRAWAL FROM THE UNIVERSITY

Voluntary Withdrawal

Graduate students must notify the Office of Academic Affairs if they withdraw completely prior to the deadline published in the Academic Calendar and during a semester in which they are registered. 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 F grades recorded for courses not completed. To receive W grades for the semester, the withdrawal must be completed by the withdrawal deadline indicated in the Academic Calendar.

Involuntary Withdrawal

Polytechnic is concerned about the health, safety and well being of its students; students judged to be a threat to themselves or to others may be involuntarily withdrawn from Polytechnic. The University seeks, whenever possible, for such students to be allowed to continue as active students if they agree to involve themselves in appropriate care of a professional. Full details concerning this policy are available from the Office of Student Development.

LEAVES OF ABSENCE AND READMISSION

Leave of Absence

Graduate students taking a leave of absence for a specified period of time, usually not exceeding one year, must obtain permission from the Office of Academic Affairs. Only if part-time or full-time students have received an approved leave of absence will the time limitation on earning a graduate degree be extended by the period of the leave. Such requests, when approved by the

Office of Academic Affairs, will constitute assurance of readmission to the degree program from which the leave was taken. If the period of absence exceeds the approved leave, students must apply for readmission.

Once PhD students begin their dissertation, they must continually register for dissertation or maintain their studies; they must file a leave of absence for semesters they do not register 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.

Automatic Withdrawal

Graduate students who do not formally file a leave of absence and who do not register for two consecutive semesters or two consecutive semesters beyond the authorized leave are automatically withdrawn. Students placed in this category must apply for readmission. If readmission is granted, students will be governed by the catalog and rules in effect at the time of readmission.

APPLICATION PROCESS FOR THE MASTER OF SCIENCE AND DOCTOR OF PHILOSOPHY

Graduate students must file a formal application for the award of any Polytechnic degree or certificate. Applications are available in the Office of the Registrar. Applications for the PhD degree are available in the Office of Academic Affairs. 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.

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.

PROJECTS, THESES AND DISSERTATIONS

Graduate Research

Investigations undertaken for graduate research help develop students' independent and creative thinking. Through them, students are trained to analyze, research and synthesize and contribute to the advancement of science and engineering.

Research for an advanced degree embodies 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.

MS students may elect to complete an MS project or MS thesis and may be required to do so in certain programs. Consult the programs section in this catalog for details. A thesis is generally a more extended piece of work, usually entailing 9 to 12 units, while the project usually entails 3 to 6 units. At this level, research should exhibit a thorough understanding of advanced scientific thought or ability to apply advanced principles constructively to engineering planning and design.

Each PhD student must complete a PhD dissertation. Research at this level must demonstrate critical and constructive thought as well as the ability to use the techniques necessary in exploring and developing new areas of knowledge in science or engineering. A successful dissertation must demonstrably advance the subject area of research. University requirements for dissertations set a minimum of 24 units of registration. 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 Projects, Theses and Dissertations

After a project, thesis or dissertation adviser and/or guidance committee has been appointed, candidates should register each semester for the number of units that realistically reflects the amount of time and effort they expect to devote to their research. They must continually register each fall and spring until they adequately complete their research effort and pass the required oral examination. Registration cannot be interrupted until a grade is entered on the permanent record except with the permission of the Office of Academic Affairs. If, at the end of any semester, the adviser deems unsatisfactory any work covered by the unit of registrations, students may be required to reregister for the same unit and be obligated to pay for full tuition and laboratory fees involved. Continuous registration is required until a final grade is submitted to the Office of the Registrar.

PhD students who have taken the minimum number of dissertation units and fin-

ished their dissertation, except for the final defense, are allowed to register for up to two semesters of "maintenance of study," as described above. MS candidates registered for thesis or project may, under exceptional and well-documented circumstances, apply for one semester of "maintenance of study" as described above.

Manuscript Presentation

Degree candidate must present their research to the appointed guidance committee in final manuscript form for official acceptance on or before the Monday seven weeks before commencement. The accepted format for the bound research document is detailed in the *Regulations on Format, Duplication and Publication of Project Reports, Theses and Dissertations* brochure available from the Office of Academic Affairs and in departmental offices. Some of the regulations are summarized below.

MS candidates must submit four bound final copies of their research; PhD candidates must submit four bound final copies and one unbound final copy to be used for microfilming. Duplication processes of high quality are acceptable. In addition, each PhD candidate must submit two copies of an abstract of not more than 350 words suitable for publication in *Dissertation Abstracts*.

All graduate students must submit the four final bound copies to their department for appropriate signatures and then present them to the Office of Academic Affairs before noon on the first Friday in December (for fall degrees) or the first Friday in May (for spring degrees). At the same time, PhD candidates must submit the unbound copy in a labeled envelope along with the two copies of the abstract. The original copy is kept permanently in the Polytechnic library.

Publication

Doctoral dissertations will be microfilmed by 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. Any interested person can purchase copies of these microfilms from University Microfilms.

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 other-

wise, its basis as a Polytechnic University dissertation.

PROJECTS, THESES AND DISSERTATIONS

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PhD students who have taken the minimum number of dissertation units and finished their dissertation, except for the final defense, are allowed to register for up to two semesters of "maintenance of study," as described above. MS candidates registered for thesis or project may, under exceptional and well-documented circumstances, apply for one semester of "maintenance of study" as described above.

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ACADEMIC SUPPORT AND COUNSELING SERVICES

DEPARTMENT OF ACADEMIC SUCCESS

The mission of the Department of Academic Success is to enhance the likelihood of students successfully completing the studies they begin at Polytechnic University. To this end, academic support functions are integrated and delivered in a comprehensive and seamless manner.

To ensure students' needs are met and addressed, Polytechnic has collaborated and coordinated services among all areas reporting to the Department of Academic Success and key offices overseen by the Division of Student Affairs.

The Department of Academic Success is ready to address students' needs that range from proper course placement to advisement and monitoring to tutoring and counseling. In addition, referrals and advocacy are provided as needed. The department oversees the following academic support services: Academic Advisement Center, the Polytechnic Tutoring Center, the Counseling Center, the Higher Education Opportunity Program (HEOP), the General Studies Program and the Office of Special Services (TRIO).

For more information about the department, visit www.das.poly.edu.

ACADEMIC ADVISEMENT CENTER

The mission of the Academic Advisement Center is to provide centralized advising for all incoming, matriculated freshmen and initial advisement for transfer students. All undergraduate students are advised by the Academic Advisement Center in their first year of study. After the first year, they are assigned advisers in their respective major departments. The staff advises students on major requirements and university regulations and refers them to appropriate campus resources. In addition, academic advisers advocate for students with University offices and assist students in dealing with issues currently affecting them.

The center also directs the review of students' progress each semester to determine academic standing. The academic advisers make decisions regarding the Dean's List, probation and disqualification, and send notifications to the students and the respective academic offices and departments. Students are directed to meet regularly with their advisers to discuss academic progress and address questions concerning their academic standing. All first-year, first-time probationary students are required to enroll in and attend SL 1020 Academic Skills Seminar.

For more information about the center, visit www.advisement.poly.edu.

POLYTECHNIC TUTORING CENTER

The Polytechnic Tutoring Center (PTC) offers a range of academic support services to all registered Polytechnic students. Tutoring is offered in math, physics, chemistry and computer science for first- and second-year courses. Tutoring is provided on a drop-in basis and in exam review sessions.

The PTC includes the Writing Center, where students receive help with college-level writing, reading and speaking assignments and with English-language mastery. The Writing Center is open to Polytechnic students at any level, from first-year undergraduates through doctoral candidates. Staff at the Writing Center work with students on a one-to-one basis.

Tutors are carefully selected and trained. They include undergraduate peer tutors, graduate students and instructors. Tutors know their subjects well and understand where students may have difficulty. They are skilled at explaining material in a variety of ways for maximum comprehension. All students' questions are respected; no question is too basic to ask. The PTC also helps students improve their learning skills in order to become more successful in college and throughout their careers.

PTC services are free of charge. For more information about the center, please visit www.tutoring.poly.edu.

COUNSELING CENTER

College students may face a range of situational or personal difficulties that interfere with their ability to succeed academically. For example, students may struggle with depression, loneliness, stress or anxiety; problems with family, relationship, motivation, time management or procrastination; questions about their major or career; or difficulty making friends at Poly. The Counseling Center offers free, confidential individual counseling to Polytechnic students. Staff members are licensed psychologists who are extensively trained to help students deal with a whole range of problems. Counselors can provide information and support to help students solve problems, achieve goals and feel better. The Counseling Center has a variety of books, self-help materials and brochures available. Staff members are also available to consult with faculty or staff members who are concerned about a student. For more information about the center, visit www.counseling.poly.edu.

HEOP

The Higher Education Opportunity Program (HEOP) is a New York State-funded program designed to provide broad and varied educational instruction to capable students who, due to limited academic and financial resources, might otherwise not have the opportunity to attend Polytechnic. Once admitted to the HEOP program, students are provided with financial assistance, counseling, tutoring, advisement and other support services throughout their college career. HEOP's goal is to retain and graduate students who are traditionally under-represented in the fields of engineering and science. More information on HEOP is included in Part 4 "Special Programs" in this catalog or, visit www.heop.poly.edu.

GENERAL STUDIES PROGRAM

The General Studies Program provides students who do not meet the traditional admissions requirements an opportunity to obtain a science, engineering, humanities and management-based education in a supportive environment. To ensure student success, the General Studies students receive a broad variety of services, beginning with a mandatory summer program prior to the start of their freshman year and continuing throughout the academic year with mandatory, weekly tutoring and advisement sessions. Once admitted into Polytechnic, students must successfully participate in the program for one year before they are allowed to officially declare their major. For additional information, please refer to Part 4 "Special Programs" in this catalog or visit www.gs.poly.edu.

OFFICE OF SPECIAL SERVICES

The Office of Special Services provides tutoring, academic counseling and various other support services to Polytechnic students. The office is a TRIO program, funded by the U.S. Department of Education; therefore, students requesting assistance must first meet eligibility requirements. The program provides eligible students with a variety of free and confidential services developed to enhance students' academic performance and maximize their potential.

Individualized tutoring is available to students through the TRIO program. The office staff assigns qualified upperclassmen to tutor students one-on-one in physics,

math, chemistry and computer science for the entire semester. Students meet weekly throughout the semester with an assigned tutor who addresses their individual concerns regarding course work. Small-group exam review sessions are also scheduled for students throughout the semester.

Academic counseling is available to assist students in managing the academic challenges of university life. The office offers individualized study skills advisement and workshops dealing with goal setting, time management and test taking. These academically related skills assist students in successfully mastering the technical curriculum at Polytechnic. The office also provides career guidance and testing and arranges on-site visits and tours to help students explore various opportunities available to them when they graduate.

Various cultural and educational workshops and trips are scheduled throughout the academic year. Workshops geared towards student personal development are scheduled monthly. Free trips, which consist of Broadway plays, industry visits, museums and other cultural events, are also scheduled throughout the academic year. In addition, the program provides eligible students with financial assistance through grants and scholarships.

For more information about the Office of Special Services, visit www.specialservices.poly.edu.

STAFF

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BS, New School University

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 Undergraduate Admissions according to criteria established by the dean of Undergraduate Admissions and the University's Undergraduate Enrollment Council.

UNDERGRADUATE

THE APPLICATION PROCESS

Application materials and information about undergraduate admissions may be obtained by contacting the Office of Undergraduate Admissions:

Office of Undergraduate Admissions
Polytechnic University
Six MetroTech Center
Brooklyn, NY 11201
Tel: 718-637-5955
Fax: 718-260-3446
E-mail: admitme@poly.edu
Web: www.poly.edu/admit

Undergraduate applicants should complete the application for admission 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 Assessment Test (SAT1) 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 timetable:

Full-time undergraduate study

November 1 – for the spring semester
March 1 – for the fall semester
January 15 – for fall semester scholarship

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 applications received after December 1 for the spring semester, nor after June 1 for the fall semester. All official records, together with notarized translations, must also be received by these dates. (See "Admission as an International Student" for additional information.)

If accepted for admission, applicants should submit an enrollment deposit of \$300 in order to reserve a place in the entering class. This deposit is applied to tuition and fees for the first semester and is not refundable.

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 freshman 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

Requirements

Applicants for admission as freshmen are required to take the Scholastic Assessment Test (SAT1). The American College Testing (ACT) Program may substitute the SAT1. Students who are admitted to Polytechnic and plan on enrolling are required to take two placement examinations prior to registration. The preferred secondary school course of study is:

Course	Years
English	4
Science	4
<i>(Chemistry is required and physics is strongly recommended)</i>	
Mathematics	4
<i>(Sequential I, II, III, precalculus, calculus)</i>	

This course of study is only a directive, not an absolute requirement. The primary concern of the members of the Admissions Committee 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. Arrangements can be made by calling the Office of Admissions at 800-POLYTECH. 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 obtaining an exceptional score 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 the Advanced Placement and the International Baccalaureate Exam, French Baccalaureate or General Certificate Exam A levels, etc., vary from department to department. Students are 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 work during the summer prior to beginning the freshman year, to make up prerequisites and courses in which weakness is shown. Freshmen are admitted to this program in the fall only.

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.

For further information, contact the office of HEOP at 718-260-3370 or consult Part 4 of this catalog.

ADMISSION AS AN INTERNATIONAL STUDENT

International students must meet four basic criteria for admission to Polytechnic and be in 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 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 with less than 30 college credits may need to submit high school transcripts and SAT 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 credits will be evaluated prior to the end of the first semester the transfer student is enrolled at the University by the Office of Academic Affairs in consultation with academic departments.

Transfer credit is awarded on the basis of current standards and curriculum. Therefore, it is possible that credits 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 in writing and/or math.

The minimum residence requirement for transfer students who wish to qualify for a Polytechnic bachelor's degree is 34 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). Part-time undergraduate students should be aware that it is not possible to complete a bachelor's degree program by attending only evening courses.

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

Following notification of acceptance, students are told 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 satisfies 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.

READMISSION

Polytechnic students who have not been in attendance for one semester or more and have not been granted an approved leave of absence (see "Leave of Absence") are required to apply for readmission through the Office of Admissions. Students who have been academically disqualified must apply for readmission through the Office of Admissions. Students applying for readmission are expected to state their reasons for leaving the University and explain why they want to return. They must also submit with their application for readmission official transcripts of college-level courses taken during this period of absence from Polytechnic.

UNDERGRADUATE ADVISERS

All undergraduate students are advised by the Academic Advisement Center in their first year of study. After the first year, they are assigned advisers in their respective major departments. These departmental advisers are available for individual appointments to discuss academic and related matters. A student’s adviser must sign all registration, program adjustment and course withdrawal forms.

GRADUATE

To be eligible for admission as a graduate student, an applicant must first 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 may be required to take additional courses for which credit towards degree requirements 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 Graduate Center for Professional Studies, Polytechnic University, Six MetroTech Center, Brooklyn NY 11201, 718-260-3182, or online at www.poly.edu/admissions/graduate.

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) is required for admission to some graduate programs. The Graduate Management Admission Test (GMAT) may be required for admission to some management 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 can be obtained from The Educational Testing Service, 20 Nassau Street, Princeton NJ 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. Late applications or 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 normally 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. For detailed information, see “English Requirement for International Students.” 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.

ENGLISH REQUIREMENT FOR INTERNATIONAL STUDENTS

In order to be granted regular admission to a graduate degree program, international students are normally required to demonstrate proficiency in English by obtaining a score of at least 550 on the traditional or 213 on the computer-based Test of English as a Foreign Language (TOEFL).

This requirement may be waived for international students who:

- Have earned a degree from an institution in a country where English is the official or major language or where English is a second language
- Have successfully completed a high school or undergraduate program in which English was the official or major language of instruction
- Can demonstrate a level of English pro-

ficiency deemed equivalent to a TOEFL score of 550 through submission of evidence acceptable to the University

For more information, contact the Office of Graduate Admissions.

International students who obtain a TOEFL (or equivalent) score of between 500 and 550 may be admitted to a graduate degree program on condition that they successfully complete an English program approved by the University. Upon successful completion of the approved English program, students will be admitted to regular study and will not be required to submit a new TOEFL score.

APPROVED ENGLISH PROGRAM

The University approves the Intensive English program offered by the ELS Language Center. Successful completion of Level 12 at the Center satisfies the University’s English proficiency requirement.

The ELS Language Center is located approximately two miles from the University at 75 Varick Street, New York NY 10013. The intensive English course requires attendance from 9AM to 4PM, Monday through Friday. Placement in the program is determined by an assessment test administered on site.

The following chart gives general equivalence between ELS levels and TOEFL scores:

ELS	Traditional TOEFL	Computer-Based TOEFL
Level 109	500	173
Level 110	520	190
Level 111	530	197
Level 112	550	213

Please note: These equivalencies are not exact and serve only as a guide. Students normally advance one level for each month of intensive English instruction. Thus a student who enters at level 109 may expect to take at least three months to attain level 112.

For more information about the ELS Center program, contact Polytechnic’s Graduate Center, or write directly to ELS Language Center, 75 Varick Street, 2nd Floor, New York NY 10013; tel: 212-431-9330; e-mail: thogan@els.com. As of 2002, the cost of attendance at the intensive English program is \$1,325 per month. Students admitted to Polytechnic University may be eligible to receive a tuition discount from ELS.

ADMISSIONS

Students may also be permitted to undertake up to 6 units of graduate study at Polytechnic while completing a program at ELS. This decision will be made by the academic department admitting the student and will be based upon the student's TOEFL score and the ELS language assessment.

While Polytechnic has recognized ELS level 112 as satisfying its English proficiency requirement for international students, attendance at other programs either abroad or in the United States may also meet the University's requirements. For further information, or to determine if a particular program qualifies, please contact the Graduate Center.

POLYTECHNIC UNIVERSITY'S ENGLISH PROGRAM

In certain cases, international graduate students may be required to attend an English program at Polytechnic upon enrollment. This decision is made at the time of admission and is normally only offered to students with TOEFL scores only slightly below the required level of 550.

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 Graduate Center.

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 Graduate Center 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 special (non-degree) student application must be submitted to the Graduate Center. 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 6 units or two courses may be taken in one semester and no more than 9 units or three courses may be applied to a Polytechnic degree program. If such courses are applied toward a degree, they are considered as having been taken "in residence" at Polytechnic. 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. Proof of that degree may be required.

Readmission

Part-time students who last attended Polytechnic within a one-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 year must file an application for readmission, which is available from the Graduate Center.

Full-time students who want to interrupt their studies must request a leave of absence for a specified period of time, usually not exceeding one year. Such requests, when approved by the Office of Academic Affairs and the Office of International Students and Scholars, will constitute assurance of readmission to the degree program from which the leave was taken. Students must apply for readmission when the period of absence exceeds the approved leave of absence.

EARLY GRADUATE ADMISSION

A Polytechnic undergraduate student who is within 18 credits of completing a BS degree and meets all criteria for graduate admission may apply for admission to graduate study in a given department. If accepted, the student will pursue two degrees simultaneously, taking both graduate and undergraduate courses for no longer than one year. Graduate courses taken during that year that do not satisfy undergraduate degree requirements are counted toward the master's degree program, and the grades are recorded on the graduate transcript. A formal application for graduate admission must be filed through the Graduate Center.

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.

ATHLETICS, INTRAMURALS AND RECREATION

The Office of Athletics, Intramurals and Recreation offers a wide range of physical activities for the benefit and enjoyment of the student body. Whether students belong to a varsity team, work out in the Fitness Center or participate in a class or intramural event, they should consider the activity part of their Polytechnic education. Sports teach students to work in teams, make decisions, respect peers and solve problems under stress. Physical activity and strength training are also necessary for good health. The more physically fit students are, the better they cope with the pressures and stress of college life.

Through sports, students have fun, make friends, improve their self image and retain long-lasting memories, such as shooting the final ball in overtime during a basketball game and winning the championship, making a fantastic play in the outfield or bench pressing the winning lift in a fitness competition. All Polytechnic students are encouraged to engage in some sort of physical activity on campus.

PHILOSOPHY OF ATHLETICS

As an NCAA Division III institution, Polytechnic University places the highest priority on the quality of the overall educational experience and success of each scholar-athlete. The Physical Education and Athletics Program's goal is to produce and support the leaders of tomorrow by establishing and maintaining an environment that values cultural diversity and gender equality among athletes and the athletic staff.

Polytechnic believes that athletics is a vital part of students' education, although their academic program has top priority. As a Division III institution, Polytechnic does not award athletically related financial aid to any students.

Student athletes, coaches and athletic staff are encouraged always to exhibit good sportsmanship, respect, fairness and honesty towards each other and their competitors. The University seeks to develop each athlete as a leader and believes that participation in athletics teaches the above and continues the student's development as a well-rounded, competent individual.

Maximum participation in athletics is encouraged and the program offers a variety of opportunities in Varsity, Club and Intramural Sports. Polytechnic supports students in their efforts to reach high levels of performance by providing adequate facilities and competent coaching and seeks to ensure that each student's athletic experience is a positive one.

The athletic program at Polytechnic offers students an area of personal growth they will need to be successful once they graduate. Athletics teaches teamwork and self-control and improves mental and physical condition. The program works to instill students' respect for themselves and their opponents as well as have them experience the great feeling of winning and be able to deal with losing, which makes them stronger as people in the long run.

The University proudly looks to its student-athletes as role models and expects their behavior, both on and off the

court/field, to bring honor to themselves and to Polytechnic. While the University's goal is for every student athlete to feel successful, it will not compromise the school's mission, vision or spirit in the pursuit of winning.

INTERCOLLEGIATE ATHLETICS

Polytechnic is a member of the NCAA (National Collegiate Athletic Association), NEAC (North Eastern Athletic Association), NECVA (North Eastern Collegiate Volleyball Association) and USJI (United States Judo Inc.). The University fields the following teams: men's and women's basketball, volleyball, soccer, tennis, cross country and track; women's softball; and men's baseball.

All full-time undergraduate students who are in good academic standing and meet the NCAA eligibility requirements for team membership are encouraged to participate and win their varsity letter.

INTRAMURALS

Intramural sports enjoy substantial success at Polytechnic. All undergraduate and graduate students are eligible for competition in basketball, soccer, flag football, handball, volleyball and badminton. New sports are offered if there is sufficient interest.

CLASSES/CLUB SPORTS

Aerobics

Basic aerobic steps and conditioning to music. Class consists of warm-up, stretching and low impact aerobics. Floor exercises focus on stomach, legs, hips and buttocks, strengthening exercises using hand weights.

Bowling

Recreational bowling club meets once a week at Maple Lanes in Brooklyn. Standings are kept and awards given at the end of the semester. Bowling tournaments are also available during the year.

Martial Arts–Judo/Beginner and Advanced

All aspects of Sport Judo from beginner to advanced. Lessons include conditioning, drills, mat work, standing techniques and contest rules. Class is offered for recreation and/or competition. Rank is given.

Martial Arts– Tae Kwon Do /Beginner and Advanced

Tae Kwon Do is taught as a traditional martial art. Lessons include patterns, basic striking, blocking and kicking techniques, calisthenics, light sparring, self-defense releases and throws. Class is offered for recreation and/or competition. Rank is given.

Swimming

Recreational swimming hours are offered at St. Francis College, 180 Remsen Street, Brooklyn, NY (about a 5 minute walk from the campus)

Table Tennis

Polytechnic offers both recreational hours and opportunities to get involved in inter-collegiate competition. Recreational players can try-out for a place on the team.

FACILITIES

Gymnasium: NCAA-regulation gym, located on first floor of the Joseph J. and Violet J. Jacobs Building (JAB).

Trainers Room: Located in the Lower Level of the Joseph J. and Violet J. Jacobs Building (JAB). Includes whirlpool, ice machine, hydroculator (hot packs) and ultra-sound and electrical stimulation machines. An athletic trainer is present at all home games and is on campus three days a week.

Fitness Center: Located in the Lower Level of the Joseph J. and Violet J. Jacobs Building (JAB). Equipment includes treadmills, steppers, stationary bicycles, rowing machines, a heavy bag and a speed bag for cardiovascular work. Strength equipment includes both single and dual weight machines and a free weight area including barbells and dumbbells.

Recreation Center: Located in the Lower Level of the JAB, includes billiards, ping pong, shuffle board, and air hockey.

Athletic Fields: Polytechnic's athletic fields for baseball, softball and soccer are located at Floyd Bennett Field in Gateway Recreation area off the Belt Parkway, Exit 11 South.

STAFF

Maureen Braziel, Director of Athletics and Recreation

MS, Hunter College

James Barrett, Operations Manager
Manager/Intramural Director

Margie Iacono, Administrative Assistant

CAREER SERVICES AND COOPERATIVE EDUCATION

The Office of Career Services and Cooperative Education assists students in meeting their varied career needs. Polytechnic students are encouraged to begin taking an early and active role in planning their career development. For this reason, the goals of the Office of Career Services are to assist students in:

- Becoming better informed of their career options
- Identifying and pursuing career options
- Finding work experiences that will give opportunities to apply skills and academic background in paid or non-paid work assignments
- Deciding when to pursue graduate study or full-time employment

Students at every academic level are encouraged to speak with the office's professional staff concerning both their career development and job placement needs. Ongoing developmental career services include career fairs, career exploration workshops and seminars, individualized counseling on 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-time and part-time job banks, summer job assistance and Polytechnic's extensive recruiting program meet the needs of job-seeking students. The demand for Polytechnic graduates is great, as evidenced by close to 300 companies that recruit on campus annually. These companies conduct approximately 1,000 interviews yearly, resulting in employment for many of our graduates. The placement rate for Polytechnic students who graduated in 2004 was 81 percent.

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.

COOPERATIVE EDUCATION

The Cooperative Education (Co-op) Program provides students with paid work experience in industry, government and public service agencies. This experience contributes to a 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.

Co-op at Polytechnic is an optional, noncredit program. It is a partnership involving the student, the employer and the Office of Co-op Education. Students may opt to participate in the alternating or parallel programs:

- **Alternating Co-op (full time)**
Students alternate semesters of full-time co-op employment. Students work a full semester (fall or spring) and return to Polytechnic the next semester to continue their courses. Students who have a full-time co-op position and are not attending classes do not pay tuition fees for that semester.
- **Parallel Co-op (part time)**
Students work on a part-time basis (15–20 hours a week) while they are enrolled full-time in classes. No fee.

At the end of each co-op assignment, students complete an evaluation provided by the Office of Co-op Education. Their co-op assignment is recorded on their transcript and is graded on a pass/fail basis.

A student may participate in the program for up to seven work periods or 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 an academic adviser. Eligible students begin the program in their sophomore year. Graduate students are not eligible for the Co-op Program.

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.

ELIGIBILITY

Before applying for the initial co-op work assignment, students must:

- Be enrolled as a full-time undergraduate
- Complete two full-time semesters at Polytechnic
- Achieve and maintain a 2.5 GPA
- Have sophomore status (28+ credits) with no course deficiencies
- Complete at least one technical course in their 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 before beginning their first work period
- Successfully complete CP 101 Career Development Seminar
- Achieve a 2.5 GPA at Polytechnic
- Obtain departmental approval for program participation (work-study plan signed by adviser)

CO-OP SEMINARS

CP 101 Career Development Seminar prepares students to enter into professional environments and is a prerequisite to participating in a work experience sequence.

CP 101 covers self-assessment, résumé-writing, interviewing, company networking and other topics that foster students' successful adjustment in the workplace. Students may also have an opportunity to meet co-op employers and other co-op students.

Students entering work assignments after sophomore year can complete up to seven field experience courses, CP 201 through CP 501. 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 Experience

0:0:NC

Prerequisite: CP 101 and departmental approval.

CP 202 Second Co-op Field

Experience 0:0:NC

Prerequisite: CP 201 and departmental approval.

CP 301 Third Co-op Field Experience

0:0:NC

Prerequisite: CP 202 and departmental approval.

CP 302 Fourth Co-op Field

Experience 0:0:NC

Prerequisite: CP 301 and departmental approval.

CP 401 Fifth Co-op Field Experience

0:0:NC

Prerequisite: CP 302 and departmental approval.

CP 402 Sixth Co-op Field Experience

0:0:NC

Prerequisite: CP 401 and departmental approval.

CP 501 Seventh Co-op Field

Experience 0:0:NC

Prerequisite: CP 402 and departmental approval.

Grades of P (pass) or F (fail) are recorded upon completion of each course. Courses will not be computed in the GPA. These grades are based upon final reports and work evaluations written by students and evaluations submitted by supervisors.

PLACEMENT STATISTICS

PLACEMENT RATE

CLASS OF 2004: 83%

STAFF

Sunil Gupta, Executive Director of Career Services and Continuing Education
MS, Polytechnic University

Frances Pesochinsky, Senior Student
Placement Manager

MS, Polytechnic University

JoAnne Davis, Coordinator of
On-campus Recruitment

BA, City College of New York

Greys Jessurum, Administrative Assistant

FINANCIAL AID

GRADUATE

GRADUATE FELLOWSHIPS

Fellowships are available for study leading to master's and PhD degrees in engineering and science. They are awarded through the department in which applicants are enrolled, or to which they have applied. Entering students apply for a fellowship by completing the appropriate question on the Application for Graduate Admission form. Continuing students should consult their academic department.

Research Fellowships

Students receiving research fellowships are assigned to research that fulfills the thesis requirement of the graduate curriculum in which they matriculate. They receive a living allowance and remitted tuition. Fellows must be registered as full-time students taking 12 or more units per semester, which may include their thesis. Typically, funding comes from grants and contracts that faculty have secured from government agencies or industry. In these cases, the student's research is also reported to the funding agency or company as part of the grant or contract requirements.

University Scholars

University Scholars participate half time throughout the academic year in assignments from the department in which they matriculate. They receive a living allowance and up to 12 units of tuition scholarship. Scholars must be registered as full-time students taking 12 or more units per semester, which may include their thesis. Students working toward a PhD must also complete the thesis requirement of the department and University.

Special Fellowships

Individual departments administer special fellowships sponsored by industry and foundations, each with its own conditions, for students in the department. Contact departmental offices for information on special fellowships.

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 program provides a one-half tuition reduction for graduate courses taken at any campus. Degree candidates and special students are eligible.

Prospective students must submit to the Office of Admissions 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. 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 Tuition Assistance Program (TAP) is an entitlement grant program administered annually by the New York State Higher Education Services Corporation (NYSHESC).

Eligible students must (1) be New York State residents and U.S. citizens or eligible noncitizens, (2) enroll full-time as a matriculated student and (3) meet income requirements established by New York State.

The award amount depends upon the tuition charge and net taxable income. Students may receive TAP for eight semesters of graduate studies. Applicants must complete the Express TAP application (ETA) through New York State Higher Education Services Corporation (NYSHESC). There are two methods for applying: (1) complete your FAFSA online at www.fafsa.ed.gov. As a New York State resident, you will be provided a link on the

final page of the FAFSA website that will direct you to complete the online ETA; (2) complete a pre-printed ETA, which will be mailed to their home after they have completed the FAFSA. If you will be attending Polytechnic University, you must make sure that the ETA lists Polytechnic as your institution for the Fall and Spring semesters, along with our school code 0610. If Polytechnic is not listed, write our school code into the boxes provided on the ETA. After reviewing the application for accuracy, sign and return it directly to NYSHESC.

FEDERAL SUBSIDIZED STAFFORD LOAN

Graduate students may apply for a Federal Subsidized Stafford Loan for \$8,500 per academic year. The interest rate is an annual variable rate based on a 91-day T-bill plus 2.3 percent with a cap of 8.25 percent. Eligible students must (1) be U.S. citizens or eligible noncitizens, (2) enroll for at least 6 credits per semester and matriculate, (3) make satisfactory academic progress and (4) demonstrate financial need. All applicants must complete a Free Application for Federal Student Aid (FAFSA) to determine need. All interest and principle payments are deferred as long as the student is enrolled for at least 6 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. Contact the Office of Financial Aid regarding the application process.

FEDERAL UNSUBSIDIZED STAFFORD LOAN

The Federal Unsubsidized Stafford Loan is open to students who do not qualify for the above Federal Subsidized Stafford Loan. The same terms, conditions, annual borrowing limits and interest rates apply. In addition, graduate students may borrow an additional \$10,000 annually. The one exception is that the borrower is responsible for interest that accrues while enrolled in school and during the six-month grace period. Contact the Office of Financial Aid regarding the application process.

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, students may draw upon such available sources as student income, family income, University grants, and federal and state funding.

All financial aid is limited to the need of the student as determined by the federal government. Students receiving financial assistance from Polytechnic 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. The following are three basic types of financial aid:

1. **Scholarships and grants:** funds awarded to students based on academic ability and financial need and that do not require repayment.
2. **Loans:** specific sums awarded to students with repayment conditions. Education loans generally have low interest rates with extended repayment terms.
3. **Employment:** part-time and summer jobs either on- or off-campus.

Approximately 90 percent of Polytechnic's undergraduate students receive aid including scholarships, grants, work-study jobs and student loans.

Applying for Financial Aid

Incoming freshmen should file a Free Application for Federal Student Aid (FAFSA) during the month of January. (Later applications will be considered on a rolling basis as funds are available.)

Transfer students should file a FAFSA by May 1, or as soon as possible thereafter.

Renewing Financial Aid

All currently enrolled students must re-apply for financial aid annually by completing the Free Application for Federal Student Aid (FAFSA) before March 1st for the upcoming academic year.

There are three methods for completing the FAFSA: (1) Complete the FAFSA online at www.fafsa.ed.gov. (2) Complete the paper Renewal FAFSA, which is mailed directly to all students who applied for federal aid in the previous year. (3) Complete a paper FAFSA application and mail it directly to the Federal Student Aid Programs. Paper applications are available at the Office of Financial Aid.

Before sending an application, students should make sure that they complete all required sections of the form, including the following:

- For the FAFSA and Renewal FAFSA, students and their parents (if applicable) must sign the application.
- For online FAFSA applications, students can download the signature page, sign and submit to the U.S. Department of Education, or sign the application with an electronic signature via the federal Personal Identification Number (PIN) system.
- Enter Polytechnic University's federal school code (002796), along with residency status for the upcoming academic year (on-campus, commuter, etc.).
- Include state residency information. This information is required to apply for the New York State Tuition Assistance Program (TAP).

Contact the Office of Financial Aid for the filing deadline date and for additional questions.

FEDERAL CAMPUS-BASED PROGRAMS

Students eligible for one of the federal campus-based programs must (1) show need, (2) be enrolled at least half time (the equivalent of at least 6 credits per semester) and (3) be either U.S. citizens or eligible noncitizens.

To apply for any of these programs, students must have been accepted to Polytechnic and have filed a FAFSA. The Office of Financial Aid determines the awards.

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

Federal Supplemental Education Opportunity Grant (SEOG)

The Federal Supplemental Education Opportunity Grant (SEOG) is awarded to undergraduates with exceptional financial need. Qualified applicants receive between \$500 and \$2,000 per year. Usually, the award will continue to be offered for four years, but it is based upon financial need.

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

Federal Perkins Loans are low-interest (5 percent) and available through the Office of Financial Aid. They are awarded as part

of a financial aid package, with a range of \$500 to \$2,000 per academic year and limited to \$4,500 for the first two years of college study. Total undergraduate Perkins Loans may not exceed \$9,000.

The repayment period and interest for Perkins Loans do not begin until nine months after students complete their studies. Interest of 5 percent per year is charged during the repayment period. Repayment begins nine 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 are found in the Perkins Loan Promissory Note.

Federal Work-Study Program

The Federal Work-Study Program provides part-time jobs for undergraduate students to help meet college-related expenses. The Office of Financial Aid determines eligibility. The Office of Career Services arranges the work schedules.

At Polytechnic, the average Federal work-study award is \$1,500 per academic year and may be higher depending upon financial need. Jobs are arranged on-campus, along with community service opportunities. Most assignments average 15 hours per week, and the work schedule is adjusted to the student's and the employer's needs. The hourly rate varies depending on the position. Students are paid biweekly.

FEDERAL AND STATE SPONSORED PROGRAMS

Federal Pell Grants

The Federal Pell Grant is a need-based 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.

Eligible students must (1) be U.S. citizens or permanent residents, (2) make satisfactory academic progress, (3) enroll at least half time (the equivalent of 6 credits per semester) and (3) meet federal income requirements.

Students apply for the Federal Pell Grant by completing a FAFSA. Students must file an application by May 1 for the current academic year.

Tuition Assistance Program (TAP)

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.

The amount of a TAP award depends on 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.)

Eligible students must (1) be New York State residents and U.S. citizens or permanent residents, (2) enroll full-time at an approved New York State post-secondary institution, (3) meet income requirements established by New York State and (4) complete a TAP application by May 1 for the current academic year.

To apply for a TAP award, students should complete an Express TAP Application (ETA) at www.hesc.com. The ETA will be pre-printed and mailed directly to students once they have completed a FAFSA.

If Polytechnic University's name does not appear on the TAP certificate, use the NYSHESC Web site at www.hesc.com to update your state school code to Polytechnic University 0610.

To continue to receive TAP benefits, students must demonstrate satisfactory academic progress. All TAP recipients must achieve a 2.0 cumulative GPA after the completion of four full-time semesters of study.

In addition, students must fulfill the following academic requirements:

1. Complete a minimum number of credits by the end of each term of full-time study
2. Maintain a minimum grade-point average. The table below provides the correspondence between TAP payment points and academic progress.

Academic Progress (For TAP Purposes)

TAP Payment Points	Min. Credits Completed Successfully	Min. CUM GPA
3-6	0	0.00
9-12	6	1.30
15-18	15	1.40
21-24	27	1.50
27-30	40	2.00
33-36	54	2.00
39-42	68	2.00
45-48	83	2.00
51-54	98	2.00
57-60	113	2.00

TAP Waiver: Students who do not meet the criteria as indicated on tables I + II may be eligible for a one-time TAP waiver. For appeal and consideration by the TAP Waiver Committee, students must file a TAP waiver request form with the TAP Certifying Officer in the Office of Student Accounts.

Contact the Office of Student Accounts for additional information.

Aid for Part-Time Study (APTS)

The Aid for Part-Time Study (APTS) Program provides state grants to less than full-time students.

Eligible students 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 (6) qualify under the New York State-managed income requirements.

To apply, students should file an application with the Office of Financial Aid no later than the second week of classes for the current semester. Students must apply annually.

Vietnam Veterans Tuition Awards (VVTA) Supplement

The Vietnam Veterans Tuition Award is an entitlement program. Eligible 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) enroll in an approved undergraduate program in a degree-granting institution in New York State; and (5) apply for TAP and Pell Grant awards. There are no income restrictions connected with this program.

VVTA provides up to \$500 per semester (full-time attendance) or \$250 per semester (part-time attendance). If students receive a TAP award, the combined awards cannot be greater than tuition and the TAP award will be reduced accordingly. VVTA is available for up to eight semesters (four years) or 10 semesters (five years) of undergraduate study if programs specifically require five years of full-time study and double the amount of time for part-time study.

To apply, students should complete an application and other materials available at the Office of Financial Aid or any Veterans Office or by writing to the New York State Higher Education Services Corporation, VVTA, Albany, New York, 12255. Part-time students must file an application by May 1. Full-time students must submit both Vietnam Veterans Tuition Supplements and the Student Payment Applications

(TAP Application) by May 1.

Students must reapply each year.

Higher Education Opportunity Program (HEOP)

HEOP is sponsored by New York State and Polytechnic for entering freshmen who meet special academic and economic criteria. All inquiries are handled directly through the Office of HEOP. Consult the "Admissions" section and Part 4 of this catalog for more information.

UNIVERSITY SCHOLARSHIPS AND GRANTS

Polytechnic awards scholarships to freshmen and transfer students with strong academic backgrounds for full-time study (12 credit hours per semester). Students apply directly to the Office of Admissions through the application for admission. Awards range up to full tuition. Scholars must maintain a 2.0 or 3.0 cumulative GPA (depending on the award) and apply for Pell and TAP. Standards of achievement for scholarship maintenance are established each semester. Students who fall below the established criteria will be given one semester of grace to restore their cumulative GPA.

Polytechnic awards the following scholarships:

Geiger/Fialkov Scholarships

Awarded to superior freshmen majoring in engineering or computer science. Scholarship amounts are equal to full tuition less any outside aid for which the students are eligible. Scholars must maintain a 3.0 cumulative GPA and apply for Pell and TAP. This award is for undergraduate study only.

Dean of Engineering Scholarships

One scholarship of \$10,000 awarded per year 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.

Scholars must maintain a 2.5 cumulative GPA and apply for Pell and TAP. Eligible students must complete a separate application form for this scholarship, available from the Office of Admissions.

High School Principal's Scholarship

High school principals in the New York metropolitan region are invited to nominate

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their outstanding graduates for a scholarship of up to \$10,000 per year. A Scholarship Committee selects recipients from among nominees. Scholars must maintain a 2.0 cumulative GPA and apply for Pell and TAP. Application forms are available in the student's high school and from the Office of Admissions.

Promise Scholarships

Awarded in varying amounts, based upon need and scholastic achievement, to students who participated in the Center for Youth in Engineering and Science (YES Center) while in high school, or to 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. Scholars must maintain a 2.5 cumulative GPA (depending upon the amount of the award) and apply for Pell and TAP. No separate application is required.

Outstanding Transfer Scholarships

Awarded to superior transfer students with a 3.0 GPA. The award amounts vary depending upon the GPA of the student. Scholars must maintain a 2.0 cumulative GPA, enroll full-time and apply for Pell and TAP. No separate application is required.

Polytechnic Grants

Awarded to students who demonstrate a high need. Students apply directly to the Office of Financial Aid by completing a FAFSA.

MERIT BASED SCHOLARSHIPS AND AWARDS

Othmer Honors College Scholarship Award

Amount: Up to Full Tuition

Who is considered: Students selected for this program are in the top 10 percent of all students accepted to Polytechnic University, and traditionally have a high school GPA of 94 or higher, and a minimum SAT score of 1350 upon entering Polytechnic. Students applying to this program must have an on-campus interview.

Renewal Process: In order for this scholarship to be renewed, students must maintain a 3.0 cumulative GPA and complete a FAFSA for each academic year.

Presidential Scholarship Award

Amount: Up to \$18,500 each year

Who is considered: The Presidential Scholarship Award was established for students with a proven track record of high academic achievement. Students that are

awarded this scholarship traditionally have a 93 or higher high school GPA and/or an overall SAT score of 1180 or higher.

Renewal Process: In order for this scholarship to be renewed, students must maintain a 2.0 cumulative GPA and complete a FAFSA for each academic year.

Dean's Scholarship Award

Amount: Up to \$15,500

Who is considered: Qualified students have a high level of academic achievement both in and out of the classroom (with a high school GPA of 87 or higher) and a minimum SAT score of 1050.

Renewal Process: In order for this scholarship to be renewed, students must maintain a 2.0 cumulative GPA and complete a FAFSA for each academic year.

Polytechnic Achievement Award

Amount: Up to \$10,500

Who is considered: This scholarship rewards students with both a strong academic background and success with extracurricular activities while attending high school.

Renewal Process: In order for this scholarship to be renewed, students must maintain a 2.0 cumulative GPA and complete a FAFSA for each academic year.

CORPORATE AND INDIVIDUALLY SPONSORED SCHOLARSHIPS

Polytechnic Scholarships are established through the generosity of sponsors. Students are notified if their particular scholarship is corporate or individually donated.

The following is a list of current scholarships at Polytechnic:

Benjamin Adler Memorial Scholarship
Sidney G. Albert Scholarship
Alden Challenge Scholarship
Anthony Alonzo Scholarship
Alumni Scholarship
Joseph M. Amendolara Scholarship
Donald J. Amoroso Scholarship
George Bachman Scholarship
Paul C. Bauerle Memorial Scholarship
Beltran Family Endowed Scholarship
Orrin Dodge Berry Scholarship
Eugene Blank Scholarship
Blecker/Hinden Scholarship
Board of Trustees Scholarship
Joseph Bommarito Scholarship
Rodney Brabson '32 Scholarship
R. Brown Scholarship
Joseph Bucich Scholarship
Dr. George Bugliarello Scholarship
Salvatore E. Cannizzaro Scholarship
L. F. Case Foundation Scholarship
George & Assunta Cha Scholarship

David and Cecilia Chang Scholarship
Chinese Institute of Engineers Endowed Scholarship

J. B. Chittenden Scholarship
Claessens Family Scholarship
Arthur Clapp Scholarship
Philip Clark Scholarship
Class of 1942 Scholarship
Class of 1944 Scholarship
Class of 1960 Scholarship
Samuel and Grace B. Cohen Scholarship
Donald and Maria Cox Endowed Scholarship

Davis/Durborow/Brierly Scholarship Fund
Joseph D'Aprile Memorial Scholarship
DeWitt Scholarship

Willard H. Dickinson Scholarship
Herman Dock Scholarship
Peter Dollard Scholarship
Aaron and Simcha Dubitzky Scholarship
W. E. Duryea Scholarship
A. S. Dwight Scholarship
Eirich/Morawetz Scholarship
Burton Erickson Scholarship
Bernard Farkas Scholarship
I. W. Fay Scholarship
Federal Cyber Service Scholarship for Service

Fisher (estate of J.R. Fisher) Scholarship
Harold and Martha Forstrom Scholarship
Sidney Friend/NACME Scholarship
William Friend Family Endowed Scholarship

Geiger-Fialkov Scholarship
Roger Gilmont Scholarship
Dr. Anthony B. Giordano Scholarship
Amir Gold Scholarship
Goldman Sachs & Company Scholarship
Harold and Helen Gottlieb Scholarship
Gordon Gould Scholarship

James Douglas Graham Scholarship
Ying Chavas Greene Scholarship
Francis and Mildred Hallenbeck Foundation Scholarship

Barbara and Morton Hatton Scholarship
William Randolph Hearst Scholarship
Alfred Helwig Scholarship
Herbert Henkel Scholarship
Professor Hessel Award
HTI Scholarship

F. M. Jabara Scholarship
Jephson Educational Trust Scholarship
James H.J. Hughes Award
Dr. Peter Kabasakalian Scholarship
Susan Kamen Scholarship
Jacob Kaplan Scholarship
Ade Howe Kent Scholarship
Nathan Kleinman Scholarship
Kirk Scholarship
Ping Ku Scholarship
Eugene R. Kulka Scholarship
John F. Kunc Scholarship

Dr. Irving Kuntz Scholarship
 Bernard and Pauline Lee Scholarship
 Saul Leitner Scholarship
 Dorothy Lemelson Scholarship
 Leona Levine Scholarship
 Steve Levy Scholarship
 Robert Linoki Memorial
 Litton Industries Scholarship
 Lockheed Martin Scholarship
 Helen T. Lowe Scholarship
 Lyons Scholarship
 Maggio Scholarship
 P.R. Mallory Memorial Scholarship
 Dr. Ines Mandl '47 '49 Scholarship
 Sir John Manniello Scholarship
 Arthur C. and Elizabeth R. Martinez
 Endowed Scholarship
 Raymond Mauro Scholarship
 Steven J. Meoli Memorial Scholarship
 E. Mitchell Scholarship
 Colonel Frank Mott Scholarship
 Alfred B. Muscari Memorial Endowed
 Scholarship
 NACME Block Grant Scholarship
 Bonnie Nagler Scholarship
 NEC Scholarship (in Dr. Sekimoto's honor)
 NECA (Northeastern Chemical
 Association) Endowed Scholarship
 William Nichols Scholarship
 Nippon Electric Scholarship
 Stanley Nisenson Memorial Scholarship
 Nordheimer Scholarship
 Theodore Nowak Scholarship
 NSC—Eddie Mitchell Scholarship
 NSS—Hughes Aircraft Co. Scholarship
 Oceanic Scholarship
 Dr. John C. Olsen Scholarship
 Open Door Foundation Scholarship
 Lilyan and Milton Oran Scholarship
 Ruth and Richard Orford Scholarship
 Dr. Donald Othmer Scholarship
 PamAmSat Scholarship
 Donald Pascal Scholarship
 Rajendra Paul Scholarship
 George S. Pearson Scholarship
 Louis J. Pignatoro Memorial
 Polytechnic 100 Scholarship
 Polytechnic Fellows Scholarship
 PROMISE Scholarship
 Radio Club Scholarship
 Bengt G. Ranby Scholarship
 Dr. Julian R. Reasenberg Memorial
 Scholarship
 Steven M. Rittvo Scholarship
 Julian Rogoff Scholarship
 Nicholas and Angelica Romanelli
 Scholarship
 Myron Rosenthal Scholarship
 Samuel Ruben Scholarship
 Sidney J. Rubin Scholarship
 Helena Rubinstein Foundation Fellowship
 Richard and Emily Sbaschnig Scholarship

Dr. John P. Schaefer Endowed Trustee's
 Scholarship
 Edward C. Schmidt Scholarship
 Paul J. Schwanenflugel Scholarship
 Dr. Sekimoto (NEC) Scholarship
 Mitsuzo Shida Scholarship
 Silleck Family Scholarship
 Skeist Scholarship
 James M. Smith Scholarship
 Frank R. and Emily E. Stammer
 Scholarship
 Michael Stock Scholarship
 William Stolze Scholarship
 Won Bong Sull Endowed Scholarship
 Solon Summerfield Foundation Scholarship
 Wai Nam Tam Scholarship
 Arlene and Irving Tashlick Scholarship
 Tau Beta Pi Scholarship
 Arnold Thompson Scholarship
 Guy Torre Memorial Book Scholarship
 Robert Tsao Endowment Fellowship
 USS Scholarship
 Kenneth G. Van Wynen Scholarship
 Dr. Ernst Weber Scholarship
 Ernst and Sonya Weber Scholarship
 Donald N and Susan C. Weisstuch
 Scholarship
 Williams Industries Inc. Endowed
 Scholarship
 Warren E. Winsche Memorial Scholarship
 William Wishnick Scholarship
 WSTA Scholarship
 Howard J. and Audrey R. Wulfken
 Scholarship
 Frank and Iris Young President's
 Scholarship
 Edward H. Zucker Scholarship

OTHER OPPORTUNITIES

Veterans Administration (VA) Educational Benefits

Eligible students must (1) be veterans who served over 180 days between January 31, 1955, and January 1, 1977; (2) continue on active duty; (3) have been honorably discharged at the end of their tour of duty; and (4) qualify because of service-connected disabilities. 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 10 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 complete an application available at the Office of Student Records, all VA offices, active duty stations and American embassies, and submit it to the Office of Student Records.

A *Summary of Veterans' Benefits* booklet is available from the Office of Student Records. 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 Student Records 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 Office of Student Records 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 outside employment with college attendance in alternate semesters.

Contact the Office of Career Services and Cooperative Education for more information.

Grant Aid To Non-New York State Residents

Some state-aid programs frequently require that awarded funds be used within the state, while other programs sometimes allow funds to be used out of state. Students who are residents of Pennsylvania, Rhode Island, Vermont or Washington, D.C., should contact the following agencies for more financial aid information:

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

FINANCIAL AID

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

LOAN PROGRAMS

Federal Subsidized Stafford Loan Program

The Subsidized Stafford Loan Program allows students to borrow money from a local lending institution to help them meet the costs of college or vocational school training. Students borrow this money at a low interest rate and do not repay as long as they meet the program's academic requirements or until six months after they graduate or withdraw from school.

Eligible students must (1) be a U.S. citizen or eligible noncitizen, (2) enroll for at least 6 credits per semester and matriculate, (3) make satisfactory academic progress and (4) demonstrate financial need. Applicants must complete a FAFSA to determine financial need and eligibility for a Pell Grant.

Academic year loan limits are \$2,625 for freshmen, \$3,500 for sophomores, and \$5,500 for juniors, seniors and fifth-year undergraduates. The interest rate is an annual variable rate based on a 91-day T-bill plus 2.3 percent with a cap of 8.25 percent.

Students with more than \$5,000 in loans (Stafford, Perkins, Supplemental Student Loan) can consolidate their loans into one repayment package with an interest rate that is the weighted average of the loans being consolidated, rounded up to the nearest whole percent. 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:

New Students: Once new students apply for financial aid and receive an award letter, their loan eligibility is electronically transmitted to the New York State Higher Education Services Corporation (NYSHESC), which then mails a preprinted loan application, referred to as a Master Promissory Note (MPN). Students must complete the reference information, select a lender, sign and return the application to NYSHESC for final processing. The loan amount is deducted directly from the tuition bill. NYSHESC also deducts a 3 percent processing fee. All funds are sent directly to Polytechnic via electronic funds transfer from the lenders. Since this is a federal program, all lenders offer the same interest rates. For assistance in selecting a lender,

contact the Office of Financial Aid.

Currently Enrolled Students: if students signed a MPN while attending Polytechnic they do not need to sign a new MPN every year. The MPN is valid for up to 10 years of continued borrowing. Once students apply for financial aid and receive an award letter, their loan eligibility is electronically transmitted to NYSHESC. The loan amount is deducted directly from the tuition bill. NYSHESC also deducts a 3 percent processing fee. All funds are sent directly to Polytechnic via electronic funds transfer from the lenders.

When student borrowers graduate, withdraw from school or drop to less than half-time study, they must see their lender and make formal arrangements for repayment, as well as attend a loan exit interview with the Office of Financial Aid. Borrowers must begin repaying the loan six months after graduating or withdrawing from school.

Students are 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 is \$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 of the entire 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 the student is a member 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. Student borrowers are 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

The Federal Unsubsidized Stafford Loan is open to students who do not qualify for a Federal Subsidized Stafford Loan (listed above). The same terms, conditions, annual borrowing limits and interest rates apply.

The only exception is that the borrower is responsible for interest that accrues while enrolled in school and during the six-month grace period. In addition, independent students may borrow an additional \$4,000 annually at the freshmen and sophomore level, or \$5,000 annually at the junior, senior and fifth-year undergraduate level. Loan applications are available at lending institutions or the Office of Financial Aid.

Parent Loan for Undergraduate Studies

Parents may borrow up to full tuition per year for each financially dependent student. A Free Application for Federal Student Aid (FAFSA) 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.

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. Students are generally awarded from \$1,000 to \$2,000 per academic year. The current interest rate is 7 percent. Repayment begins three months 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

Students should contact the Office of Financial Aid for information concerning financial aid programs available, the companies that sponsor them and the necessary application procedures.

POLYTECHNIC PAYMENT PLANS

The University currently offers three types of payment plans: monthly, deferred and third party.

Monthly Payment Plan

A monthly payment plan spreads out annual tuition charges over 10 months, beginning in July and ending in April. The monthly payment plan is interest-free, regardless of the balance amount, with a one-time enrollment fee accessed at the beginning of

the plan. Monthly payment plans are also available on a semester basis.

Deferred Payment Plan

Students who submit written proof of eligibility for tuition reimbursement from their employers will be allowed to defer payment until the end of the semester. Eligibility is contingent upon the signing of a promissory note, with a one-time enrollment fee assessed at the beginning of each semester.

Third Party Payment

Students receiving sponsorship from government agencies, employers or other organizations must provide the University with proof of coverage and permission to bill a third party. Students are required to pay or make arrangement for payment of any uncovered portion of the bill. Sponsorships are arranged between the student and a third party; students are responsible for University debt if the third party does not make payment.

HOME EQUITY LOAN/HOME EQUITY LINE OF CREDIT

Many parents underestimate the resource value of the equity in their homes or apartments. Currently, numerous 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 should contact a local lender.

OTHER OPPORTUNITIES

There are several scholarship programs, usually directed by local and civic organizations, that are not based on need. High school guidance offices and the Internet are the best sources 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 for financial aid, students must enroll for at least 6 credits per semester. However, all TAP grants and Polytechnic scholarships and grants require students to enroll full-time to qualify.
- Financial aid applicants (including Stafford Loan applicants) must apply for a Pell Grant and, in the case of New York residents, for TAP. Polytechnic schol-

arships and grants, combined with federal and state grants, may not exceed tuition.

- 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 the student's reapplying, continuing to demonstrate financial need where applicable and fulfilling of other requirements stipulated by the awards. To renew most Polytechnic scholarships, students must maintain between a 2.0 and 3.0 cumulative GPA. To renew a Board of Trustees Scholarship, students must maintain a 3.0 cumulative GPA.
- Standards of achievement for scholarship maintenance are established each semester. Students who fall below the established criteria will be given one semester of grace to restore their cumulative 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 unwise to enroll at Polytechnic without financial aid support on the assumption that financial aid will be available at a later date. 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 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 Grants, Supplemental Educational Opportunity Grant, College Work Study, Perkins Loan and Stafford Loan) are contingent upon provision of the following six 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
 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 must make appropriate plans to finance that part of their education that 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 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, students must maintain full-time, matriculated (degree) status and must complete a minimum number of quarter credit hours with a minimum GPA to be considered making satisfactory academic progress toward their degree, as illustrated in the "Academic Policies" section of this catalog. Failure to make satisfactory academic progress may result in the loss of financial aid.
 - Students who lost eligibility for financial aid may request reinstatement due to unusual or extraordinary circumstances. Students who wish to appeal must submit a written appeal to the Financial Aid Committee on Academic Progress within 20 days of notification. Students must give reasons for the appeal and provide documentation. If necessary, students will also be expected to appear in person to meet with a member of the committee.

INTERNATIONAL STUDENTS AND SCHOLARS AND STUDY ABROAD

Graduate and undergraduate international students come from more than 47 countries and make up 13 percent of the student body. They are an integral part of the Polytechnic community. All new international students and visiting scholars (researchers and faculty) are required to report with immigration documents, including I-20's, DS-2019's, and passports, to the Office of International Students and Scholars (OISS) immediately upon arrival. In addition, all new students and scholars must attend a mandatory orientation held at the beginning of every semester.

The office provides information and counseling regarding immigration compliance, travel, employment, acculturation, housing, health insurance and special events. International students, researchers and faculty may contact the office in person or by telephone, and are encouraged to attend on-site workshops offered at designated times during the academic year. All international students are required to carry health insurance.

For additional information regarding admissions and academic requirements please consult those sections dealing with undergraduate and graduate admissions and academic policies and degree requirements.

STUDY ABROAD

Opportunity to study abroad offers students a chance to experience life in countries rich in history, culture and accomplishment. Immersion experience in another culture strengthens understanding of the world and appreciation of international contribution to knowledge. It offers an opportunity to learn how to cope in international environment and communicate across barriers of language, custom, geography and politics. Skills developed in the course of this experience will add another invaluable dimension to the quality of well-rounded education that will ultimately enhance professional and personal endeavors in this developing global community.

Students may apply for short-term, faculty-sponsored programs, a semester or an academic year of study abroad. Students may select from one of 50 institutions around the world with which Polytechnic has entered into direct exchange agreements.

Participation in the study abroad program is open to undergraduate students who completed one year of academic study and are maintaining a 2.5 GPA. While these are the minimum Poly requirements to participate in the program, please note that host institutions will be making their own determinations about admissibility.

Academic credits earned during study abroad are transferable to Polytechnic University and may be applied to degree requirements subject to university policies and the approval of the student's major department.

STAFF

Michael Gendel, Director
MA, University of Massachusetts
Carmen Villafane-Nieves,
Administrative Assistant

PROGRAMS AND SERVICES FOR FIRST-YEAR STUDENTS

ACADEMIC ADVISEMENT CENTER

The mission of the Academic Advisement Center is to provide centralized advising for all incoming, matriculated freshmen and initial advisement for transfer students. The staff advises students on major requirements and university regulations and refers them to appropriate campus resources. In addition, academic advisers advocate for students with University offices and assist students in dealing with issues currently affecting them.

NEW STUDENT ORIENTATION

Polytechnic seeks to ease new students' transition to their new environment with a variety of programs designed to orient and welcome new students every semester. These programs include an on-campus new student orientation program in the fall and spring semesters and SL 1010 Freshman Seminar (see following section).

FRESHMAN SEMINAR (SL 1010)

The Freshman Seminar (SL 1010*) is required for all entering first-year college students with fewer than six matriculated 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.

*SL 1010 is a zero-credit course that counts toward bachelor's degree requirements.

SL 1010 introduces first year students to Polytechnic University, provides campus resources information, opportunities for them to develop new skills and supports their efforts to achieve success in the college environment. New academic challenges and responsibilities; new people and situations; and, new time demands and commitments are among the factors in the transition to college. The SL 1010 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, presentations and sessions reserved for small group discussion on topics of particular importance to college-aged students. This diversified experience sets the stage for all first year students at Polytechnic to explore why they chose Polytechnic, as well as how they can get the most out of their Polytechnic education.

Topics covered in the course include:

- Study skills (including note taking, test taking, effective reading)
- Time management and goal setting
- University resources and support services
- Campus involvement and student activities
- Effective library research skills
- Career awareness
- Effective communication techniques
- Diversity and Multiculturalism
- Sexual Harassment
- Healthy Lifestyles Choices (Eating, Sleeping, Stress Management, Safe Sex/Abstinence)
- Alcohol and Drug Abuse Prevention

REGISTRATION

Registration is the process of obtaining academic advisement and approval of courses from a faculty adviser, recording courses with the Office of the Registrar and paying tuition and fees to the Office of Student Accounts, according to published deadlines. To receive academic credit, registration is required each semester for every course, including theses, projects and guided studies. Class attendance without registration is not permitted.

ADVISEMENT FOR REGISTRATION

Polytechnic University encourages 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 approval for their anticipated program of study. A list of advisers and their office numbers may be obtained from each respective departmental office and is available from the Office of 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 normally 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 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 in the fall semester are registered during the summer preceding their admission.

Regular Registration: all continuing degree-seeking students (graduate and undergraduate) are expected to register for the next semester during the latter part of each ongoing semester. All students are encouraged to take advantage of regular registration using PS Data, the student online registration system. Payment of tuition and fees, or arrangement for payment, is due to the Office of Student Accounts no later than the deadline date announced.

Late Registration: this usually takes place during the week preceding the start of classes. A late fee is assessed to all continuing students. New students and special students receive information from the Office of Admissions. Payment of tuition and fees is due on the day of registration.

Final Registration: students are expected to complete registration by the end of the fifth day of the semester. This final period, during the first five days of classes, provides the 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 to 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.

RESIDENTIAL LIFE AND HEALTH INSURANCE

RESIDENTIAL LIFE AND CAMPUS HOUSING

A residential life program is an integral part of college life and can greatly enhance students' 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 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 all students. It is not appropriate for married students seeking housing for their families. Inquiries about campus housing should be made to the Office of Residential Life at 718-260-4160 or reslife@poly.edu. Off-campus housing information is also available through the Office of Residential Life.

CAMPUS HOUSING FACILITY

Located on the Brooklyn campus, the Donald F. and Mildred Topp Othmer Residence Hall is a 20-story building, housing over 400 students in two-bedroom suites and two-bedroom apartments with

kitchenettes and data, voice and cable television ports for every student. The building includes student lounges, study rooms, laundry facilities and outdoor space. The housing staff—comprising two full-time professional staff members, graduate and undergraduate student resident assistants and security personnel—supervise the students and building 24 hours a day.

CAMPUS HOUSING REQUIREMENTS

All students living in the Othmer Residence Hall are required to have medical insurance coverage and a meal plan.

ACCIDENT AND HEALTH INSURANCE

All students with 9 or more credits or those considered full-time students are required to carry health insurance on their own, through family coverage or through the University's health insurance program. Proof of coverage is required. Spouses and dependents of full-time students are eligible for insurance coverage. In addition, all full-time students (graduate and undergraduate) are covered by accident insurance.

STAFF

Rosa Rizzo, Director of Residential Life
MBA, St. John's University

Robert Swantek, Assistant Director of Residential Life

Rona Tyson, Administrative Assistant

STATISTICS ON ENROLLMENT AND THE STUDENT BODY

ENROLLMENT 2004–2005

FALL 2004

	Undergraduate			Graduate			Total
	FT	PT	TOT	FT	PT	TOT	
Brooklyn	1471	72	1543	409	481	890	2433
Long Island	—	—	—	26	144	170	170
Westchester	—	—	—	29	75	104	104
Broad Street	—	—	—	96	16	112	112
Total	1471	72	1543	560	716	1276	2819

STUDENT BODY

FALL 2004

	Undergraduate		Graduate	
	Men	Women	Men	Women
Brooklyn	1250	293	707	183
Long Island	—	—	136	34
Westchester	—	—	83	21
Broad Street	—	—	79	33
Total	1250	293	1005	271

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 freshmen (students who never attended college before) who enter Polytechnic. The data measures retention patterns and indicates the amount of time needed to complete undergraduate degrees at Polytechnic. For a cohort study of first-time, full-time students who entered Polytechnic as freshmen in fall 1997, 37 percent received their Bachelor of Science degree within four years, 51 percent graduated in five years and 55 percent completed their degree within six years.

PERSISTENCE AND COMPLETION INFORMATION

First-time, full-time undergraduate students
continuing at the University, 2003–2004

University-wide:	82.6%
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ENROLLMENT BY RACIAL/ETHNIC STATUS (USING STANDARD FEDERAL CLASSIFICATIONS)

	Undergraduate Students	Graduate Students
Asian, Pacific Islander	35%	14%
Caucasian	29%	26%
Black, Non-Hispanic	11%	6%
Hispanic	9%	2%
Native American	0%	0%
International*	8%	27%
Unknown	8%	25%

*International students come from more than 47 countries.

STUDENT ACTIVITIES AND DEVELOPMENT

OFFICE OF STUDENT DEVELOPMENT

The Office of Student Development 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 Office of Student Development seeks to assist students in achieving success and enrichment in their endeavors at Polytechnic. Students needing assistance are encouraged to speak with a Student Development staff member. Some of the areas handled by this office include:

- New student programs, such as the New Student Orientation and the freshman seminar (SL 1010)
- Student leadership development
- Student advocacy
- Disciplinary policy administration
- Services for students with disabilities
- Student co- and extra-curricular activities

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 40 student organizations, honors societies and fraternities and sororities at Polytechnic. 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 at the University. New groups and organizations can be created by complying with the appropriate procedures set by the Student Council. Please view the Student Handbook or web site for all current student organizations.

STUDENT COUNCIL

The Student Council is the undergraduate student voice and governing body at Polytechnic. The Student Council is the umbrella organization for all student clubs and organizations. It is responsible for administering student activities fees, social and cultural programming and other co- and extra-curricular activities.

DEPARTMENTAL, PROFESSIONAL AND TECHNICAL 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.

FRATERNITIES AND SORORITIES

Polytechnic currently has four social and service fraternities and two social sororities. The fraternities and sororities hold an impressive array of social functions for their own members and provide service to the University community. They coordinate blood donation drives, annual charity drives, athletic tournaments, parties and more.

SOCIAL, CULTURAL, RELIGIOUS, MEDIA AND OTHER ORGANIZATIONS

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

NEW STUDENT ORIENTATION

Polytechnic seeks to ease the new students' transition to their new environment with a variety of programs designed to orient and welcome new students every semester. These programs include an on-campus new student orientation programs during the summer and at the beginning of the fall and spring semesters, as well as SL 1010 Freshman Seminar (see following section).

FRESHMAN SEMINAR (SL 1010)

The Freshman Seminar (SL 1010*) is required for all entering first-year college students with fewer than six matriculated 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.

* *SL 1010 is a 0-credit course that counts toward bachelor's degree requirements.*

SL 1010 introduces freshmen to Polytechnic University, provides opportunities for them to develop new skills and resources and supports their efforts to achieve success in the college environment. New academic challenges and responsibilities, new people and situations and new time demands and commitments are among the factors in the transition to college. SL 1010'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, presentations and sessions reserved for small group discussion on topics of particular interest to each group. This diversified experience sets the stage for all freshmen at Polytechnic to explore why they chose Polytechnic and how they can get the most out of their Polytechnic education.

Topics covered in the course include:

- Study skills (including note taking, test taking, effective reading)
- Time management and goal setting
- University resources and support services
- Campus involvement and student activities
- Effective library research skills
- Career awareness
- Effective communication techniques
- Diversity and Multiculturalism
- Sexual Harassment
- Healthy Lifestyles Choices (Eating, Sleeping, Stress Management, Safe Sex/Abstinence)
- Alcohol and Drug Abuse Prevention

STAFF

Cheryl A. McNear, Director of Student Development

BS, Polytechnic University

Robert Demetrius Griffin, Coordinator for Student Programs and Services

Bonnie Harper, Administrative Assistant

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 Office of Student Accounts before the start of each semester and on the office's website, www.poly.edu/administration/stu-accounts.cfm.

TUITION COSTS

The following costs are in effect at the time of publication, beginning with the fall 2005 term.

Undergraduate students

Full-time (12–20 credits*)	
Each semester	\$13,820
Credits in excess of 20 credits per credit	\$880
Part-time (0.5–11.99 credits)	
Each credit/credit hour	\$880
Zero credit remedial courses	\$3,340

Graduate students

Each unit	\$950
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**All credits/units in excess of 20 are charged at the per credit/unit rate.*

Tuition rates are set by the Polytechnic 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 challenges 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 the Dibner Library and the facilities of the Office of Student Development.

OTHER CHARGES AND FEES

University Fee¹ (required of all students each term of registration)

Full Time	
Undergraduate (12 credits or more)	\$505
Graduate (9 units or more)	\$495
Part Time	
Undergraduate (6-11 credits)	\$320
Undergraduate (0-5 credits)	\$185
Graduate (6-8 units)	\$330
Graduate (0-5 units)	\$175

Acceptance Deposit² \$300

New Student Orientation Fee \$100

Alumni Audit Fee (per course) \$600

Application Fee
Undergraduate \$60
Graduate \$65

Payment Plan Enrollment Fee \$85

Credit by Examination Fee (undergraduate courses) per credit \$80

Diploma Replacement Fee \$50

Doctoral Dissertation Microfilm Fee \$80

Seminar Fees³

Special Late Registration Fee⁴ \$150

Tuition Deferment Fee⁵ \$150

Validation Credit (graduate courses) per unit \$80

Maintenance of Study \$175

1. University Fee covers network technology support, decentralized network printers, access to computer labs and remote dial-up access to the University network.

2. To be applied toward first term's tuition.

3. Lists of these charges, by course, are given in the Schedule of Classes.

4. Charged to all continuing students who register on or after the first day of classes

5. Charged to all students who elect to participate in the University's deferment program because

they are receiving reimbursement from their employer.

Other fees include the returned check fee, late payment penalty fee and, for transfer students, possible charges for supplies or kits.

All fees are nonrefundable.

HOUSING

Housing is available on the Brooklyn campus and varies by type of accommodations. For more information, contact the Office of Residence Life. A deposit is also required.

PAYMENT OF TUITION AND FEES

Each semester, tuition and fee payments are due in full from all students at the time of registration.* The University reserves the right to de-register students from classes and deny access to campus buildings if payment or payment arrangements are not made 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, MasterCard, American Express and Discover only), financial aid, grants and loans or tuition arrangements authorized by the Office of Student Accounts. Evidence of financial aid must be presented to the Office of Student Accounts in order to use the anticipated aid to satisfy tuition costs.

Tuition must be paid in full, including disbursement of loans and all other aid, in order to receive permission to register for the next semester. Students participating in a 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 and participation in graduation activities, from students whose financial obligations have not been fully met.

**This does not apply to early registration. In this case, payment is due by the date specified in the tuition billing invoice, usually about one month prior to the start of classes.*

PAYMENT OPTIONS

The University provides monthly, by semester and yearly payment options. The monthly tuition payment plan is available

TUITION AND FEES

through Tuition Management Systems, an independent agency. Specific information about these plans is outlined below and in the “Financial Aid” section of this catalog.

Graduate students who submit written proof of 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 semester. Complete details are available at the Office of Student Accounts and on its website, www.poly.edu/administration/stuaccounts.cfm.

Semester Payment Plan

Tuition bills are sent on a semester basis. After deducting all forms of scholarships, grants and loans for the semester, students must pay the remaining tuition balance in full at the beginning of each term. Students who use semester payment plan do not incur finance charges.

Monthly Payment Plan

A monthly payment plan spreads out annual tuition charges over 10 months, beginning in July and ending in April. The monthly payment plan is interest-free, regardless of the balance amount, with a one-time enrollment fee assessed at the beginning of the plan on an annual basis. Monthly payment plans are also available on a semester basis. The enrollment fee is the same as for the Annual Plan.

Deferred Payment Plan

Students who submit written proof of eligibility for tuition reimbursement from their employers will be allowed to defer payment until the end of the semester. Eligibility is contingent upon the signing of a promissory note, with a deferment fee assessed at the beginning of each semester.

Third Party Payment

Students receiving sponsorship from government agencies, employers or other organizations must provide the University with proof of coverage and permission to bill a third party. Students are required to pay or make arrangement for payment of any uncovered portion of the bill. Sponsorships are arranged between the student and a third party; students are responsible for University debt if the third party does not make payment. Third parties are billed at the beginning of the semester, and payment is due upon receipt of the bill.

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 Time	% Refund
Prior to and including 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. Overpayments resulting from program adjustments or withdrawals will be automatically refunded and mailed to the student within 10 days. For details on refund schedules, visit <http://www.poly.edu/administration/stuaccounts.cfm>.*

Refund Appeals

Appeals for an exception to the refund schedule must be submitted in writing to the Office of Student Accounts, along with documentation supporting the request.

Students are expected to be aware of the University refund policy and withdrawal procedures; lack of knowledge is not sufficient reason for making or granting an appeal

Impact of Withdrawal on Financial Aid

In 2000, Polytechnic University adopted a new Federal Refund Policy to comply with new federal regulations (section 668.22) of the Higher Education Amendments of 1998. In accordance with federal regulations, students who withdraw from the University and have Federal Title IV financial assistance (Federal Stafford Loan, Federal Parent Loan for Undergraduate Students, Federal SEOG, Federal Perkins Loan or Federal Pell Grant) that has been credited or could have been credited to their tuition account will be subject to the Federal Refund Policy regarding the possible return of Title IV funds awarded. In addition, the amount of refundable institutional charges will be determined based upon the University's policy.

The amount of the semester's Federal Title IV that has been earned by the student (as a result of the prorated amount of time the student has been in school for the semester) will be eligible for retention on the student's behalf. Any Federal Title IV aid that is not earned must be returned to its source. The amounts to be returned to the Federal Programs will vary based upon type of program, the total amount to be returned, and the government's determination of the order in which aid is returned to the various programs. If there is a student account balance, resulting from these adjustments, the student is responsible for payment.

When returning Federal Title IV aid, federally mandated priority listing will be used:

1. Federal Unsubsidized Stafford Student Loan Program
2. Federal Subsidized Stafford Student Loan Program
3. Perkins Loan
4. Federal Parent Loan for Undergraduate Students (PLUS)
5. Federal Pell Grant
6. Supplemental Educational Opportunity Grant (SEOG)

A written outline of the Federal Refund Policy, along with federal worksheets and sample refund calculations, are available upon request in the Office of Financial Aid.

The calculation for impact of withdrawal on financial aid is the same for all students. The determination of tuition refund is based on length of attendance.

UNIVERSITY COMPLIANCE POLICIES AND OTHER GUIDELINES

FAMILY EDUCATIONAL RIGHTS AND PRIVACY ACT (FERPA)

The Family Educational Rights and Privacy Act (FERPA) (20 U.S.C. § 1232g; 34 CFR Part 99) is a federal law that protects the privacy of student education records. The law applies to all schools that receive funds under an applicable program of the U.S. Department of Education.

The following explains the procedures used by Polytechnic University for compliance with the Family Educational Rights and Privacy Act (FERPA), also known as the Buckley Amendment. Under FERPA, students at Polytechnic are afforded certain rights with respect to their education records. A student is defined as any individual who is or has been in attendance at Polytechnic and regarding whom Polytechnic maintains education records.

These rights include:

- The right to inspect and review the student's education records within 45 days of the day the University receives a written request for access. Students should submit the request to the Office of the Registrar that identifies the record they wish to inspect. The University official will make arrangements for access and notify the student of the time and place where the records may be inspected. If the records are not maintained by the University official to whom the request was submitted, that official shall advise the student of the correct official to whom the request should be addressed. The University has the right to prohibit students from reviewing and inspecting education records that include the financial records of their parents, as well as those records consisting of confidential letters and statements of recommendation regarding their admission to the University, their application for employment or their receipt of an honor or honorary recognition.
- The right to request the amendment of education records that the student believes is inaccurate, misleading or in violation of his/her right to privacy. Students may ask the University to amend a record that they believe is inaccurate. They should write the University official responsible for the record, clearly

identify the part of the record they want changed and specify why it is inaccurate. If the University is in agreement with the student's request to amend his/her record, the record in question will be amended accordingly and the student will be informed of the amendment in writing. If the University decides not to amend the record as requested by the student, the University will notify the student of the decision and advise the student of his/her right to a hearing regarding the request for amendment. Additional information regarding the hearing procedures will be provided to the student when notified of the right to a hearing.

- The right to consent to disclosures of personally identifiable information contained in the student's education records, except to the extent that FERPA authorizes the University to disclose without the student's consent. Consent to disclosures of personally identifiable information must be done by the students in a written request to the Office of the Registrar.
- The right to file a complaint with the U.S. Department of Education concerning alleged failures by the University to comply with the requirements of FERPA.

Release of Information

Polytechnic must have written permission from the student in order to release any personally identifiable information from his/her education records. In addition, the University may disclose personally identifiable information, without consent, to the following parties or under the following conditions (34 CFR § 99.31):

- School officials with legitimate educational interest in such information in order to fulfill their professional responsibility. (A school official is a person employed by the University in an administrative, supervisory, academic or research, or support staff position [including law enforcement unit personnel and health staff]; a person or company with whom the University has contracted [such as an attorney, auditor or collection agent]; a person serving on the Board of Trustees; or a student serving on an official committee, such as a

disciplinary or grievance committee, or assisting another school official in performing his or her tasks.)

- Other schools to which a student seeks enrollment.
- Where disclosure is to certain federal, state and local authorities.
- Where disclosure is in connection with financial aid for which the student has applied or received.
- Where disclosure is in connection with studies being conducted for or on behalf of the University.
- Where disclosure is made to accrediting organizations.
- To comply with a judicial order or lawfully issued subpoena.
- Appropriate officials in cases of health and safety emergencies.
- Information designated as "directory information."
- Where the information disclosed is the final results of a disciplinary hearing, and the disclosure is made to an alleged victim of a crime of violence or non-forcible sex offense.
- To parents or legal guardians regarding a violation of any federal, state, local law or University policy governing the use or possession of alcohol or a controlled substance if a student is under the age of 21 and if the University determines that the student has committed such violation.

FERPA permits the release of directory information to third parties outside Polytechnic without prior written consent, provided that students have been given the opportunity to withhold such disclosure. Polytechnic reserves the right to disclose the following directory information related to a student without consent:

- Student's name
- Class year
- Major field of study, as well as similar information (e.g., title of master's or doctoral dissertation, distinguished academic performance)
- Participation in recognized activities and sports
- Dates of attendance at Polytechnic
- Degrees, honors and awards
- Most recent previous educational institution attended

All requests for information must be supported by identifying and/or authenticating documents.

Polytechnic must inform students about directory information and allow them a reasonable amount of time to request that the University not disclose directory information to requesting parties.

Polytechnic must notify students annually of their rights under FERPA. The actual means of notification (such as, but not limited to, special letter, student handbook or newspaper article) is left to the discretion of Polytechnic.

Students can request that Polytechnic not disclose directory information about them through the Office of the Registrar.

STUDENTS WITH DISABILITIES

Polytechnic University 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. Likewise, the University does not discriminate in its admissions practices and bases acceptance decisions primarily on academic records.

Polytechnic is committed to assisting students with disabilities in developing the personal, as well as academic, skills necessary to fully participate in student programs. To that end, services are provided to students with disabilities based on their individual needs. The University is particularly interested in working with these students so they may become effective self-advocators.

Services for students with disabilities do not include the waiving of academic course requirements.

Although not every student with a disability requires services, registering with the Office of Student Development is advised.

ALCOHOL AND DRUGS

In compliance 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, unless otherwise noted. 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.

All student organizations or groups

wishing to hold events where alcohol is served must obtain permission from the Director of Student Development or designee, who will be solely responsible for making that decision and applying conditions and obligations to that permission.

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.

- Students will not be expelled or refused admission to the University because they are unable to participate in any examination, study or work requirement due to their religious obligations and practices.
- Students who are absent from school because of their religious obligations and practices will be given an equivalent opportunity to make up any examination, study or work requirement that was missed because of such absence on any particular day or days.
- Students must notify their instructors and The Office Student Development in writing, no later than the fifteenth day after the first day of the semester, that they will be absent from a class scheduled on a day that conflicts with their 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 will happen to students who follow these guidelines on religious observances.

REQUIRED IMMUNIZATION

New York State law requires students to show proof of immunity to measles, mumps and rubella. Polytechnic complies fully with the provisions of this law. The law applies to all students (graduate and undergraduate) born on or after January 1, 1957.

Immunization status is checked as part of the registration process. Students who are

not in compliance with the law (1) are barred from attending class (and are not entitled to any tuition refund); (2) do not receive grades; and (3) are denied further registration.

For forms or information on this requirement, or to submit the required proof, please contact the Office of Residential Life.

UNIVERSITY CODE OF CONDUCT

The University Code of Conduct is edited and administered by the Office of Student Development and is available to all students at www.poly.edu/codeofconduct.

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.

For further information regarding the Code of Conduct, contact the Office of Student Development at 718-260-3800.

FREEDOM FROM HARASSMENT

Polytechnic University is committed to a work and learning environment in which all individuals are treated with respect and dignity. Each individual has the right to work and learn in a professional atmosphere that promotes equal employment and academic opportunities and prohibits discriminatory practices, including harassment. Therefore, Polytechnic expects that all relationships among persons at the University (in the workplace and in the classroom) will be business-like and free of bias, prejudice and harassment.

STUDENT IDENTIFICATION

All students are required to carry and maintain at all times photo-identification cards issued by the Office of Facilities Management. IDs 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 or her degree. Student numbers are assigned when students are admitted to the University. This number is computer generated and used solely by Polytechnic.

PART 2

ACADEMIC DEPARTMENTS



OTHMER DEPARTMENT OF CHEMICAL AND BIOLOGICAL SCIENCES AND ENGINEERING

Head: Jovan Mijovic

The Othmer Department of Chemical and Biological Sciences and Engineering was created in 2002, replacing the Department of Chemical Engineering, Chemistry and Materials Science. The creation of the new department was motivated by the emergence of biology as the enabling science for the 21st century and the ever-increasing interest in engineering of biological principles.

To face the demands and challenges in modern industry, the department offers educational and research programs that focus on novel molecules, advanced materials properties and processes and high quality optimization. Undergraduate programs in 1) chemical and biological engineering and 2) biomolecular science prepare students to enter the workforce in an array of fields that include tissue, genetic and metabolic engineering, drug delivery for cancer and AIDS cure, DNA on a chip, biological weapons and sensors, pharmaceuticals and cosmetics, biomaterials and biocatalysis, petroleum engineering, alternative energy sources, microelectronics and so on. Chemical and biological engineers are most flexible and versatile engineers, with highest starting salaries. Our graduate programs focus on advanced research in those areas. Job growth rates in these fields are the highest in the technical professions.

The department's faculty comprises leading educators and active researchers in their fields. Research activities are supported by both government and industrial cooperation. To meet the needs of industry, the department offers evening courses, part-time study opportunities, on-site research in the industrial workplace and the possibility of classes via Internet as attractive options.

MISSION STATEMENT

The mission of the Othmer Department of Chemical and Biological Sciences and Engineering is to develop graduates capable of contributing to the advancement of chemical and biological sciences and engineering. The department strives to be at the forefront in selected areas of research and its rigorous educational programs are designed to produce graduates who are well grounded in the fundamentals of their chosen discipline, skilled in state-of-the-art techniques and able to understand the importance of new developments in their discipline in a global and societal context.

DEGREES OFFERED

Bachelor of Science

- Biomolecular Science
- Chemical and Biological Engineering

Master of Science

- Bioinformatics
- Biomedical Engineering
- Chemical Engineering
- Chemistry

Doctor of Philosophy

- Chemical Engineering
- Materials Chemistry

Graduate Certificates

- Bioinstrumentation
- Biomedical Materials

CONTACT INFORMATION

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Web: cbse.poly.edu

UNDERGRADUATE PROGRAMS

The undergraduate program in chemical and biological engineering provides a sound foundation in sciences and engineering and builds on this a strong and integrated set of courses in chemical and biological engineering. Thorough instruction is given in chemistry, physics, biology, mathematics and 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.

An undergraduate program leads to a Bachelor of Science in Chemical and Biological Engineering and is accredited by the Accreditation Board for Engineering and Technology (ABET). Chemical and biological engineering is the fastest growing undergraduate engineering discipline in the United States, and Polytechnic is no exception. The curriculum provides a background that enables graduates to select professional careers from an extremely broad spectrum of opportunities. Graduates are prepared to take employment in a number of capacities in a great variety of industry sectors (chemicals, oil, fuels, paper, food, pharmaceutical, biotechnology, biomedical, microelectronics, etc.), or to enter graduate/medical school for advanced study.

The BS in Biomolecular Science provides a modern exposure to both chemical and biological sciences. Students select their curriculum to prepare them for careers in medicine, dentistry, osteopathy, veterinary medicine, podiatry, optometry or biotechnology.

GRADUATE PROGRAMS

Graduate programs in chemical engineering introduce students to advanced research in cutting edge area of chemical engineering. The department offers programs leading to an MS and PhD in Chemical Engineering. Strong emphasis is placed on processing and properties of synthetic and biological polymers, optimization of chemical and biological processes, alternative energy sources, and a variety of topics that combine engineering with biology and medicinal sciences, such as drug delivery for cancer cure, tissue engineering and metabolic engineering.

The MS in Chemistry and the PhD in Materials Chemistry are designed to provide students with a broad competence in the chemical sciences. In addition to offering fundamental courses, the department offers a series of advanced specialized courses that focus on new materials and techniques. Students can focus on the synthesis of novel molecules, polymers and biomaterials, the characterization of these materials or the evaluation of the performance of products developed from these materials. On-site research and electives in other disciplines like management are encouraged for part-time students.

The MS in Bioinformatics introduces students to the computational methods involved with sequence analysis, protein structure, functional prediction and chemoinformatics. The program offers fundamental courses for students to be familiar with the biological molecules as well as with the basics of computational methods. Additional advanced special-topics courses allow students to specialize in selected areas.

FACULTY

PROFESSORS

Stephen Arnold, Thomas Potts
Professor of Physics, University
Professor of Physics
PhD, City University of New York
*Optics, microparticle photophysics,
organic solid-state physics*

Bruce A. Garetz, Professor of Physical
Chemistry
PhD, Massachusetts Institute of
Technology
*Laser spectroscopy, laser light scattering,
nonlinear optics, laser-induced
nucleation and multiphoton processes*

Mark M. Green, Professor of Organic
Chemistry
PhD, Princeton University
*Macromolecular stereochemistry:
synthesis and structure*

Richard A. Gross, Herman F. Mark
Professor of Polymer Science, Director
of NSF Center on Biocatalysis and
Bioprocessing of Macromolecules
PhD, Polytechnic University
*Interface between biology and polymer
science, enzymes in organic media for
regio- and enantioselective polymeriza-
tions, whole-cell systems for the
generation of polymeric structures,
bioresorbable polymers*

Kalle M. Levon, Professor of
Chemistry, Associate Provost for
Research and Intellectual Property
DrAgr, University of Tokyo (Japan)
*Phase separation in polymer blends and
solutions, conducting polymers*

Jovan Mijovic, Professor of Chemical
Engineering and Department Head
PhD, University of Wisconsin at
Madison
*Relaxation dynamics in synthetic and
biological complex systems, modeling of
processing of polymers, in-situ monitor-
ing of reactive processes, structural
relaxation in the glassy state*

Edward L. Wolf, Professor of Physics
PhD, Cornell University
*Experimental condensed matter physics,
superconductivity, scanning tunnel
microscopy and electron tunneling
spectroscopy*

ASSOCIATE PROFESSORS

Mary K. Cowman, Associate Professor
of Biochemistry
PhD, Case Western Reserve University
*Molecular biomechanics of connective
tissue polysaccharides. Solution confor-
mation and interactions of hyaluronan,
novel methods for structure characteri-
zation, connective tissue organization
and function*

José Pinto, Associate Professor of
Chemical Engineering
PhD, Carnegie Mellon University
*Mixed integer organization, planning
and scheduling, design and synthesis*

Iwao Teraoka, Associate Professor of
Polymer Chemistry
PhD, University of Tokyo (Japan)
*Polymer solution dynamics, fractiona-
tion of polymers*

Edward N. Ziegler, Associate Professor
of Chemical Engineering
PhD, Northwestern University
*Kinetics and reactor design, air pollu-
tion control, fluidization*

Walter P. Zurawsky, Associate
Professor of Chemical Engineering
PhD, University of Illinois
*Plasma polymerization, mass transfer in
membranes*

ASSISTANT PROFESSOR

Stavroula Sofou, Assistant Professor of Chemical Engineering
PhD, Columbia University
Engineering principles of drug delivery for cancer cure

INSTRUCTOR

Michael Joesten, Instructor of Biology
PhD, St. John's University
Molecular biology

RESEARCH FACULTY

Menachem Lewin, Research Professor of Polymer Science and Engineering
PhD, Hebrew University (Israel)
Science and technology of fibers

Yoshiyuki Okamoto, Research Professor of Organic and Polymer Chemistry
PhD, Purdue University
Organic and polymer synthesis, characterizations and applications

Eli M. Pearce, University Research Professor
PhD, Polytechnic University
Polymer synthesis and degradation

Arnost Reiser, Distinguished Research Professor of Chemistry
DrIng, University of Prague (Czech Republic)
Polymer photochemistry, photoresists, image science

Edward D. Weil, Research Professor for Polymer Research Institute
PhD, University of Illinois
Additives for polymers, flammability

FACULTY EMERITI

Robert C. Ackerberg, Professor Emeritus of Chemical Engineering
PhD, Harvard University

Robert F. Benenati, Professor Emeritus of Chemical Engineering
PhD, Polytechnic University

William H. Kapfer, Professor Emeritus of Chemical Engineering
EngScD, New York University

Ernest Loebel, Professor Emeritus of Physical Chemistry
PhD, Columbia University

Herbert Morawetz, Institute Professor Emeritus of Polymer Chemistry
PhD, Polytechnic University

Shirley M. Motzkin, Professor Emeritus of Biology
PhD, New York University

DEPARTMENT OF CIVIL ENGINEERING

Head: Roger P. Roess

The Department of Civil Engineering mission involves its faculty in a wide variety of state-of-the-art research, and in the development of innovative curricula for the civil engineers of the 21st century.

Its research focuses on many aspects of urban infrastructure, playing a national leadership role in many areas, while at the same time, being integrally involved in a host of regional and local issues of great importance. Through its involvement in regional issues, students are exposed to a daily laboratory of infrastructure issues and projects all around them. The department is involved in four major interdisciplinary research centers: The Urban Infrastructure Institute, the Urban Utilities Institute, the Transportation Research Institute and the Urban Security Initiative. Its research covers a broad range of topics: highway capacity and level of service, remote monitoring of infrastructure elements and use, management of urban utilities, intelligent transportation systems technologies, construction materials properties and monitoring, urban infrastructure security, and other topics.

All of the department's faculty members teach, and all teach undergraduate as well as graduate students. Thus, the student is exposed to instructors who are in the forefront of their fields and who are frequently working on projects and topics of current interest, often within the region. The full-time faculty are augmented by an excellent group of adjunct faculty who teach specialty courses in areas of their expertise, bringing a strong practical applications element to the classroom.

The department's programs are well-rounded and balanced, including all the necessary theoretical elements with a strong dose of design and application. Its graduates will be versed in state-of-the-art techniques, and will develop the skills needed to become leaders in the profession. Among these skills are the ability to communicate effectively in verbal and written form, and the ability to understand the context of civil engineering projects in a complex society.

MISSION STATEMENT

The mission of the Department of Civil Engineering is to develop engineering graduates capable of contributing to and advancing the practice of civil engineering and its sub-disciplines.

DEGREES OFFERED

The department's undergraduate programs deliver a broad civil engineering background to the beginning engineer. Graduate programs are designed to allow students to specialize in particular areas or sub-disciplines, as well as to pursue general graduate work across several different areas.

Bachelor of Science

- Civil Engineering
- Construction Management

Master of Science

- Civil Engineering
- Construction Management
- Environmental Engineering
- Environmental Science
- Transportation Management
- Transportation Planning and Engineering
- Urban Systems Engineering and Management

Doctor of Philosophy

- Civil Engineering
- Transportation Planning and Engineering

Graduate Certificates

- Construction Management*
- Executive Construction Management (Exec21)
- Hazardous Waste Management
- Traffic Engineering
- Transportation Management and Economics
- Transportation Planning

**Offered in conjunction with the Department of Management.*

Specific information on each of these programs is found in the programs section of this catalog.

CONTACT INFORMATION

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Web: www.poly.edu/cee

CIVIL ENGINEERING PROFESSION

Civil engineers are responsible for the planning, design, construction, maintenance and operation of today's infrastructures. These areas cover a wide range of urban and regional systems and functions, including buildings, roads, bridges, airports, rail systems, dams, irrigation systems, water supply systems, environmental ecosystems, and solid and liquid waste treatment and disposal systems and processes. The civil engineer practices in a broad and exciting field that has a major impact on society in general and on its infrastructure environment in particular.

Modern civil engineering also deals with rapidly expanding information technologies. These technologies monitor, control, operate and manage complex infrastructure systems. From smart buildings to remote monitoring of transportation, water supply, sewage and other infrastructures, the modern civil engineer applies information technologies to improve the quality of the infrastructure environment.

FACULTY

PROFESSORS

George Bugliarello, University Professor, President Emeritus
ScD, Massachusetts Institute of Technology
Fluid mechanics, bio-socio-machine interactions, sustainable urban development, megacities, knowledge parks, infrastructure, science and technology policy.

Lawrence Chiarelli, PE, Esq., Industry Professor of Construction Management
JD, Brooklyn Law School
MS, The Cooper Union
Construction law, contracts and administration. Cost estimation for complex construction projects. Modeling of construction projects.

John C. Falcocchio, PE, Professor of Transportation Planning and Engineering, Executive Director of Urban Intelligent Transportation Systems Center
PhD, Polytechnic University
Transportation planning, public transportation, travel demand, traffic engineering, transportation system evaluation, transportation systems management

Fletcher H. (Bud) Griffis, PE, Professor of Civil Engineering, Provost, Vice President and Dean of Engineering and Applied Sciences, Director of Center for Construction Management Technology
PhD, Oklahoma State University
Three-dimensional computer models and the fully integrated and automated project process, model-based simulation, applications of operations research principles to construction, dredging and dredged material disposal, infrastructure design, construction and management, engineering economics

Ilan Juran, Professor of Civil Engineering, Executive Director of Urban Infrastructure Institute
PhD, DSc, University of Paris IV, École Nationale de Ponts et Chaussées (France)
Geotechnical engineering, soil improvement technologies, geosynthesis engineering, in-situ soil testing, urban engineering

Roger P. Roess, Professor of Transportation Engineering, Department Head
PhD, Polytechnic University
Highway capacity and level of service analysis, traffic control and operations, public transportation operations, transportation economics, engineering pedagogy

ASSOCIATE PROFESSORS

Masoud Ghandehari, Associate Professor of Civil Engineering
PhD, Northwestern University
Mechanics of fracture, durability of concrete structures, structural materials

Magued G. Iskander, PE, Associate Professor of Civil Engineering
PhD, University of Texas at Austin
Foundation engineering, marine geotechnology, pile foundations, alternative foundations, geotechnical instrumentation and monitoring, transparent soils

Alan H. Molof, Associate Professor of Environmental Engineering
PhD, University of Michigan
Water and wastewater treatment processes, nutrient removal, river and stream pollution, industrial waste treatment

Elena S. Prassas, Associate Professor of Transportation Engineering
PhD, Polytechnic University
Traffic engineering, software systems and simulation for transportation applications, transportation economics, AI applications

Jose M. Ulerio, Industry Associate Professor of Transportation Engineering
MS, Polytechnic University
Transportation and traffic engineering; collection, handling, and analysis of large-scale transportation data bases; highway capacity and quality of service analysis; travel demand forecasting; geometric design of highways.

ASSISTANT PROFESSOR

Konstantinos Kostarelos, Assistant Professor of Environmental Engineering
PhD, University of Texas at Austin
Subsurface remediation of toxic substances, water treatment technologies, fluid flow in porous media, tracer technology, geotechnical engineering, design of landfill and cover systems

LECTURER

Roula Maloof, Lecturer of Civil Engineering
PhD, Polytechnic University
Non-destructive evaluation, fracture mechanics, finite element analysis, stress analysis

ADJUNCT FACULTY**Construction Management and Engineering**

Stylianos Aniftos, PE, Adjunct Lecturer in Civil Engineering
PhD, Polytechnic University
President, Technico Construction Services Inc.

Robert Otruba, PE, Adjunct Lecturer of Civil Engineering
BS, Syracuse University
Associate Director, Navigant Consulting Inc.

Jerome White, PE, Adjunct Professor of Civil Engineering
BS, Polytechnic University
President, Jerome B. White PC

Exec 21 Program in Construction Management

Albert DiBernardo, Adjunct Lecturer of Civil Engineering
MS, Purdue University
Principal, Weidlinger Associates

Joseph M. Giglio, Adjunct Professor of Civil Engineering
PhD, Northeastern University
Senior Academic Specialist; Executive Professor of General Management, Northeastern University

Jack Leibler, Adjunct Lecturer of Civil Engineering
LLB, Yale Law School
President, Leibler and Associates LLC

Frank Lombardi, PE, Adjunct Lecturer of Civil Engineering
MS, Columbia University
Chief Engineer, The Port Authority of New York and New Jersey

John Osborne, Esq, Adjunct Lecturer of Civil Engineering
JD, University of South Carolina Law Center
Partner, John E. Osborne PC

Luis Tormenta, PE, Adjunct Lecturer of Civil Engineering
BCE, Manhattan College
Vice Chairman and Chief Operating Officer, LiRo Group

Louis A. Tucciarone, Adjunct Lecturer of Civil Engineering
MS, University of California at Berkeley
Senior Vice President, URS Corporation

Environmental and Water Resource Engineering

Raoul Cardenas Jr., Adjunct Professor of Environmental Engineering
PhD, New York University

Structural and Geotechnical Engineering

J. Jong Lou, PE, Adjunct Professor of Civil Engineering
PhD, Northwestern University
President, J.J. Lou Associates LLPC

Khaled Mahmoud, PE, Adjunct Lecturer of Civil Engineering
PhD, City University of New York
Director of Research and Development, URS Corporation

Patrick Prandl, PE, Adjunct Lecturer of Civil Engineering
PhD, City University of New York
Project Engineer, New York State Department of Transportation

Sri K. Sinha, PE, Adjunct Lecturer in Civil Engineering
MS, Polytechnic University
Director of Plant Improvements and Asset Management, Lucius Pitkin Inc.

Alfonso Whu, Adjunct Lecturer in Civil Engineering
MS, Polytechnic University

Transportation and Highway Engineering

Andrew Bata, Adjunct Professor in Civil Engineering
MS, Northwestern University
New York City Transit Authority

Philip A. Habib, PE, Adjunct Professor of Transportation Engineering
PhD, Polytechnic University
President, Philip A. Habib Associates

Michael Horodniceanu, PE, Adjunct Professor of Transportation Engineering
PhD, Polytechnic University
President, Urbitran Associates

Richard Malchow, Adjunct Professor of Transportation Engineering
MS, Union College
Vice President, Management and Budget, Urbitran Associates

Ramon Patel, Adjunct Lecturer of Transportation Engineering
PhD, Polytechnic University

Genaro Sansone, Adjunct Lecturer of Transportation Engineering
MBA, Iona College
New York City Transit Authority

FACULTY EMERITI

Paul R. DeCicco, PE, Professor Emeritus
MCE, Polytechnic University

Alvin S. Goodman, PE, Professor Emeritus
PhD, New York University

Albert H. Griswold, PE, Professor Emeritus
MSCE, Columbia University

Stephen T. Mikochnik, Professor Emeritus
MS, Rutgers University

Robert C. Veit, Professor Emeritus
MSE, Polytechnic University

Ping-Chun Wang, PE, Professor Emeritus
PhD, University of Illinois

DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE

Head: Stuart A. Steele

Computers are now used in practically every area of human endeavor and are radically changing both the way people live their lives and notions of the limits of human capabilities. Job opportunities in computer and information science are challenging and diverse. According to the U.S. Bureau of Labor Statistics, the future job potential in computer science is among the highest of any technical profession.

Polytechnic's Department of Computer and Information Science offers programs of studies leading to the BS, MS and PhD in Computer Science and the MS in Information Systems Engineering. The department offers joint programs with the Department of Electrical and Computer Engineering, leading to the BS and MS in Computer Engineering and the MS in Telecommunication Networks. The department also offers an advanced certificate in software engineering.

The department faculty is involved in research at the frontiers of many key areas of computer science. Current research includes the analysis and development of data mining, highly efficient Internet search engines, imaging, very large database systems, security with digital watermarking, advanced algorithms, interactive graphics and high performance networks. Major research is done data bases and information retrieval, visualization, software engineering, algorithms and complexity, cyber security and network centric software systems. Application of the research is in all business areas such as finance, transportation, education, government, entertainment and telecommunications. Software and the intelligence developed for these areas are growing rapidly and is a major challenge in computer science.

The faculty works closely with Polytechnic's Center for Advanced Technology in Telecommunications (CATT) and has relationships with various industries that support research and activity in their areas of special interest.

Polytechnic University is designated as a Center of Excellence for Information Assurance Education by the National Security Agency (NSA).

The department provides students with a wide variety of advanced computer and software systems. These support PC and UNIX technology along with highly distributed networks. The department has four dedicated computer science laboratories (virtual lab) for upper-level undergraduate students. They are the Software Engineering Laboratory, Parallel and Distributed Systems Laboratory, Visualization and Graphics Laboratory and Computer System and Security Integration Laboratory. Multimedia and Web-based laboratories are also available.

MISSION STATEMENT

The Department of Computer and Information Science is committed to preparing its undergraduate and graduate students for leadership roles in professional and research activities in the information technology sector. The department fosters an environment that encourages lifelong learning in the information age. Graduates lead and grow in diverse working environments and apply the theories and skills of computer and information science to real-world problems. Toward this end, the department conducts state-of-the-art research in theoretical and applied computer science and maintains strong educational programs that emphasize on breadth and depth in technical knowledge, and proficiency in verbal and written communication skills.

DEGREES OFFERED

Bachelor of Science

- Computer Engineering*
- Computer Science

Master of Science

- Computer Science
- Information Systems Engineering
- Telecommunication Networks*

Master of Engineering

- Interdisciplinary Studies in Engineering (Wireless Innovation**)

Doctor of Philosophy

- Computer Science

Graduate Certificates

- Computer Engineering*
- Cyber Security
- Information Security Professional
- Information Systems Administration
- Software Engineering

* Offered in conjunction with the Department of Electrical and Computer Engineering.

** Offered in conjunction with the Department of Management and the Department of Electrical and Computer Engineering.

CONTACT INFORMATION

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Fax: 718-260-3609
E-mail: cis@poly.edu
Web: http://cis.poly.edu

UNDERGRADUATE PROGRAMS

COMPUTER SCIENCE

The undergraduate program in computer science is accredited by the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET). The computer science program offers a curriculum that prepares students for professional careers as computer scientists or for graduate studies in computer science leading to research or teaching careers.

COMPUTER ENGINEERING

The computer engineering curriculum provides the fundamental knowledge and techniques that graduates need to design computer systems and work with computer hardware and software. The computer engineering program is accredited by the Accreditation Board for Engineering and Technology (ABET). The undergraduate program is a joint program and administered by the Department of Electrical and Computer Engineering. More details are available in that depart-

ment's section as well as in the programs section of this catalog.

GRADUATE PROGRAMS

COMPUTER SCIENCE

The MS program in computer science develops graduate skills 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 PhD program develops graduate skills in a broad range of areas as well as expertise in one or more specific areas and the ability to think critically and conduct independent research. Outstanding PhD students are advised to apply for financial aid in the form of teaching assistantships, research assistantships or partial tuition remission.

TELECOMMUNICATION NETWORKS

The MS program in telecommunication networks prepares graduates for professional careers in designing, managing and operating telecommunication networks. This program includes a wide variety of courses ranging from fundamental topics to recent technological advances in the field of telecommunication networks.

INFORMATION SYSTEMS ENGINEERING

The information systems engineering program educates industry people who are faced with the challenges and opportunities of integrating computers and communication systems. The program combines courses from electrical engineering, computer science and management with an emphasis on information systems engineering. Polytechnic offers the program only at its Westchester campus, courses follow an executive format and classes meet every other weekend for two full days, Friday and Saturday.

SOFTWARE ENGINEERING

The advanced certificate in software engineering consists of a series of five graduate-level courses designed to give students the knowledge and skills they need to compete successfully in the software development arena. Students who want to continue in their studies can apply these courses to the MS program in computer science.

FACULTY

PROFESSORS

Boris Aronov, Professor of Computer Science
PhD, New York University
Algorithms, computational and combinatorial geometry

Phyllis G. Frankl, Professor of Computer Science
PhD, New York University
Software testing and analysis

K. Ming Leung, Professor of Physics and Computer Science
PhD, University of Wisconsin
Computer programming, computer simulation

Nasir Memon, Professor of Computer Science
PhD, University of Nebraska
Pulse compression, computer security, image processing

Keith W. Ross, the Leonard J. Shustek Distinguished Professor of Computer Science
PhD, University of Michigan
Computer networking, queuing theory, audio and video streaming

Richard Van Slyke, Professor of Electrical Engineering and Computer Science
PhD, University of California at Berkeley
Combinatorial optimization, information network design, algorithms

ASSOCIATE PROFESSORS

Yi-Jen Chiang, Associate Professor of Computer Science
PhD, Brown University
Computer graphics, computer algorithms

Alex Delis, Associate Professor of Computer Science
PhD, University of Maryland at College Park
Database management systems, analysis of systems, and software engineering

Lisa Hellerstein, Associate Professor of Computer Science
PhD, University of California at Berkeley
Computational learning, complexity theory

Gleb Naumovich, Associate Professor of Computer Science
PhD, University of Massachusetts at Amherst
Static analysis of concurrent software, software engineering, programming languages

Torsten Suel, Associate Professor of Computer Science
PhD, University of Texas
Database, parallel computation, algorithms

Joel Wein, Associate Professor of Computer Science
PhD, Massachusetts Institute of Technology
Parallel and distributed computation, combinatorial optimization, scheduling theory, algorithms, network optimization

Edward K. Wong, Associate Professor of Computer Science
PhD, Purdue University
Computer vision, image analysis, pattern recognition

ASSISTANT PROFESSORS

Hervé Brönnimann, Assistant Professor of Computer Science
PhD, Princeton University
Algorithms and geometric computing

Joshua Gluckman, Assistant Professor of Computer Science
PhD, Columbia University
Computer vision, imaging

John Iacono, Assistant Professor of Computer Science
PhD, Rutgers University
Computational geometry

INDUSTRY FACULTY

David R. Doucette, Industry Professor of Engineering and Computer Science
PhD, Polytechnic University
Systems integration, software engineering, operating systems

Robert J. Flynn, Industry Professor of Computer Science
PhD, Polytechnic University
Computer architecture, operating systems

Haldun Hadimioglu, Industry Associate Professor of Computer Science
PhD, Polytechnic University
Computer architecture, high-performance systems

Stuart A. Steele, Industry Professor of Computer Science, Department Head
PhD, Pennsylvania State University
Software engineering and management, programming languages, real-time systems

Fred J. Strauss, Industry Associate Professor of Computer Science
MS, Polytechnic University
Operating systems, software engineering, computer engineering

RESEARCH FACULTY

Gad M. Landau, Research Professor of Computer Science
PhD, Tel-Aviv University (Israel)
Algorithms, string matching, computational biology, pattern recognition, communication networks

Binay Sugla, Research Professor of Computer Science
PhD, University of Massachusetts, Amherst
Wireless technology

Xiaolin Wu, Research Professor of Computer Science
PhD, University of Calgary (Canada)
Visual computing and communications, Multimedia data compression, computer graphics

LECTURERS

John B. Sterling, Lecturer of Computer Science
MS, New York University

INSTRUCTORS

Evan Gallagher, Instructor of Computer Science
MS, New York University

Daniel Katz-Braunschweig, Instructor of Computer Science
MS, Iona College

ADJUNCT FACULTY

Thomas P. Cahill, Adjunct Professor of Computer Science
MS, Polytechnic University

Elliote R. Harold, Adjunct Lecturer of Computer Science
MS, New Jersey Institute of Technology

Edward Lancevich, Adjunct Professor of Computer Science
PhD, Polytechnic University

Clifford Marshall, Adjunct Professor of Computer Science
PhD, Columbia University

FACULTY EMERITI

Arthur E. Laemmel, Professor Emeritus of Electrical Engineering and Computer Science
BEE, Polytechnic University

James T. LaTourrette, Professor Emeritus of Electrical Engineering and Computer Science
PhD, Harvard University

Stanley Preiser, Professor Emeritus of Mathematics and Computer Science
PhD, New York University

Henry Ruston, Professor Emeritus of Electrical Engineering and Computer Science
PhD, University of Michigan

Martin L. Shooman, Professor Emeritus of Electrical Engineering and Computer Science
DEE, Polytechnic University

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Head: H. Jonathan Chao

Through innovations in telephones, electric power systems, rapid transit, radio, television, medical electronics, computers, microelectronics, the Internet and wireless communications, electrical and computer engineers contributed more to the quality of 20th century life than any other profession. The first half of the present century will be equally exciting.

The Department of Electrical and Computer Engineering is well respected throughout the world for its major contributions to the profession and its tradition of excellence in teaching and research. Polytechnic electrical and computer engineering graduates are prominent in university faculties, industrial labs and company boardrooms spanning the entire range of the electrical, electronic and information-technology industries.

The department enters the 21st century with strong teaching and research programs in the most exciting fields in the information age: the Internet, wireless communications, computers, multimedia signal processing, robotics, automatic control and electric power generation.

In the intimate Polytechnic environment, undergraduates benefit from frequent access to faculty members and laboratories at the forefront of innovation. The acclaimed Electrical and Computer Engineering Distinguished Lecture series brings the world's technology leaders to the MetroTech campus on a weekly basis to present their latest advances and discuss them with students and faculty.

MISSION STATEMENT

The mission of the Department of Electrical and Computer Engineering is to perform teaching and research that maximizes the value of a Polytechnic University degree. The educational program couples knowledge of electro technology with design and analytic skills to develop creative leaders in their profession. The research places the Polytechnic community at the forefront of Information Age technology and maintains the University's high status in the technical, business and government communities.

DEGREES OFFERED

The Department of Electrical and Computer Engineering offers the following degree and certificate programs. Separate sections of this catalog present the objectives, requirements, advising resources and courses for the individual programs.

*Bachelor of Science**

- Computer Engineering**
- Electrical Engineering
- Electrical and Computer Engineering

Master of Science

- Computer Engineering**
- Electrical Engineering
- Electrophysics
- Systems Engineering
- Telecommunication Networks**

Master of Engineering

- Interdisciplinary Studies in Engineering (Wireless Innovation***)

Doctor of Philosophy

- Electrical Engineering

Graduate Certificates

- Computer Engineering**
- Image Processing
- Telecommunication Network Management
- Wireless Communications

**Accredited by the Accreditation Board for Engineering and Technology (ABET).*

***Offered in cooperation with the Department of Computer and Information Science.*

****Offered in cooperation with the Department of Management and the Department of Computer and Information Science.*

CONTACT INFORMATION

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Web: www.ece.poly.edu

GRADUATE CERTIFICATE PROGRAMS

The department offers Advanced Certificate Programs on themes of current interest. The programs recognize students for successful completion of four or five graduate courses focused in areas of interest to working engineers. More details about these programs are available below in the sections about related degree programs. Courses completed for an advanced certificate are applicable toward a master's degree in a related field. The department's Graduate Manual and Web site should be consulted for the latest list of these programs that follow current trends in technology.

SPECIAL UNDERGRADUATE OPTIONS

BS/MS Honors Option: there are seven options for qualified students to jointly earn two degrees following an accelerated schedule: (1) BS/MS Electrical Engineering/Electrical Engineering, (2) BS/MS Electrical Engineering/Computer Engineering, (3) BS/MS Electrical Engineering/Telecommunications Networks, (4) BS/MS Computer Engineering/Electrical Engineering, (5) BS/MS Computer Engineering/Computer Science, (6) BS/MS Computer Engineering/Computer Engineering, and (7) BS/MS Computer Engineering/Telecommunication Networks. The program is available to exceptional undergraduate students, enabling them to earn both the bachelor's and master's degrees in as little as four years of study.

Dual Major Electrical Engineering/Computer Engineering: Bachelor of Science Program (142 credits)

STUDENT ORGANIZATIONS

Institute of Electrical and Electronics Engineers (IEEE), Professional Organization, Student Chapter. Eta Kappa Nu, Electrical Engineering Honor Society.

SPECIALTY LABS

Keeping pace with the dynamic advances in electrical and computer engineering, the department maintains state-of-the-art laboratories for student instruction and experimentation. Laboratory courses combine lectures, experiments and project work. They provide students with a rich set of elective choices, opportunity to work on senior projects with faculty researchers, valuable hands-on experience to enhance and supplement material they learn in their lecture classes, and forums to practice their oral and written communication skills. Technologies developed in these labs include multimedia information communications and processing, local area networks, wireless information networks, electrical machinery, very large-scale integrated circuits, control/robotics and microwaves.

The Wireless Lab provides formal experiments, lectures and project work on state-of-the-art commercial spread spectrum wireless access systems, including bit error rate analysis and UHF channel propagation measurements.

The Multimedia Lab is equipped with PC-based multimedia workstations, providing students with hands-on experience to acquire, process and communicate voice, image and video as well as create multimedia documents.

The Local Area Networks Lab includes a set of weekly experiments using X-terminals, Ethernet LANs, routers and bridges and associated software to conduct a variety of LAN/WAN experiments and projects.

The VLSI Design Lab treats Very Large-Scale Integrated circuit design, performance analysis and circuit characterization using modern VLSI CAD tools such as VHDL. Students study the design of MOS, CMOS and BiCMOS logic, standard cells and gate arrays and mixed (analog/digital) circuits.

The Power Electronics/Machinery Lab provides projects and structured experiments on electrical machinery and power-related laboratory measurements. These include transformers, induction motors, synchronous machines, dc machines,

DC/DC converters and AC/AC cycloconverters.

The Control/Robotics Lab provides a variety of experiments and project work focusing on feedback control, data acquisition and computer control.

The Microwave Lab treats the design, fabrication and testing of passive and active circuits and antennas using modern CAD and measurement software and hardware.

CENTER FOR ADVANCED TECHNOLOGY IN TELECOMMUNICATIONS

Through the New York State Center for Advanced Technology in Telecommunications (CATT), electrical and computer engineering faculty collaborate with industry in research, education and technology transfer in telecommunications and information systems. CATT is distinguished for its innovations in many fast-moving areas, including, broadband networks, peer-to-peer networking, switch design and implementation, security hardware, ad hoc wireless networks, cellular networks, wireless local area networks, digital filtering, software design and reliability, search engine technology, network design tools traffic planning and capacity engineering, image and video communications and image compression and pattern recognition.

WIRELESS INTERNET CENTER OF ADVANCED TECHNOLOGY

The Wireless Internet Center of Advanced Technology (WICAT) is a joint research center created by Columbia and Polytechnic University. As a National Science Foundation Industry/University Cooperative Research Center, WICAT partners with companies and organizations from across the industry, from telecommunications and manufacturing giants to wireless customers and small start-up firms.

The IUCRC program helps industry and academia come together to overcome practical research challenges. For WICAT, this means that companies who become our partners help to direct future areas of wireless study and gain first access to new research. This research anticipates not only their needs, but also the needs of their clients, suppliers and the industry as a whole.

FACULTY

PROFESSORS

Frank A. Cassara, Professor of Electrical and Computer Engineering, Director of Long Island Graduate Center PhD, Polytechnic University
Electronic circuits, wireless communication systems

David C. Chang, Professor of Electrical and Computer Engineering PhD, Harvard University
Electromagnetics, microwave integrated circuits

H. Jonathan Chao, Professor of Electrical and Computer Engineering, Department Head PhD, Ohio State University
High-speed network, routers/switches, network security and VLSI implementations

David J. Goodman, Professor of Electrical and Computer Engineering, PhD, Imperial College, University of London (England)
Communications systems

Farshad Khorrami, Professor of Electrical and Computer Engineering PhD, Ohio State University
Robotics, control systems

Spencer P. Kuo, Professor of Electrical and Computer Engineering and Electrophysics PhD, Polytechnic University
Magnetohydrodynamics

I-Tai Lu, Professor of Electrical and Computer Engineering PhD, Polytechnic University
Electromagnetics, acoustics, wireless communication

Shivendra S. Panwar, Professor of Electrical and Computer Engineering, Director of Center for Advanced Technology in Telecommunications PhD, University of Massachusetts, Amherst
Communication networks

S. Unnikrishna Pillai, Professor of Electrical and Computer Engineering PhD, University of Pennsylvania
Signal processing and communications

Yao Wang, Professor of Electrical and Computer Engineering
PhD, University of California, Santa Barbara
Image coding, pattern recognition

Zivan Zabar, Professor of Electrical and Computer Engineering
ScD, Technion (Israel)
Power electronics, electric drives, power systems

ASSOCIATE PROFESSORS

Dariusz Czarkowski, Associate Professor of Electrical and Computer Engineering
PhD, University of Florida
Power electronics, power quality

Nirod K. Das, Associate Professor of Electrical and Computer Engineering
PhD, University of Massachusetts
Electromagnetics, antennas, microwave integrated circuits

Zhong-Ping Jiang, Associate Professor of Electrical and Computer Engineering
PhD, École des Mines de Paris (France)
Control systems

Ramesh Karri, Associate Professor of Electrical and Computer Engineering
PhD, University of California, San Diego
VLSI, CAD, computer engineering

Ivan W. Selesnick, Associate Professor of Electrical and Computer Engineering
PhD, Rice University
Signal processing

Peter Voltz, Associate Professor of Electrical and Computer Engineering
PhD, Polytechnic University
Communications and signal processing

ASSISTANT PROFESSORS

Elza Erkip, Assistant Professor of Electrical and Computer Engineering
PhD, Stanford University
Wireless communication, communication theory, information theory

Yong Liu, Assistant Professor of Electrical and Computer Engineering
PhD, University of Massachusetts, Amherst
Communication networks

Andrej Stefanov, Assistant Professor of Electrical and Computer Engineering
PhD, Arizona State University
Communication theory, wireless

Kang Xi, Visiting Assistant Professor of Electrical and Computer Engineering
PhD, Tsinghua University (China)
High-speed networking

RESEARCH FACULTY

Philip Balaban, Research Professor of Electrical and Computer Engineering
PhD, Polytechnic University

Onur G. Guleryuz, Research Professor of Electrical and Computer Engineering
PhD, University of Illinois, Urbana Champaign

Mike Yang, Research Professor of Electrical and Computer Engineering
PhD, Harvard University

ADJUNCT FACULTY

Andrew Bach, Adjunct Lecturer
BS, Pratt University

Mehran Bagheri, Adjunct Lecturer
PhD, Columbia University

Tushar Bhattacharjee, Adjunct Lecturer
PhD, Jadavpur University (India)

Matthew Campisi, Adjunct Lecturer
MS, Polytechnic University

Edward Chen, Adjunct Lecturer
MSc, Yale University

Xiao-Kang Chen, Adjunct Lecturer
PhD, Polytechnic University

Robert DiFazio, Adjunct Lecturer
PhD, Polytechnic University

Robert Gordon, Adjunct Lecturer
PhD, Polytechnic University

Ian Harris, Adjunct Lecturer
PhD, Herriot-Watt University (Scotland)

Howard Hausman, Adjunct Lecturer
MS, Polytechnic University

Zhu Liu, Adjunct lecturer
PhD, Polytechnic University

Schuyler Quackenbush, Adjunct Lecturer
PhD, Georgia Institute of Technology

Ben Spherling, Adjunct Lecturer
PhD, Leningrad Polytechnic University (Russia)

George Sullivan, Adjunct Lecturer
MS, Polytechnic University

Fred Winter, Adjunct Lecturer
PhD, Polytechnic University

Tao Zhang, Adjunct Lecturer
PhD, University of Massachusetts, Amherst

Zhenxue Zhao, Adjunct Lecturer
PhD, Polytechnic University

FACULTY EMERITI

Leonard Bergstein, Professor Emeritus of Electrical Engineering
PhD, Polytechnic University

Henry L. Bertoni, Professor Emeritus of Electrical Engineering
PhD, Polytechnic University

Leo Birenbaum, Associate Professor Emeritus of Electrical Engineering and Electrophysics
MS, Polytechnic University

Donald Bolle, Professor Emeritus of Electrical Engineering, Emeritus Provost
PhD, Purdue University

Joseph J. Bongiorno Jr., Professor Emeritus of Electrical Engineering
DEE, Polytechnic University

Edward S. Cassedy, Professor Emeritus of Electrical Engineering
DrEng, Johns Hopkins University

Bernard R. S. Cheo, Professor Emeritus of Electrical Engineering
PhD, University of California at Berkeley

Douglas A. Davids, Associate Professor Emeritus of Electrical Engineering
PhD, Johns Hopkins University

Rudolf F. Drenick, Professor Emeritus of Electrical Engineering
PhD, University of Vienna (Austria)

Herman Farber, Associate Emeritus Professor of Electrophysics
MEE, Polytechnic University

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Leopold B. Felsen, University Professor Emeritus
DEE, Polytechnic University

Richard A. Haddad, Professor Emeritus of Electrical Engineering
PhD, Polytechnic University

Donald F. Hunt, Professor Emeritus of Electrical Engineering
BS, University of Pennsylvania

Ludwik Kurz, Professor Emeritus of Electrical Engineering
EngScD, New York University

James T. LaTourette, Professor Emeritus of Electrophysics
PhD, Harvard University

Nathan Marcuvitz, University Professor Emeritus
DEE, Polytechnic University

Maurice C. Newstein, Professor Emeritus of Electrophysics
PhD, Massachusetts Institute of Technology

Arthur A. Oliner, Professor Emeritus of Electrophysics
PhD, Cornell University

Istvan Palocz, Professor Emeritus of Electrical Engineering and Electrophysics
PhD, Polytechnic University

Philip E. Sarachik, Professor Emeritus of Electrical Engineering
PhD, Columbia University

Harry Schachter, Professor Emeritus of Electrical Engineering
PhD, Polytechnic University

Benjamin Senitzky, Professor Emeritus of Electrophysics
PhD, Polytechnic University

Sidney S. Shamis, Professor Emeritus of Electrical Engineering
MS, Stevens Institute of Technology

Leonard G. Shaw, Professor Emeritus of Electrical Engineering
PhD, Stanford University

Jerry Shmoys, Professor Emeritus of Electrical Engineering
PhD, New York University

Theodore Tamir, University Professor Emeritus
PhD, Polytechnic University

Wen-Chung Wang, Professor Emeritus of Electrical Engineering and Electrophysics
PhD, Northwestern University

Gerald Weiss, Professor Emeritus of Electrical Engineering
DEE, Polytechnic University

Dante C. Youla, University Professor Emeritus
MS, New York University

UNDERGRADUATE ADVISER

Ellen Daniels
MS, Polytechnic University

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

Head: Harold P. Sjursen

The Department of Humanities and Social Sciences offers a variety of degree programs, minors, concentrations and elective courses to provide a means for students to expand their understanding of the society and culture in which they live, and to obtain skills that can lead to successful and enriching careers. In a world of narrowly focused specialists, human progress depends upon those who can synthesize knowledge and communicate it with real understanding. Students are not locked into rigid academic disciplines and patterns of thinking, they are as intellectually comfortable in the sciences as in the humanities and social sciences. While such students are rare, they are in demand in virtually every profession and can expect to fill vital roles in fields that are only now being explored.

MISSION STATEMENT

The mission of the Department of Humanities and Social Sciences is to provide students with the kind of integrated education that can give them a breadth of knowledge and perspective. The department fulfills its mission with degree programs for humanities and social science majors, and plays an essential role in the education of students specializing in other departments. Today's engineers and scientists need a background in the humanities and social sciences 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.

DEGREES OFFERED

Bachelor of Science

- Liberal Studies (Concentrations in Philosophy, Literature, Psychology, History and History of Science, Digital Media)
- Technical Communication

Accelerated BS/MS

- Digital Media
- Environment–Behavior Studies
- History of Science
- Technical Communication / Specialized Journalism

Master of Science

- Environment–Behavior Studies
- History of Science
- Integrated Digital Media
- Specialized Journalism

Graduate Certificates

- Environment–Behavior Studies
- History of Science and Technology
- Technical Communication
- Technical Communication (online)

Awarded for successful completion of a five-course sequence at the graduate level. Students must take two core courses, and three electives.

MAJORS OFFERED

- Environment–Behavior Studies
- History of Science
- Liberal Studies
- Technical Communication

MINORS

A 16-credit sequence, approved by the department, in any one of the subjects listed below:

SUBJECTS

- AH Art History
- AN Anthropology
- DM Digital Media
- EC Economics
- EN English/Literature
- HI History
- LW Law and Technolog
- MU Music
- PO Political Science
- PS Psychology
- SO Sociology
- TC Technical Communication/ Specialized Journalism

CONTACT INFORMATION

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Web: www.humanscience.poly.edu
E-mail: hsjursen@poly.edu

RESEARCH CENTERS

CENTER FOR HISTORY AND PHILOSOPHY OF SCIENCE STUDIES

The center encourages discussion among philosophers, engineers, computer scientists and other practitioners from the scientific and technological professions on the ethical, political and general cultural connotations of contemporary technological activity, as well as straightforward research in the traditional philosophical questions concerning technology. The center also fosters various types of interdisciplinary education.

By bringing the humanities, communications and social science disciplines closer together and reaching out to other academic departments in the University, the center helps facilitate the exploration of intellectual common ground.

INTEGRATED DIGITAL MEDIA INSTITUTE

The Integrated Digital Media Institute develops and supports creative partnerships between the following:

- Students and faculty
- Polytechnic University and leading individuals, organizations, and enterprises in electronic media
- The most advanced thinkers and practitioners in the humanities, arts, social sciences and communications technologies

GENERAL EDUCATION REQUIRED COURSES

See the Liberal Studies Program in Section 3 of this catalog for course descriptions. All humanities and social science courses used to fulfill the graduation requirement are organized according to principles of breadth and depth into three categories:

1. Level I Basic Courses required of all students
2. Level II Elective Courses
3. Level III Elective Courses

To fulfill the general education requirement, students must complete the following:

- Three basic courses (EN 1014 / EN 1034, EN 1204 and HI 2104, taken in order)
- Two Level II Elective Courses
- One Level III Elective Course cognate with at least one Level II Course (i.e., which has a Level II Elective Course as a prerequisite)

Courses used to meet the above requirement carry the following prefixes:

AH Art History
AN Anthropology
EC Economics
EN English/Literature
HI History
MU Music
PL Philosophy
PO Political Science
PS Psychology
SO Sociology

Courses that carry the following prefixes may NOT be used to fulfill the requirement:

DM Digital Media
LA Liberal Arts
LW Law
TC Technical Communication

BS/MS HONORS PROGRAM

The Department of Humanities and Social Sciences offers a BS/MS honors program for exceptional first-year students and advanced undergraduates. Through this unique program, students can earn both a Bachelor of Science and a Master of Science in Technical Communication/Specialized Journalism in just four to five years.

The accelerated program allows students to take up to 9 credits that fulfill both undergraduate and graduate degree requirements. In addition, credit may be granted for high school Advanced Placement

courses where a student earns a 4 or 5 on the AP test. Students accepted into the program may also earn up to 18 credits through one or more undergraduate and graduate internship opportunities.

All candidates for the program must pass an entrance examination administered by the department and be interviewed by a program adviser. Once enrolled in the program, students are expected to maintain a 3.0 GPA.

FACULTY

ASSOCIATE PROFESSORS

Jonathan Bain, Associate Professor of Philosophy of Science
PhD, University of Pittsburgh
Quantum theory, philosophy of space and time

Jean Gallagher, Associate Professor of English
PhD, City University of New York Graduate Center
Feminist theory, 19th- and 20th-century American literature, composition and rhetoric

Sylvia Kasey Marks, Associate Professor of English
PhD, Princeton University
Shakespeare, Samuel Richardson, the 18th- and 19th-century British novel, public speaking, expository writing

Francis David Mulcahy, Associate Professor of Anthropology
PhD, University of Massachusetts
Language and culture of China and Spain

Lowell L. Scheiner, Associate Professor of Humanities and Communications
MS, Columbia University Graduate School of Journalism
MA, Columbia University
Technical writing, journalism

Jonathan Soffer, Associate Professor of History
PhD, Columbia University
JD, University of Denver
Twentieth-century American political and foreign relations history, urban history with a specialization in the history of New York City since 1945

Romualdas Sviedrys, Associate Professor of History of Technology

PhD, Johns Hopkins University
Technology forecasting and technology assessment, history of technology and science

Richard E. Wener, Associate Professor of Psychology
PhD, University of Illinois at Chicago
Environmental psychology

ASSISTANT PROFESSORS

Teresa Feroli, Assistant Professor of English
PhD, Cornell University
Renaissance literature, Shakespeare, women's studies

V. Hugo Lane IV, Assistant Professor of History
PhD, University of Michigan
Eastern European history

INDUSTRY FACULTY

Jerry MacArthur Hultin, Industry Professor of Law, Management and Public Policy; University President
JD, Yale University
Innovation Management, global development, modern university education, technology policy

Noel N. Kriftcher, Industry Professor of Humanities, Executive Director of David Packard Center for Technology and Educational Alliances
EdD, Hofstra University

Ann Lubrano, Industry Associate Professor of Sociology, Associate Director of Othmer Institute for Interdisciplinary Studies, Associate Dean of Honors College
PhD, City University of New York
Technology and social change, organizations

Harold P. Sjurson, Industry Professor of Philosophy, Department Head, Associate Provost for International Studies
PhD, New School University
History of philosophy, ethics, philosophy of science and technology

LECTURERS

Donald S. Phillips, Lecturer of Psychology
BS, Polytechnic University
Experimental and physiological psychology, physical anthropology, paleontology

Carl Skelton, Lecturer of Digital Media,
Director of Integrated Digital Media
Institute
MVA, University of Alberta (Canada)
Digital media

INSTRUCTORS

Natasha V. Assa, Instructor of History
PhD, London University
World history, late Imperial Russia

Alph Edwards, Instructor of English
MA, Hunter College
Developmental writing

Sadrul A. Khan, Instructor of History
PhD Ludwig Maximilian University
(Germany)
*World history, Asian history, political
science*

James P. Lewis, Instructor of
Psychology
MA, Stony Brook University
Humanistic psychology

Elisa Linsky, Instructor of Technical
Communications
BA, Wittenberg University
*Technical writing, technical presenta-
tions, writing across the curriculum*

Alan M. Nadler, Instructor of English
MFA, Columbia University
*Contemporary poetry, the European
novel*

RESEARCH FACULTY

Lauren Kozol, Research Assistant
Professor of English
PhD, City University of New York
Literature and the fine arts

Bethany Saltman, Research Assistant
Professor of English
MFA, Brooklyn College
Literature, writing

ADJUNCT FACULTY

Kenseth Armstead
BFA Corcoran School of Art, Whitney
Museum of American Art (Independent
Study Program)

Asya Blue
BFA, Parsons School of Design

Keith Bunin
MA, Columbia University

Erin Hayes
MA, City University of New York

Michael Laderman
DMA, Stony Brook University

Chris Leslie
MA, City University of New York

Cynthia Madansky
MFA, Rutgers University

Louis Menashe
Adjunct Professor of History
PhD, New York University

Frank Meola
BA, Columbia University

David Mermelstein
Adjunct Professor of Economics
PhD, Columbia University

Andrew Miller
BA, Columbia University

Naomi Nemtzow
MFA, American University

Dominic Pettman
PhD, University of Melbourne
(Australia)

Meredith Schuman
MFA, Brooklyn College

James Waller
MA, Columbia University

Shannon Welch
MFA, University of Iowa

FACULTY EMERITI

Lester Bumas
John G. Cavanna
Wolhee Choe
Duane DeVries
Anne Eisenberg
Marvin Gettleman
Helmut Gruber
Bernard Rechtschaffen
Thomas B. Settle

DEPARTMENT OF INTRODUCTORY DESIGN AND SCIENCE

Head: Lorcan M. Folan

Polytechnic created the Department of Introductory Design and Science as part of Curriculum 2000, an ambitious reorganization of the University's undergraduate degree programs. The department provides undergraduate instruction in basic sciences and engineering design and enhances learning through instructional innovation, hands-on laboratory work, curricular integration and the use of enabling technologies. Faculty members are dedicated educators who seek to exploit technological advances to enrich the classroom and laboratory experiences of students.

MISSION STATEMENT

The mission of the Department of Introductory Design and Science is to instill in undergraduate students an understanding and appreciation of the physical sciences and engineering design, providing a solid foundation for more advanced instruction in their area of specialization. The department supports the University's mission by providing high quality and innovative instruction and developing leadership qualities among students through the undergraduate teaching assistants program.

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Web: <http://feynman.poly.edu>

FACULTY

ASSOCIATE PROFESSOR

Lorcan M. Folan, Associate Professor of Physics, Department Head
PhD, Polytechnic University

INDUSTRY PROFESSORS

Gunter W. Georgi, PE, Industry Professor of Engineering and Computer Science
MS, Columbia University

David R. Doucette, Industry Professor of Engineering and Computer Science
PhD, Polytechnic University

Valery A. Sheverev, Industry Associate Professor of Physics, Director of Physics Laboratory Program
PhD, Saint-Petersburg State University (Russia)

LECTURERS

Victor Barinov, Lecturer of Physics
PhD, Academy of Science of the Ukraine

S. John DiBartolo, Lecturer of Physics
PhD, University of Virginia

Charles P. Martucci, Lecturer of Chemistry
PhD, Columbia University

Myron I. Pollack, Lecturer of Chemistry
PhD, New York University

Vladimir I. Tsifrinovich, Lecturer of Physics
DSc, Academy of Science of the USSR

INSTRUCTORS

Janice Aber, Instructor of Chemistry
PhD, Polytechnic University

Partha P. Debroy, Instructor of Physics
PhD, Carnegie Mellon University

David T. Mugglin, Instructor of Physics
PhD, Lehigh University

PARTICIPATING FACULTY

Faculty members involved in delivering the department's courses with appointments in other departments or programs include the following:

Stephen Arnold, Thomas Potts Professor of Physics, University Professor of Physics
PhD, City University of New York

Bruce A. Garetz, Professor of Physical Chemistry
PhD, Massachusetts Institute of Technology

Edward L. Wolf, Professor of Physics
PhD, Cornell University

ADJUNCT FACULTY

Dimitrie James Cordista, Adjunct Professor of General Engineering
BS, Polytechnic University

Akhil Lal, Adjunct Professor of Physics
PhD, Polytechnic University

Vladimir Ostrovsky, Adjunct Professor of Physics
DSc, Academy of Science of the Ukraine

DEPARTMENT OF MANAGEMENT

Head: Fletcher H. (Bud) Griffis

“Mastering broadly defined technology, and innovation management increasingly determines success or failure in business today. The Department of Management at Polytechnic University is an acknowledged pioneer and leader in the New York City/tri-state region in offering courses and programs dealing with these increasingly critical arenas, including services, bio-pharma and modern knowledge-intensive business. The department serves a diverse and broad range of professionals, and its faculty and students comprise a vital and forward-thinking research and learning community. Firms represented in the department’s programs encompass a wide range of service companies, retailing, media and technology-driven manufacturing firms, IT-intensive businesses and bio-medical/pharmaceuticals—the areas of greatest growth and opportunity in the emerging economy.”

—Mel Horwitch, DBA
*Professor and Director, Institute for
Technology and Enterprise*

MISSION STATEMENT

The mission of the Department of Management is to act as a major educational gateway and premier learning, research and development hub explicitly devoted to broadly defined innovation, and technology management. As such, all its carefully tailored learning programs and the intellectual capital it produces enable the department to provide unique and valuable opportunities for students, other professionals and scholars. The department has as its policy an unequivocal commitment to upgrade and revise continually its learning programs and courses to meet fast-changing demands of a dynamic, technology-driven and competitive environment.

DEGREES OFFERED

Bachelor of Science

- Business and Technology Management

Master of Science

- Financial Engineering
- Management
- Management of Technology (executive format)
- Organizational Behavior
- Telecommunications and Information Management (executive format)

Master of Engineering

- Interdisciplinary Studies in Engineering (Wireless Innovation*)

Doctor of Philosophy

- Technology Management

Graduate Certificates

- Construction Management**
- Electronic Business Management
- Entrepreneurship
- Financial Engineering
- Financial Technology Management
- Human Resource Management
- Information Management
- Operations Management
- Organizational Behavior
- Risk Management
- Technology Management
- Telecommunications Management

**Offered in conjunction with the Department of Electrical and Computer Engineering and the Department of Computer and Information Science.*

***Offered in conjunction with the Department of Civil Engineering.*

CONTACT INFORMATION

Brooklyn Campus

Dibner/CATT Bldg., Room 401
Polytechnic University
Five MetroTech Center
Brooklyn, NY 11201
Tel: 718-260-3760
Fax: 718-260-3874
E-mail: mgt-dept@poly.edu
Web: www.managementdept.poly.edu

Manhattan Location

MOT and TIM Executive Master’s Programs and FE Master’s Program
Institute for Technology and Enterprise
55 Broad Street, Suite 13B
New York, NY 10004
Tel: 718-260-4014
Fax: 212-547-7029
E-mail: mot-tim@poly.edu
Web: www.mot-tim.poly.edu

Departmental representatives are available for student advising on the Long Island and Westchester campuses.

RESEARCH AND DEVELOPMENT

The department has achieved its preeminent position with a continuous stream of high-quality and relevant research, development and pacesetting learning programs. With its outstanding faculty, the department contributes to theory and practice in an increasingly knowledge-intensive age. The department’s research and development work is varied, including scholarly books and articles in the most respected journals and timely case studies. Some of this material (especially cases, which are in print or Web-based digital formats) form part of the content in the department’s educational programs, helping to keep its programs up to date and distinctive. The department is also committed to integrating wisely technology into all of its educational programs to enhance learning.

UNDERGRADUATE PROGRAM

The Department of Management offers a Bachelor of Science in Business and Technology Management (BTM). This program prepares students to be the next generation of managers in fields dominated by technological innovation and information intensity. Students completing this program are prepared to succeed in positions such as technology project leaders, new economy entrepreneurs, technology and IT analysts, customer rela-

tionship managers and in other cross-functional roles.

MINOR IN MANAGEMENT

Students may obtain an undergraduate minor in management by completing 14 credits of MG courses. An overall GPA of at least 2.0 must be maintained in these classes. At least 8 of the 14 credits must be taken by students while enrolled at Polytechnic.

GRADUATE AND CERTIFICATE PROGRAMS

Because all managers must now understand how technology and innovation are essential for delivering value to organizations and the market, the department offers a portfolio of continually updated educational programs, all dealing in some fashion with the broad spectrum of innovation, technology and information management in the modern economy.

The department offers six graduate and professional degrees, two of which are earned in executive management programs (meeting every other week on Thursday evening and all day Saturday) and three evening graduate programs:

- Master of Science in Financial Engineering
- Master of Science in Management
- Master of Science in Management of Technology (MOT Executive Program)
- Master of Science in Organizational Behavior
- Master of Science in Telecommunication and Information Management (TIM Executive Program)
- Doctor of Philosophy in Technology Management

The Master of Science degrees in Management, Organizational Behavior and Financial Engineering may be pursued either part time or full time with an evening schedule. Each has concentrations that allow students to specialize in selected areas of Management, Organizational Behavior or Financial Engineering.

The department also offers certificates from the Management, Financial Engineering and Organizational Behavior Programs, which consist of sequences of selected courses leading to advanced knowledge in a desired area of specialization.

DOCTOR OF PHILOSOPHY IN TECHNOLOGY MANAGEMENT

Modern technologies increasingly and profoundly affect management of products, services, processes, organizational forms, business models, the shape of industry structures and modern business environments, the kinds of the technology-enabled innovation available, and the capability of integrating technology and management to create value for customers and organizations. The ability to conduct research on and to educate on the managerial implications of such topics—all comprising technology management—is a highly sought-after and important arena for business scholarship and education. The PhD in Technology Management is designed for this increasingly significant set of scholarly and educational opportunities.

This degree program is designed for research-oriented students. Admission criteria includes academic record, professional experience, research potential, GMAT or GRE scores and references.

Visit www.phd-tim.poly.edu for more information.

All management undergraduate and graduate degree programs, as well as certificate programs, are further described in this catalog under the appropriate entries.

STUDENT PROFESSIONAL SOCIETIES, ASSOCIATIONS AND ORGANIZATIONS

The Management of Technology and the Telecommunications and Information Management Executive Programs Alumni Association actively seeks to continue and expand shared professional experience gained during and after the programs. Members meet face to face or electronically to share insights obtained in their work experiences and to debate issues broadly relevant to technology management.

The Organizational Behavior Program sponsors an award-winning student chapter of the Society for Human Resources Management (SHRM). The chapter sponsors forums with experts and provides an excellent means for professional networking to further enhance the student's education and overall career.

The Financial Engineering Student Club (FESC) is quite active in promoting a distinguished speaker series and in organizing career opportunity events.

The student club associated with the Bachelor of Science in Business and Technology Management degree program

is a strong and valued component of the social fabric of undergraduate life at Polytechnic. This organization works to create professional knowledge and opportunities for its members.

INSTITUTE FOR TECHNOLOGY AND ENTERPRISE

The Institute for Technology and Enterprise (ITE) is supported by the Department of Management at Polytechnic University. Located at 55 Broad Street in Manhattan, ITE is New York City's research and education hub for the management of technology and innovation and modern e-business, telecommunications and networking decision making. Located in the heart of high-technology New York City, ITE is a focal point and R&D engine for building managerial knowledge and developing learning programs suited particularly to technology-intensive and "hybrid"—i.e., digital and physical—settings. ITE's emphasis is on the creation of new value by users of technology. Hence, ITE's emphasis is often on such sectors as media, entertainment, financial and professional services, bio-medical and health-care and other industries comprising much of the New York City economy.

ITE is also a gathering place for a unique, diverse and interdisciplinary community, comprising faculty members from the Department of Management and other Polytechnic departments, industry leaders, and participating professionals in department's executive master's programs. These highly committed professionals and scholars take part in ITE round tables and workshops in New York City and around the world, and, working together, develop relevant research and learning materials that are used in learning programs and other international events.

ITE activities include:

- Round tables and executive workshops on such subjects as wireless innovation, media management, e-business decision making and new business models, managerial challenges in the biotechnology industry in Israel, innovation in the post-NASDAQ-crash, post-9/11 world, and new dimensions in global innovation.
- Research and curriculum development on modern innovation management, the transformation of the print media industry, value creation in financial services, global innovation strategy, and the emerging homeland security sector's impact on U.S. technology decision

making in firms.

ITE is closely aligned with the activities of the Department of Management; in particular, ITE has a strong and mutually reinforcing relationship with Polytechnic's executive master's programs in the Management of Technology (MOT) and Telecommunications and Information Management (TIM), which are also held at 55 Broad Street in Manhattan.

For further information, call 718-260-3610, fax: 212-547-7029, e-mail ite@poly.edu, or visit www.ite.poly.edu.

CENTER FOR FINANCE AND TECHNOLOGY

The Center for Finance and Technology (CFT) addresses the evolving financial and technology enabled-innovation needs of the financial services industry. CFT is a hub for research and acts as a laboratory for generating new ideas and tools for the industry. CFT also hosts Round Tables and undertakes collaborative research projects, providing ideas, methods and tools with scholarly and practical applications.

For further information, contact, Frederick Novomestky at 718-260-3436; e-mail: fnovomes@poly.edu; web: www.cft.poly.edu.

EXTENSION IN ISRAEL

The Department of Management offers the MS in Management and the MS in Organizational Behavior at its extension in Rehovot, Israel, home of the prestigious Weizmann Institute of Science and many technology-based firms. The programs are identical to the evening curricula in New York, with selected concentrations specifically designed for professionals and managers working in Israeli business and industry. Moreover, the programs bring cutting-edge technology and people management approaches taught by Polytechnic professors together with Israeli faculty to address the advanced state of technology in Israel.

For further information about the Department of Management extension in Israel, contact Academic Director Harold Kaufman at 718-260-3485 in New York and 08-939-0520 in Israel, or by e-mail at hkaufman@poly.edu.

FACULTY

PROFESSORS

Fletcher H. (Bud) Griffiths, PE, Professor of Civil Engineering, Department Head, Vice President and Dean of Engineering and Applied Sciences, Director of Center for Construction Management Technology PhD, Oklahoma State University
Leadership, management of construction and application of four-dimensional CAD modeling in management of construction

Mel Horwitch, Professor of Management, Director of Institute for Technology and Enterprise, Co-director of Executive Management Master's Programs DBA, Harvard University
Innovation, technology management, technology policy

Harold G. Kaufman, Professor of Management, Academic Director of Organizational Behavior Program, Academic Director of Department of Management Extension in Israel PhD, New York University
Managing professional and technical workers, career management, obsolescence of knowledge and skills, research methods

Charles S. Tapiero, the Morton and Angela Topfer Distinguished Professor in Technology Management PhD, New York University
Financial engineering, risk technology and management, supply-chain management

ASSOCIATE PROFESSOR

Bharat P. Rao, Associate Professor of Management PhD, University of Georgia
Strategic alliances, collaborative new product development, supply chain management, strategic management, electronic commerce

ASSISTANT PROFESSORS

Oded Nov, Assistant Professor of Management PhD, University of Cambridge, Judge Institute of Management (England)
Organizational knowledge sharing practices, creative idea generation processes and information systems

INDUSTRY FACULTY

Barry S. Blecherman, Industry Associate Professor of Management, Associate Provost for Undergraduate Education and Innovation, Academic Director for BTM and MSM Programs PhD, Wharton School, University of Pennsylvania
Information economics and strategy, decision theory, business negotiations

Jerry MacArthur Hultin, Industry Professor of Law, Management and Public Policy; University President JD, Yale University
Innovation management, global development, modern university education, technology policy

Fredrick Novomestky, Industry Professor of Management, Academic Director of Financial Engineering Program, Director of Center for Finance Technology PhD, Polytechnic University
Asset/liability modeling and management, technologies for interactive management education, evolutionary computational algorithms for business optimization, systems with distributed objects, quantitative investment strategy

Nina D. Ziv, Industry Associate Professor of Management, Co-director of Executive Master's Programs, Academic Director of Institute for Technology and Enterprise PhD, New York University
Content innovation, global entrepreneurship, media management, wireless innovation, e-business

ELECTRICAL AND COMPUTER ENGINEERING AND COMPUTER SCIENCE

Zhong-Ping Jiang, Assistant Professor of Electrical and Computer Engineering PhD, École des Mines de Paris (France)
System optimization

Richard Van Slyke, Professor of Electrical Engineering and Computer Science PhD, University of California at Berkeley
Financial models, linear and non-linear optimization, distributed computing

HUMANITIES AND SOCIAL SCIENCES

Richard. C. Wener, Associate Professor of Psychology
PhD, University of Illinois at Chicago
Environmental psychology, crowding, assessment of the built environment

ADJUNCT FACULTY

Sassan Alizadeh, Adjunct Associate Professor of Financial Engineering
PhD, University of Pennsylvania
Term structure model, quantitative trading strategies

Paul Beiderman, Adjunct Associate Professor of Financial Engineering
PhD, New School University
Financial market regulation, industry economic analysis

Yair Berson, Adjunct Associate Professor of Management
PhD, SUNY Binghamton
Organizational behavior, leadership of high technology firms, strategic leadership

Robert Biolsi, Adjunct Associate Professor of Management
PhD, Graduate Center, College University of New York
Inflation, equity prices, and commodity diversification, electricity deregulation

Srimat T. Chakradhar, Adjunct Associate Professor of Management
PhD, Rutgers University
Design/test distributed, networked computing systems, embedded systems

Joe Chizmarik, Adjunct Associate Professor of Management
MS, Stevens Institute of Technology
Telecommunications management and MIS

Arnold Cohen, Adjunct Associate Professor of Management
MBA, City College of New York
Marketing

Lance Cohen, Adjunct Associate Professor of Management
PhD, Columbia University
MIS

Robert Cohen, Adjunct Associate Professor of Management
MBA, New York Institute of Technology
Management information systems, quality control and systems

Vaughan L. Coleman, Adjunct Associate Professor of Management
MA, New York University
Human resource information systems, Internet applications in human resources

Michael Cortegiano, Adjunct Associate Professor of Management
BS, Fairfield University
Accounting and finance

Jan Damsgaard, Adjunct Associate Professor of Management
PhD, Copenhagen Business School (Denmark)
e-business

Matthew J. DeLuca, Adjunct Associate Professor of Management
MPA, University of Pittsburgh
Labor relations, performance appraisal, compensation management, organizational consulting

Ducarmel Dorceus, Adjunct Associate Professor of Financial Engineering
MA, New York University
Accounting of financial products

Rohan Douglas, Adjunct Associate Professor of Financial Engineering
BSc, Sydney University (Australia)
Market theory

Philip Dorin, Adjunct Associate Professor of Management, Management Department Adviser for Long Island Campus
PhD, University of Connecticut
Organizational behavior, human resource management, training and development

Alberto Fernandez, Adjunct Associate Professor of Management
PhD, Lynn University
Program marketing, financial management

Philip Ferrara, Adjunct Associate Professor of Management
PhD, Hofstra University
Organizational staffing, job design

Roy Freedman, Adjunct Associate Professor of Financial Engineering
PhD, Polytechnic University
Evolutionary information technology, quantitative methods in finance, artificial intelligence

Sanjay Ghandi, Adjunct Associate Professor of Management
BS, Clarkson University
Marketing, entrepreneurship

Marv Golland, Adjunct Associate Professor of Management
MBA, New York University
MIS

Robert R. Goodman, Adjunct Associate Professor of Management
MBA, Harvard University
Corporate and government management

Sara Grant, Adjunct Associate Professor of Management
MA, Indiana University, MA, Columbia University
Organizational theory and design, human resource management, conflict management, organizational behavior, organizational theory and design, research methods

Edward Greenbaum, Adjunct Associate Professor of Management
MS, Cornell University
Industrial and labor relations

Bohdan Hoshovsky, Adjunct Associate Professor of Management
MS, Polytechnic University
Organizational behavior, project management, general management

Thomas Hutchinson, Adjunct Associate Professor of Financial Engineering and Management
MA, McMaster University (Canada)
Investment banking, financial economics

Pamela Lassiter, Adjunct Associate Professor of Management
JD, University of Virginia
Organizational behavior

David Lefferts, Adjunct Associate Professor of Management
MBA, Columbia University
Emerging financial technologies, financial products, e-business

James Lichtenberg, Adjunct Associate Professor of Management
BA, Harvard University
Information technology

Peter Lubell, Adjunct Associate Professor of Management
MS, Polytechnic University
Data-communications management

Steven Mandel, Adjunct Associate Professor of Financial Engineering
PhD, New York University
Risk management, portfolio optimization, return attribution

Ingrid Marshall, CPA, Adjunct Associate Professor of Financial Engineering
MBA, St. John's University
Corporate financial accounting

Thomas Mazzone, Adjunct Associate Professor of Management
MBA, Theseus Institute (France)
Operations management, supply chain management

Sonia Miller, Adjunct Associate Professor of Management
JD, New York Law School
Nanotechnology

Pavlos Mourdoukoutas, Adjunct Associate Professor of Management
PhD, University of Connecticut
Economics

Carl Nelson, Adjunct Associate Professor of Management
MIE, New York University
Operations management

Jim Paguagua, Adjunct Associate Professor of Management
MBA, Pace University
New product development, marketing

Jerzy Pawlowski, Adjunct Associate Professor of Financial Engineering
PhD, State University of New York
Credit derivatives, energy derivatives

Lisa Marie Plantamura, Adjunct Assistant Professor of Management
MBA, Fairleigh Dickinson University
Human resource information systems

John Reilly, Adjunct Assistant Professor of Management
MA, Columbia University
Human resource information systems

Timothy W. Reinig, Adjunct Associate Professor of Management
JD, State University of New York at Buffalo
e-business, e-commerce marketing, Internet law and intellectual property

David Rosensaft, Adjunct Associate Professor of Management
MS, Polytechnic University
Managerial decision making

Fred Schlissel, Adjunct Associate Professor of Management
MBA, Columbia University
Entrepreneurship

Sandor Schweiger, Adjunct Associate Professor of Management
JD, School of Law, New York University

Ronald T. Slivka, Adjunct Associate Professor of Financial Engineering
PhD, University of Pennsylvania
Quantitative approaches to derivative securities valuation and applications, quantitative investment strategies

Wendy Stahl, Adjunct Associate Professor of Management
MBA, Harvard University
Marketing new product development

Thomas Stiles, Adjunct Associate Professor of Management
MBA, New York University
Telecommunications management

John Thomas, Adjunct Associate Professor of Management
MBA, University of Rochester
Operations, quality and project management

Kenneth Walden, Adjunct Associate Professor of Management
MS, New York Institute of Technology
Human resource management

Richard Walton, Adjunct Associate Professor of Management
MBA, New York University
Management

Edward Weinberger, Adjunct Associate Professor of Financial Engineering
PhD, Courant Institute, New York University
Credit risk measurement and management

Gerald Wisz, Adjunct Associate Professor of Financial Engineering and Management
PhD, Johns Hopkins University
Corporate financial strategy, quantitative methods applied to finance and operations research

Anthony Zinsser, Adjunct Associate Professor of Management
PhD, Stevens Institute of Technology
Organizational behavior, organizational development

FACULTY EMERITI

Seymour Kaplan, Associate Professor Emeritus of Operations Management and Management Science
PhD, New York University
Operations research and management

A. George Schillinger, Research Professor Emeritus of Management
Eng ScD, Columbia University
Management of innovation, technology management, science and technology policy

DEPARTMENT OF MANAGEMENT

ADVISORY BOARDS: CORPORATE AND ACADEMIC

The Department of Management maintains close and deep ties with a wide range of firms in a host of knowledge- and innovation-intensive sectors. The department is honored to have a distinguished and active Corporate Advisory Board. The department also works closely with high quality academic institutions and colleagues throughout the world and is honored to have an active and highly respected Academic Advisory Board. Both boards meet regularly throughout the year to discuss and review the department's learning programs, research and plans for the future. In this manner, the department stays informed, meets the pragmatic and scholarly needs and critical challenges confronting technology and innovation executives and makes certain that its courses and programs are state-of-the-art and relevant.

CORPORATE ADVISORY BOARD MEMBERS

Mark Chardack

Chief Financial Officer
LextraNet.com

John Clippinger

Founder and Chairman
Parity Communications

Patrick S. Finn

Director, Northeast Market
Development
CISCO Systems

Edward Fitzpatrick

First Deputy Controller
City of New York

Elke Geising

Partner
Pendulum Systems

John Gilbert

Executive Vice President, COO
Rudin Management Inc.
Chief Technology Officer
New York Information Technology
Center

Michael Hora

Vice President (retired)
A.T. Kearney

Alan Kantrow

Chief Content Officer
The Monitor Group

George Lieberman

CEO
Pragmatic Vision

Stephen J. Newman

Program Director
Executive Development
LM Ericsson

Dennis O'Brien

Technical Program Manager
Telica

J. R. (Jay) Topper Jr.

Senior Vice President
Applied Graphics Company

ACADEMIC ADVISORY BOARD

Michael Cusumano

Sloan School of Management, MIT
Cambridge, Massachusetts

Alan Kantrow

Chief Content Officer
Monitor Company

Shlomo Maital

Technion Institute
Haifa, Israel

Pedro Nueno

IESE
Barcelona, Spain

Ananth Raman

Professor
Harvard Business School

Denis Fred Simon

Provost and Vice President for Academic
Affairs
Neil D. Levin Graduate Institute of
International Relations and Commerce,
CUNY

Raymond-Alain Thietart

University of Paris-Dauphine
Paris, France

N. Venkatraman

David J. McGrath Jr. Professor of
Management
Boston University School of
Management
Boston, Massachusetts

PROGRAM ADMINISTRATION AND PROFESSIONAL STAFF

Paul Sunda

Administrative Director
MOT-TIM Executive Masters Programs
MSEd, Baruch College, CUNY

Bohdan Hoshovsky

Executive Assistant and Deputy
Webmaster and Adjunct Associate
Professor of Management
MS, Polytechnic University

Janelle Meehan

Program Coordinator
BA, Lycoming College

Juliette Acker

Administrative Assistant
MA, American University

DEPARTMENT OF MATHEMATICS

Head: Erwin Lutwak

The Department of Mathematics is committed to excellence and innovation in the teaching and research of mathematics. Current active areas of research include geometric analysis, partial differential equations, mathematical physics, sports science and mathematics education. The bachelor's, master's and doctoral degree programs provide both a solid foundation in mathematics and extensive exposure to how mathematics is used in practice. Half of a mathematics major's courses are taken in other departments. The department also offers a complete spectrum of undergraduate and graduate courses.

Students taking departmental courses become confident in their abilities to reason rigorously, use the language of mathematics properly, write and speak about mathematical ideas precisely and concisely and appreciate the amazing power of mathematics to describe phenomena in the world. Students learn how to use mathematical software appropriately as a tool in the study and application of mathematics.

The department also has degree programs in its own discipline, with a strong interdisciplinary focus. The BS in Mathematics, for instance, has an optional concentration in physics. The MS in Mathematics focuses on strong abstract and quantitative reasoning abilities. The PhD in Mathematics encourages work applying advanced mathematics in other disciplines, with the major adviser from those disciplines.

To support its academic quality and to strengthen interdisciplinary work, the department's research excels in the areas of convex geometry and the analysis of nonlinear partial differential equations arising from gauge field theory.

MISSION STATEMENT

The mission of the Department of Mathematics is to develop and implement innovative teaching strategies designed to help each student understand fundamental mathematical concepts and to use these concepts to excel in subsequent science and engineering courses.

DEGREES OFFERED

Bachelor of Science

- Mathematics

Master of Science

- Mathematics

Doctor of Philosophy

- Mathematics

CONTACT INFORMATION

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E-mail: chair@math.poly.edu
Web: www.math.poly.edu

FACULTY

PROFESSORS

Keith Ball, Professor of Mathematics
PhD, Cambridge University
Functional analysis, combinatorics, convexity

Erwin Lutwak, Professor of Mathematics, Department Head
PhD, Polytechnic University
Geometric analysis

Edward Y. Miller, Professor of Mathematics
PhD, Harvard University
Differential topology

Deane Yang, Professor of Mathematics
PhD, Harvard University
Geometric analysis

Yisong Yang, Professor of Mathematics
PhD, University of Massachusetts at Amherst
Partial differential equations, mathematical physics

Gaoyong Zhang, Professor of Mathematics
PhD, Temple University
Geometric analysis

ASSOCIATE PROFESSORS

Juan Carlos Álvarez-Paiva, Associate Professor of Mathematics
PhD, Rutgers University
Symplectic and Finsler geometry

Kathryn Kuiken, Associate Professor of Mathematics
PhD, Polytechnic University
Complex analysis, group theory

Joel C. W. Rogers, Associate Professor of Mathematics
PhD, Massachusetts Institute of Technology
Partial differential equations, fluid mechanics, numerical methods

INDUSTRY FACULTY

David V. Chudnovsky, Distinguished Industry Professor of Mathematics
PhD, Institute of Mathematics,
Ukrainian Academy of Science
Theoretical mathematics: number theory, partial differential equations, Hamiltonian systems. Mathematical physics: field theories, quantum systems. Computer science: computer algebra and complexity, large-scale numerical mathematics, parallel computing and digital signal processing

Gregory V. Chudnovsky,
Distinguished Industry Professor of Mathematics
PhD, Institute of Mathematics,
Ukrainian Academy of Science
Number theory: analytic number theory, diophantine approximations and transcendence theory. Mathematical physics: nonlinear equations, quantum and classical fields. Computer science: computer algebra and complexity, large-scale numerical mathematics, parallel computing and digital signal processing

Chandni Shah, Industry Associate Professor of Mathematics, Deputy Head for Undergraduate Studies
PhD, University of Texas at Austin
Commutative algebra

LECTURER

Zsuzsanna Gönye, Lecturer of Mathematics, Director of Freshman Mathematics
PhD, Stony Brook University
Complex analysis

INSTRUCTORS

Carolyn D. King, Instructor of Mathematics
MA, New York University
Mathematics education

Harvansh Manocha, Instructor of Mathematics
PhD, Panjab University (India)
LIE groups and special functions

Alina Stancu, Instructor of Mathematics
PhD, University of Rochester
Geometric analysis

Lindsey Van Wagenen, Instructor of Mathematics
PhD, Columbia University
Applied physics

ADJUNCT FACULTY

Kirby Brown, Adjunct Lecturer of Mathematics
BA, BS, College University of New York, Queens College

Oleg Friedman, Adjunct Lecturer of Mathematics
MS, Samarkand State University (Uzbekistan)
Quantitative finance, artificial intelligence, functional analysis

Boris Ganelin, Adjunct Lecturer of Mathematics
BS, Polytechnic University

Amakoe Gbedemah, Adjunct Lecturer of Mathematics
MA, College University of New York, Queens College

Rachel Jacobovits, Adjunct Lecturer of Mathematics
MS, Polytechnic University
Operations research

Michel P. Lobenberg, Adjunct Professor of Mathematics
PhD, Columbia University
Pseudo-differential operators, mathematical physics

Sudhakara Mishra, Adjunct Lecturer of Mathematics
PhD, City University of New York
Number theory, algebraic topology, statistics, 3D graphics, pattern recognition, medical imaging, diagnostics algorithms

Tom Pranayanuntana, Adjunct Lecturer of Mathematics
PhD, Polytechnic University
Elliptic Brunn-Minkowski theory

Dorjan Puleri, Adjunct Lecturer of Mathematics
BS, Polytechnic University

Penina Roberg-Orenstein, Adjunct Professor of Mathematics
PhD, Middlesex University (England)
Optimization, mathematical modeling, game theory, wireless communications

Hanna A. Ulman, Adjunct Professor of Mathematics
MA, Tel-Aviv University (Israel)
Real analysis

EMERITI FACULTY

George Bachman
Heinrich Guggenheimer
Leon Herbach
Harry Hochstadt
Burton Lieberman
Clifford W. Marshall
Lesley Sibner
Andrew J. Terzuoli
Hermann Waldinger
Georges Weill
Erich Zauderer

DEPARTMENT OF MECHANICAL, AEROSPACE AND MANUFACTURING ENGINEERING

Head: Said Nourbakhsh

Mechanical, aerospace and manufacturing engineers design and build the modern products and processes that society needs. The wide range of dynamic and continually evolving areas where such engineers are the prime movers of innovation and change include bioengineering, energy systems, aircraft, aerospace, environmental engineering, controls for mechanical systems, mechanical-electrical devices, automobiles, materials engineering, automated manufacturing, structural engineering, robotic systems, fluidic systems and devices, production planning and control and combustion processes and systems.

MISSION STATEMENT

The mission of the Department of Mechanical, Aerospace and Manufacturing Engineering is to prepare its students for professional development, life-long learning and contributions to society. Add value to the student's market/career potential by an emphasis on (a) understanding the physical world through project, tools, and practice, and (b) providing the foundation tools for leadership.

DEGREES OFFERED

Bachelor of Science

- Mechanical Engineering
(Concentration in Aerospace Engineering available)

Master of Science

- Industrial Engineering
- Manufacturing Engineering
- Materials Science
- Mechanical Engineering
(Concentrations in Mechanical Analysis/Design, Systems/Controls/Robotics and Thermal/Fluids)

Doctor of Philosophy

- Mechanical Engineering
(Concentrations in Aerospace, Materials Science, Mechanical Analysis/Design, Systems/Controls/Robotics and Thermal/Fluids)

Graduate Certificates

- Achieving World Class Quality
- Industrial Engineering
- Manufacturing Engineering and Production Science
- Manufacturing Excellence by Design: Holistic Approach

CONTACT INFORMATION

Rogers Hall, Room 502

Tel: 718-260-3160

Fax: 718-260-3532

E-mail: maiming@www.poly.edu

Web: <http://mechanical.poly.edu>

THE DEPARTMENT

The Department of Mechanical, Aerospace and Manufacturing Engineering offers students diverse and multidimensional programs that address fundamental understanding of the underlying sciences, design methodology, manufacturing processes, methods and techniques, material properties and economic and industrial implications. These programs are discussed in the individual sections related to the mechanical, industrial, manufacturing engineering and materials science programs. The undergraduate degree is accredited by the Engineering Accreditation Commission (AEC) of the Accreditation Board of Engineering and Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012-telephone: 410-347-7700 The doctoral degree is approved by the New York State Doctoral Program Review.

DEGREE PROGRAMS

The department offers programs in mechanical engineering, manufacturing engineering, industrial engineering and materials science. The undergraduate program in mechanical engineering allows students to: (1) acquire the fundamental principles in mechanical engineering, mathematics and the sciences, which provide a foundation for and inspire professional development; (2) understand the interrelationship of technology and social and ethical issues; (3) formulate, analyze and design thermal and mechanical components and systems; (4) skillfully use modern engineering tools; (5) work in and lead multi-disciplinary teams; and (6) communicate effectively.

Students are encouraged to join Polytechnic's student chapters of the American Society of Mechanical Engineers (ASME), American Institute of Aeronautics (AIAA), National Society of Black Engineers (NSBE), Society of Women Engineers (SWE) and Society of Automotive Engineers (SAE), as well as honor societies (Pi Tau Sigma for mechanical engineers and Tau Beta Pi for engineers in general).

The department offers graduate programs in Mechanical Engineering, Manufacturing Engineering and Industrial Engineering. Specific information about these programs may be found in the programs section of the catalog.

FACULTY

PROFESSORS

Sunil Kumar, Professor of Mechanical Engineering
PhD, University of California at Berkeley
Thermal fluid sciences, applied mathematics

William R. McShane, Professor of Mechanical and Systems Engineering, Director of Manufacturing and Industrial Engineering Programs
PhD, Polytechnic University
Quality control, controls and simulation, engineering economics

Said Nourbakhsh, Professor of Materials Science, Department Head
PhD, Leeds University (England)
Phase transformation, electron microscopy, mechanical behavior, composite materials, smart materials, ferro-electric thin films

M. Volkan Ötügen, Professor of Mechanical Engineering
PhD, Drexel University
Experimental and theoretical fluid mechanics, unsteady and turbulent flows, optical diagnostics, combustion aerodynamics

Sung H. Whang, Professor of Materials Science
DEngSc, Columbia University
Mechanical properties and microstructure of nanostructured materials, titanium aluminides, intermetallic compounds, processing and properties of rapidly solidified materials, characterization of electronic materials and ceramic superconductors

ASSOCIATE PROFESSORS

Iraj M. Kalkhoran, Associate Professor of Aerospace Engineering
PhD, University of Texas at Arlington
Gas dynamics, high speed flows, wind tunnel testing, shock tubes

Vikram Kapila, Associate Professor of Mechanical Engineering
PhD, Georgia Institute of Technology
Linear/nonlinear control with applications to robust control, saturation control, closed-loop input shaping, distributed spacecraft formation flying, spacecraft attitude control and mechatronics

Richard S. Thorsen, Associate Professor of Mechanical Engineering, Vice President for Development and University Relations
PhD, New York University
Heat transfer, nuclear reactor safety, solar energy

George C. Vradis, Associate Professor of Mechanical Engineering
JD, Brooklyn Law School
PhD, Polytechnic University
Computational fluid dynamics and heat transfer, non-Newtonian flows, flow measurement, combustion, energy systems

ASSISTANT PROFESSORS

Nikhil Gupta, Assistant Professor of Mechanical Engineering
PhD, Louisiana State University
Micro- and nano-composite materials/mechanics

INDUSTRY FACULTY

Michael Greenstein, Industry Professor of Mechanical Engineering
MBA, University of Louisville
Design for manufacturability

Blair R. Williams, Industry Professor of Mechanical Engineering
MBS, University of Chicago
Computer integrated manufacturing

ADJUNCT FACULTY

Joseph Boroweic
PhD, Polytechnic University
Finite elements, numerical methods

Ali Vedavarz
PhD, Polytechnic University
HVAC

Paul Kadar
MS, Polytechnic University
Computer-aided design

Israel Aran
MS, Polytechnic University
Industrial design

David Soukup
MS, University of Tennessee
Factory simulation, project planning and control

FACULTY EMERITI

Philip Abrami, Professor Emeritus
MS, Polytechnic University

Vito D. Agosta, Professor Emeritus
PhD, Columbia University

Anthony E. Armenakas, PE, Professor Emeritus
PhD, Columbia University

William B. Blesser, Professor Emeritus
MEE, Polytechnic University

Martin H. Bloom, Institute Professor
PhD, Polytechnic University

Irving B. Cadoff, Professor Emeritus
DEngSc, New York University

Louis S. Castleman, Professor Emeritus
ScD, Massachusetts Institute of Technology

John R. Curreri, Professor Emeritus
MEE, Polytechnic University

Carmine D'Antonio, Professor Emeritus
MMetE, Polytechnic University

George J. Fischer, Professor Emeritus
MMetE, Polytechnic University

Joseph Kempner, PE, Professor Emeritus
PhD, Polytechnic University

Jerome M. Klosner, PE, Professor Emeritus
PhD, Polytechnic University

Harold Margolin, Professor Emeritus
DEngSc, Yale University

Gino Moretti, Professor Emeritus
PhD, University of Turin (Italy)

Wheeler K. Mueller Jr., Professor Emeritus
PhD, University of Illinois

Sharad A. Patel, Professor Emeritus
PhD, Polytechnic University

Bernard W. Shafer, PE, Professor Emeritus
PhD, Brown University

William P. Vafakos, PE, Professor Emeritus
JD, Brooklyn Law School
PhD, Polytechnic University

PART 3

ACADEMIC PROGRAMS



A BRIEF GUIDE TO COURSE DESCRIPTIONS

Each program described in this catalog contains detailed descriptions of the courses offered within the program. A sample course description follows:

MA 123 Experimental Design

2½:1½:0:4

Principles of modern statistical experimentation, including practice using 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) that *must* have been completed before registering for the described course. “Co-requisites” are courses taken concurrently with the described course.

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.

ACCELERATED MANAGEMENT OF TECHNOLOGY PROGRAM

Program Director: Nina D. Ziv

The Accelerated Management of Technology (AMOT) Program is a one-year, full-time intensive program in the management of technology, designed for participants who are recent college graduates or those who are in the early stages of their careers and want to pursue a degree in technology management. The aim of the AMOT program is to develop managers who are able to integrate their knowledge of technology and management and assume leadership positions in established firms as well as new ventures. The curriculum emphasizes innovation in various settings, new business models, strategic management issues and global management issues. Along with traditional courses in technology management and innovation, the AMOT program includes specialized modules in selected topics, internships as well as a study abroad module.

Courses for the AMOT program are held during the day in lower Manhattan at 55 Broad Street. Participants in the AMOT program receive a Master of Science in Management of Technology (MOT).

PROGRAM PHILOSOPHY

The AMOT Program is based on a cohort system in that all participants enter at the same time and take the same sequence of courses throughout the program, except where choices may be offered such as in the mini-modules. The cohort system is an intrinsic part of the philosophy of the program and is essential for developing a cohesive group of participants. It enables participants to establish relationships with one another and easily develop project teams, and promotes a sense of camaraderie among the participants.

PROGRAM STRUCTURE AND CURRICULUM

The AMOT Program has a trimester structure. Participants take a total of 36 units to complete the degree program. While the majority of courses in the curriculum are traditional stand-alone courses, because of the unique nature of the program, specialized modules in technology management as well as field work and/or internships are part of the curriculum.

MINI MODULES

One of the curricular features of the AMOT programs are courses in which selected topics from a particular subject area are covered in a short period of time. The AMOT curriculum has three such courses (i.e., mini modules), which focus on topics that enrich the study of technology management. Such modules take place during the semester or between semesters.

CAPSTONE PROJECT

An important aspect of the AMOT curriculum is the capstone project in which participants work with faculty on in-depth case studies and research related to technology management. The capstone project might entail an internship at a firm in the metropolitan area.

A COMMUNITY PERSPECTIVE

One of the major goals of the AMOT program is to develop a community of learners that extends to strategic partners, faculty, participants, colleagues around the world, industry leaders and networks of people who can be called upon to enrich the experiences of the participants as well as of others in the community. The Institute for Technology and Enterprise (ITE), located at 55 Broad Street, which has served as a focal point for building managerial knowledge and developing learning programs particularly suited to technology-intensive settings, is a major partner in developing this community. ITE is already committed to the executive master's programs and has a strong and mutually reinforcing relationship with these programs.

A GLOBAL PERSPECTIVE

Because of the trend toward a more global view of business, it is important to have an international component in this program. Along with their regular curriculum, AMOT program participants will study at a location outside of the United States during part of the module on global innovation. Locations under consideration include India, France and Korea.

FACULTY

The faculty for the AMOT program includes full-time faculty from the Department of Management, faculty members from universities abroad and other experts who give specialized courses in their field. In addition, practi-

tioners from the field are regularly invited to participate in seminars and other events designed to enrich the participants' experiences.

ADMISSIONS CRITERIA

The AMOT program is selective. Candidates must have an undergraduate degree from an institution of higher learning either in the United States or abroad. Candidates are required to have a minimum of a 3.0 grade-point average or equivalent in their undergraduate degree. Candidates are required to take the Graduate Management Admission Test (GMAT). International students are required to take the TOEFL exam.

AMOT CURRICULUM

Please see the Management of Technology (MOT) program in this catalog for course listings

Semester I		units
MG 609	Managerial Accounting and Finance	3
MG 865	Managing Innovation	3
MG 603	Organizational Behavior and Management Processes in Innovative Corporations	3
MG 693	Information Technologies, Systems and Management in Organizations	3

Semester II		units
MG 607	Marketing	3
MG 608	Managerial Economics and the Economic Environment	3
MG 792	Operations Management for Knowledge Based Enterprises	3
MG 795	Global Innovation (includes study-abroad module)	3
	Mini Module I	1½

Semester III		units
MG 774	Advanced Trends in Technology Management & Innovation	3
MG 950	MOT Capstone Project/Internship	3
MG 785	High Tech Leadership	1½
	Mini Module II	1½
	Mini Module III	1½

Examples of Mini Modules

MG787	Intellectual Property for Technology and Information Managers
MG820	Project Management
MG786	High Tech Entrepreneurship
MG784	Negotiation in Technology Intensive Sectors
MG782	Competitive Information Strategies

For more information on the program, please contact Professor Nina D. Ziv, AMOT Program director, 55 Broad Street, Suite 13B, New York, NY 10004; 718-260-3817.

BIOINFORMATICS PROGRAM

Academic Adviser: Kalle M. Levon

Bioinformatics is a relatively new branch of science that organizes and interprets the overwhelming amount of data recently available on living organisms as a result of the human genome project and follow-up projects. The need for this branch of science is very real; while it is becoming increasingly simple to obtain experimental information on DNA, RNA and protein sequences and expression levels, the interpretation of this information is far from straightforward. There is a critical scarcity of individuals with the training in biology, chemistry, computer science and the specific methods of bioinformatics to interpret this data. The need is very real in academia and especially in industry. The need for individuals with a focused expertise in bioinformatics emerged a few years ago and is growing rapidly.

Polytechnic's MS in Bioinformatics is designed to provide a solid, carefully tailored program of study. It is responsive to the needs of (1) persons with BS degrees seeking entry into the field and (2) persons with advanced degrees who may be employed in sectors that now value and require such expertise. The latter typically have primary (PhD level) expertise in chemistry, molecular biology or chemical modeling, and may be employed in the biotechnology or pharmaceutical sectors. A master's program, with flexible on-site requirements and extensive use of Web-based or other remote-access training concepts, such as multimedia instruction, addresses the needs of both groups.

The curriculum is flexible, allowing sufficient exposure to and mastery of computer science skills to enable students to be effective in their home environments or competitive in the job market. In addition to traditional computer science, students gain expertise with such commercial databases as Oracle and Psibase, in addition to theory and hands-on experience with widely used methods in bioinformatics, including dynamic programming, profiles, hidden Markov chains and neural nets to predict protein secondary structure.

GOALS AND OBJECTIVES

The Master of Science program in Bioinformatics is a crucial component in offering a mechanism to train individuals seeking reassignment to fast growing bioinformatics positions within the pharmaceutical or biotechnological industries. The goal of the MS program is to fill the present educational needs with flexible on-site requirements and extensive use of web-based or other remote-access training concepts such as multimedia instruction. In addition to the traditional computer science components, the program entails training in commercial databases and exposure to theory and to hands-on experience with widely used methods in bioinformatics such as dynamic programming, profiles, hidden Markov chains and neural nets to predict protein secondary structure. Thus, the basic understanding of sequence analysis, protein structure prediction and the structure/function relationship are the core educational goals.

REQUIREMENTS FOR THE MASTER OF SCIENCE

The Master of Science degree is intended for students from various backgrounds seeking depth knowledge in informatics in chemical and biological sciences.

Admission to the master's program requires a bachelors' degree from an accredited institution, with superior undergraduate academic record with completion of all prerequisite courses. Students not meeting all these requirements will be considered for admission on an individual basis and may be admitted subject to completing appropriate undergraduate courses to remove deficiencies.

Applicants who are otherwise sufficiently prepared for admission without undergraduate deficiencies may nevertheless be required to take specified undergraduate and introductory level graduate courses. Such courses count towards a master's degree.

To satisfy the requirement for the degree Master of Science, students must complete a total of 36 units and hold an overall B grade in all graduate courses. Students must take all four of the required

core courses and at least two of the basic core courses. The knowledge in all basic core courses is required, thus all these courses are required only when such knowledge can not be proven. Computational proficiency is expected.

Students may elect research and a thesis (12 units). An oral defense of the thesis is held after the typed written thesis has been submitted. A grade of A or B is required. Students not electing to write a thesis may elect to take from 3 to 6 units of guided studies (BI 871, BI 872) with submission of a written report. Electives can be selected from the existing courses.

Main Courses for the MS degree:

Basic Core Courses		Units
BI 751	Chemical Foundation for Bioinformatics	3
BI 752	Biological Foundation for Bioinformatics	3
MA 5414	Stringology: Mathematics of String Comparisons in Computational Biology	4
CM 5714	Molecular Modeling and Simulation	4

Required Core Courses		Units
BI 753	Bioinformatics I: Sequence Analysis	3
BI 754	Bioinformatics II: Protein Structure	3
BI 755	Bioinformatics III: Functional Prediction	3
BI 756	Cheminformatics	3

GRADUATE COURSES

BI 751 Chemical Foundation for Bioinformatics *2 1/2:0:0:3*

An intensive review of those aspects of organic chemistry and biochemistry necessary to begin research in bioinformatics and to enter graduate courses in biology. Covalent bonding, quantum mechanical basis of bond formation, three-dimensional structure of molecules, reaction mechanisms, catalysis, polymers, enzymes, thermodynamic and kinetic foundations, metabolic pathways, sequence and structure of macromolecules. This course makes extensive use of computer approaches to convey the essential computational and visual nature of material to be covered. *Prerequisites:* CM102, general chemistry, general physics, organic chemistry and calculus.

BI 752 Biological Foundation for Bioinformatics 2½:0:0:3

An intensive review of those aspects of biochemistry, molecular biology and cell biology necessary to begin research in bioinformatics and to enter graduate courses in biology. Areas covered include cell structure, intracellular sorting, cellular signaling (receptors), Cytoskeleton, cell cycle, DNA replication, transcription and translation. This course makes extensive use of computer approaches to convey the essential computational and visual nature of the material to be covered. *Prerequisites: CM102, general chemistry, general physics, organic chemistry, calculus or instructor's permission.*

BI 753 Bioinformatics I: Sequence Analysis 1½:2:0:3

Computer representations of nucleic acid and protein sequences, pairwise and multiple alignment methods, available databases of nucleic acid and protein sequences, database search methods, scoring functions for assessment of alignments, nucleic acid to protein sequence translation and codon usage, genomic organization and gene structure in prokaryotes and eukaryotes, introns and exons, prediction of open reading frames, alternative splicing, existing databases of mRNA, DNA protein and genomic information. An overview of available programs and of resources on the web. Lab is an integral part of this course.

BI 754 Bioinformatics II: Protein Structure 1½:2:0:3

Protein folding representations, databases of protein folding classes, secondary structure prediction, tertiary structure prediction via computer folding experiments threading, and homology model building, prediction of post translation modification sites, active and binding sites in proteins, representations of contiguous and non-contiguous epitopes on protein surfaces at the sequence level, representations of functional motifs at the three dimensional and at the sequence level. Lab is an integral part of this course. *Prerequisite: BI 753.*

BI755 Bioinformatics III: Functional Prediction 1½:2:0:3

Functional classifications of proteins, prediction of function from sequence and structure, Orthologs and paralogs, representations of biological pathways, available systems for the analysis of whole genomes and for human-assisted and automatic functional prediction. Lab is an integral part of this course. *Prerequisite: BI 754.*

BI 756 Chemoinformatics 1½:2:0:3

Review of Database Theory, Chemical Structure Representation; connection tables, line notations, structure diagrams, Representations of Chemical Reactions, Structure manipulation: Graph Theory, Structure Analysis: ring perception, structural fingerprints, symmetry perception, Molecular Modeling Algorithms, Genetic Algorithms, Simulated Annealing, QSAR historical approaches, Structural Search of Chemical Databases, Commercial Chemical Information Databases, Combinatorial Chemistry and diversity assessment.

BI 757 Special Topics in Bioinformatics Presentation at intervals of various advanced or specialized topics in chemo- or bioinformatics.

BI758/9 Guided Studies in Bioinformatics as arranged

BI 760 Research in Bioinformatics as arranged

Original research, which serves as basis for master's degree. 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 have passed required oral examinations. Research credits registered for each semester realistically reflect time devoted to research. *Prerequisites for MS candidates: degree status and consent of graduate adviser and thesis director.*

CM 5714 Molecular Modeling and Simulation 3:3:0:4

Introduces students to principles and applications of modern molecular modeling and simulations methods, using commercially available software packages on powerful computer workstations. Algorithms for visualization and prediction of structural and physical properties of molecules and molecular aggregates are taught, based on the principles of quantum, classical and statistical mechanics, which will be reviewed in a mathematically simplified form. The accompanying laboratory part focuses on acquiring practical skills in application of commercial software packages to illustrative problems in physical chemistry, chemical engineering, biology and medicine. *Prerequisites: completion of core undergraduate courses in mathematics and science (grade C or better) in CM, CH, ME, EE, CS, PH, CE or equivalent.*

MA 5414 Stringology: Mathematics of String Comparisons in Computational Biology 3:3:0:4

Addresses basic combinatorial problems of string manipulation - string matching, string editing, string distance computations, arising from areas of text processing, computational biology and genomics. Classical, modern and entirely new approaches to these problems will be presented with all necessary mathematical and computer science backgrounds. Emphasis is on practical and effective algorithm implementations.

BIOMEDICAL ENGINEERING PROGRAM

Academic Director: Richard A. Gross

THE MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

GOALS AND OBJECTIVES

The primary goal of the MS in Biomedical Engineering Program is to provide students with an in-depth, advanced education that gives them the tools needed to perform fundamental and applied research in biomedical engineering. Alternatively, students gain the requisite technical knowledge that they may wish to apply to management, marketing, sales and other entrepreneurial activities related to biomedical engineering.

Specific objectives include:

- To enroll students who have a BS or a more advanced degree in any engineering discipline, mathematics or in any of the natural sciences
- To provide students with a cutting-edge program that integrates engineering, biological and medical sciences. Students will acquire the skills to participate in technological innovations that provide people with longer, healthier and more productive lives
- To merge the leadership and talents found at Polytechnic in chemistry, engineering and computer science with the expertise in medical sciences at SUNY Downstate Medical Center
- To give students an opportunity to focus on topics that include biomedical instrumentation, biomaterials and therapeutic systems, bioinformatics and biomolecular engineering
- To give students the option of doing research in the laboratories at Polytechnic and/or SUNY Downstate Medical Center. Students may also substitute research credits with course electives

In the years ahead, health and human productivity can be vastly improved through major advances in medicine. These advances will happen through the successful, seamless integration of biology and modern engineering. Scientists antic-

ipate future breakthroughs ranging from the design of drugs customized to an individual's genome to the perfection of artificial implantable organs. Aggressive and intelligent integration of engineering and the biological and medical sciences will hasten the realization of these and other innovations, leading to longer, healthier and more productive lives. Scientists can now visualize structures inside the body with a level of clarity thought impossible only a decade ago. With the improved diagnosis that comes from these advances and those that will follow, further discoveries in the area of treatment will be added.

Today, miniature devices can be manipulated through endoscopes, making it possible to perform surgical procedures with minimal invasion and thus minimal trauma to the patient. In the future, the microfabrication of biomedical devices at Polytechnic and elsewhere will further enable surgery and increase the functionality of the physically impaired in applications ranging from congenital defects to improving the function of major organs, such as the heart, kidneys and liver. Other areas show similar promise—breakthroughs in human tissue research point to the possibilities of replacing damaged or diseased bone, cartilage, and other tissues with newly engineered materials. Bioresorbable materials will substitute for permanent implants allowing recovery of tissues with subsequent clearance from the system of the degraded implant material. New imaging systems are emerging that provide new information and monitoring possibilities. Wireless technology will integrate into medical devices and home-care systems. There is little doubt that these and other extraordinary developments will dramatically impact lives over the next few decades.

By merging the leadership and talents found at Polytechnic in chemistry, engineering and computer science with the expertise in biomedical sciences at the SUNY Downstate Medical Center, the University is well positioned to offer a cutting-edge program with a broad range of opportunities to its students. The partnership between Polytechnic and SUNY

Downstate is dedicated to this new mode of biomedical education, and to the development of students with both practical and fundamental knowledge. Students will have the opportunity to move freely between the University and SUNY Downstate, taking advantage of both facilities, their faculty and associated research programs. In some cases, courses will be team-taught by faculty from both locations. The outcome is the creation of courses of superior quality. Polytechnic's goal is to provide students with the best in classroom and laboratory education to give them the skills to succeed in the wide range of opportunities that will be open to them upon graduation.

A Perfect Formula for a Successful Biomedical Engineering Program

The recent strategic alliance between SUNY Downstate Medical Center and Polytechnic University created the framework that has resulted in Downstate's important contribution to Polytechnic's Masters of Science in Biomedical Engineering Program. The two institutions have coextensive research interests with complementary technological expertise. Noteworthy common areas of scientific investigation include:

- Telemetry
- Neurorobotics
- Optical imaging
- Bioresorbable Biomedical Materials
- Drug Delivery Systems
- Tissue Engineering
- Microchip Sensors
- Biosensors

FULL AND PART-TIME STUDENTS

Students entering this master's program may wish to complete the degree rapidly by taking a full course load, or proceed at a slower pace if they are working professionals with other full or part-time commitments. The curriculum structure and class schedule for this program were constructed to accommodate both part-time and full-time students. Thus, most of the 3-credit courses offered are given as two-and-a-half hour lectures one evening per week during the semester. Evening research opportunities are also available.

ADMISSION AND DEGREE REQUIREMENTS

The Master of Science degree is intended for students from various backgrounds seeking in-depth knowledge in biomedical engineering. Students may apply to the master's program if they have one or more of the following: (1) BS or a more advanced degree in any engineering discipline, (2) BS or more advanced degree in mathematics or (3) BS or more advanced degree in any of the natural sciences.

Admission into the program may be contingent upon the student satisfying certain course work that is deemed necessary for the student to succeed in the MS in Biomedical Engineering program. For example, in most cases students with a BS in Biology will be asked to take MA 1132 Numerical Methods for Calculus, MA 2012 Elements of Linear Algebra I and MA 2132 Ordinary Differential Equations. Alternatively, they can satisfy this admission requirement if they have already completed these courses or their equivalent. A program adviser will review with successful applicants what undergraduate courses, if any, must be taken. Such courses will not count towards the master's degree. In addition, students may enter the program with sufficient background knowledge so that they can petition the program director to waive the Program Bridge Courses.

THE CURRICULUM

To satisfy the requirement for the MS in Biomedical Engineering, students must complete a minimum of 36 units of courses, with an overall average of B in all graduate courses, as required by the University.

Two tracks have been established to accommodate entrance of students with formal undergraduate biology, mathematics or engineering training and bachelor's degrees. This is accomplished by "bridge" courses that are specially designed to meet the individual needs of students who come to the program from different backgrounds.

Students may elect BE 871/872 Thesis Research in Biomedical Engineering (6 units). An oral defense of the thesis is held after the typed written thesis has been submitted. A grade of A or B is required. Students not electing to write a thesis may elect to take BE 873/874 Guided Studies in Biomedical Engineering (6 units) and submit a writ-

ten report. Alternatively, a student may substitute BE 871/872 or BE 873/874 with electives chosen from the list of electives given below. Students who do not plan further graduate studies are recommended to take the MS in Biomedical Engineering Program without Thesis.

In consultation with their academic adviser, students should define a plan of study that satisfactorily meets University requirements. The program 36 units may be taken from Bridge Courses, Core Courses, Track Courses, a Guided Studies or Thesis Option and Recommended Technical Electives. The division of credits between these different components of the program is as follows:

6 units of Bridge Courses
12 units of Core courses
6 units of Track courses

The remaining 12 units may be taken from:

(a) A combination of 6 units of Guided Studies or Thesis Option and 6 units of the Recommended Technical Electives
(b) 12 units of the Recommended Technical Electives

At least 21 of the 36 units must be taken from biomedical engineering or other engineering courses.

Bridge Courses

Required courses for students entering with a Bachelor of Science in any scientific or mathematical discipline:

CH 615 Applied Mathematics in Chemical Engineering
BE 616 Transport Phenomena in Biological Systems

or

Required course for students entering with a bachelor's degree in any engineering discipline:
CM 950 Principles of Biological Systems

Core Courses

Required courses for all students in the MS in Biomedical Engineering Program:

BE 625 Biosensors
BE 650 Biomedical Instrumentation I
BE 630 Bio-optics
BE 670 Materials in Medicine

Track Courses

Students in the Biomedical Engineering Program are required to take the two courses in either the (1) Biomedical Instrumentation Track or the (2) Biomaterials and Therapeutic Systems Track. In addition, students in the pro-

gram may choose to select courses from the other track as part of the elective course options.

1. Biomedical Instrumentation

BE 620 Biomedical Imaging I
BE 621 Biomedical Imaging II

2. Biomaterials and Therapeutic Systems

CM 792 Natural Polymers and Materials
BE 660 Drug Delivery

Total units satisfied prior to taking electives and/or guided studies/thesis research: 24

Recommended Technical Electives

Twelve additional units must be selected from the following technical electives. Of these, 3 or 6 of the units may be selected from the remaining track courses. The student may choose to take 6 of their remaining units by doing either the Guided Study or Thesis for Bioengineering Option. In choosing technical electives, students must make selections so that a minimum of 21 of the total 36 units taken for the master's degree are in biomedical engineering or another engineering discipline. Some of the technical electives below may have prerequisites or requirements associated with their corresponding specialization. Students may be permitted to take other technical electives at the discretion of the program director.

Guided Study/Thesis Option

BE 871/872 Guided Studies in Biomedical Engineering
BE 873/874 Thesis for Bioengineering

Bioinformatics

CM 53 Bioinformatics I: Sequence Analysis
CM 754 Bioinformatics II: Protein Structure
CM 755 Bioinformatics III: Functional Prediction

Molecular Engineering

CM 905 Enzyme Catalysis in Organic Synthesis
CM 906 Combinatorial Chemistry
CM 5714 Molecular Modeling and Simulation
BE 660 Drug Delivery*

Materials

CM 792 Natural Polymers and Materials*
CM 771 Introduction to Polymer Science
CM 782 Macromolecules in the Solid State
MT 600 Structure-Property Relationships in Materials
MT 620 Plastic Deformation and Fracture

Instrumentation

BE 620 Biomedical Imaging I*
BE 621 Biomedical Imaging II*
MT 603 Introduction to Electron Microscopy
EL 611 Signals, Systems and Transforms
EL 522 Sensor Based Robotics
EL 621 System Theory and Feedback Control I

Biosystems

CM 941	Biochemistry
CM 952	Molecular and Cellular Biology
BE 601	Molecular immunology
BE 610	Cellular and Molecular Neuroscience
BE 616	Transport Phenomena in Biological Systems**

* If not taken as a Track Course.

**If not taken as a Bridge Course.

ADVANCED CERTIFICATE PROGRAMS

The Biomedical Engineering Program administers two certificate programs: (1) Biomedical Materials and (2) Bioinstrumentation.

The Advanced Certificates in Biomedical Materials and Bioinstrumentation is intended for students from various backgrounds seeking in-depth knowledge in a specialty area within Biomedical Engineering. Students may apply to the certificate program if they have one or more of the following: (1) BS or a more advanced degree in any engineering discipline, (2) BS or more advanced degree in mathematics and/or (3) BS or more advanced degree in any of the natural sciences. The program adviser reviews with successful applicants any pre-requisites that may be required for successful completion of the certificate courses.

A certificate program requires five courses (15 units), designed for working professionals who seek advanced training in a specific subject area within the Biomedical Engineering Program. Three of the courses are required, and two courses may be selected according to the individual needs of the student. Students must have an average of B or better in all graduate courses. No more than 3 of the 15 units may be taken outside this program. Such courses taken outside are not used to compute the student GPA in this certificate program.

Upon completion of a sequence with an average grade of B or better, students are issued Advanced Certificates. Those who choose to work towards the master's degree in biomedical engineering are able, upon admission, to apply all courses taken toward a certificate toward fulfilling the degree program. Additional information may be obtained from the department.

To satisfy the requirement for the Advanced Certificate in Biomedical Materials, students must complete a minimum of 15 units.

1. Certificate Requirements for an Advanced Certificate in Biomedical Materials**Required:**

MT 600	Structure-Property Relationships in Materials
BE 660	Drug Delivery
BE 670	Materials in Medicine

Select two from the following:

CM 782	Macromolecules in the Solid State
CM 771	Introduction to Polymer Science
MT 620	Plastic Deformation and Fracture
CM 792	Natural Polymers and Materials

2. Certificate Requirements for an Advanced Certificate in Bioinstrumentation**Required:**

BE 620	Biomedical Imaging I
BE 625	Biosensors
BE 630	Bio-optics

Select two from the following:

BE 621	Biomedical Imaging II
BE 650	Biomedical Instrumentation I
MT 603	Introduction to Electron Microscopy
EL 611	Signals, Systems and Transforms
EL 621	System Theory and Feedback Control I

THE DOCTOR OF PHILOSOPHY IN BIOMEDICAL ENGINEERING

The primary goal of the PhD in Biomedical Engineering is to provide students with an in-depth, advanced education that will give them the tools needed to perform fundamental and applied research in biomedical engineering. Alternatively, students will gain the requisite technical knowledge that may wish to apply to management, marketing, sales and other entrepreneurial activities related to biomedical engineering.

Specific Objectives include:

- To allow students entrance into the program that have a BS or a more advanced degree in any engineering discipline, BS or more advanced degree in mathematics, or a BS or more advanced degree in any of the natural sciences.
- To provide students with a cutting-edge program that integrates engineering, biological and medical sciences. The result will be that students will acquire the requisite skills to participate in technological innovations that provide people with longer, healthier and more productive lives.
- To better accomplish the above, to merge the leadership and talents found

at the Polytechnic University in chemistry, engineering and computer science with the expertise in medical sciences at the Health Sciences Center at SUNY Downstate Medical Center.

- To give students an opportunity to focus on topics that include biomedical instrumentation, biomaterials and therapeutic systems, bioinformatics and biomolecular engineering.
- To give students the option of doing research in the laboratories at Polytechnic University and/or SUNY Downstate Medical Center. Students may also substitute research units with course electives.

STRUCTURE AND REQUIREMENTS FOR DEGREE COMPLETION:

While the MS in Biomedical Engineering consists of 36 course units, the PhD in Biomedical Engineering program consist of 46 course units, excluding the required thesis research, for the SUNY students and 90 units for Poly students. The program has three separate, entry-level pathways to accommodate students entering with a bachelor's degree in any of the following disciplines: (1) chemical engineering; (2) mechanical engineering, electrical engineering, computer science engineering or physics; and (3) chemistry, biology or premedical studies. By accommodating these students with varying academic backgrounds, we intend to further encourage communication, in keeping with the interdisciplinary nature of biomedical engineering. Students will be required to take at least one, but not more than two, of Polytechnic's management of technology courses. Students will be obliged to participate in a short course on responsible conduct in research, as required by the National Institutes of Health (NIH) for training grant funding joint institutionally; to participate in Journal Clubs; and to attend a the jointly sponsored SUNY/Poly Biomedical Engineering Seminar Series. The required PhD thesis research may be conducted under the supervision of a faculty member from either institution. We expect that these students will need five to six years to complete the doctoral program.

In keeping with the goal of preparing our graduates for the changing career marketplace, students will be required to complete two complementary laboratory rotations, each of approximately three

months' duration, prior to selection of a thesis laboratory. At least one rotation should be in an industrial setting; the other should be in an academic setting, i.e., in a laboratory of a Downstate Medical Center clinical department engaged in translational research, or in a basic science laboratory of either Polytechnic or Downstate. Both types of settings will provide mentor-based, individualized training of the highest quality. Both basic science and clinical faculty with active research and graduate school appointments may supervise rotations, and ultimately, thesis projects. Senior scientists in companies of the new Advanced Biotechnology Park, located adjacent to the Downstate campus, and in Poly's planned I/UCR & EP will be eligible for adjunct faculty status and, as such, may be supervisors of rotations and co-supervisors of thesis projects. In order to become a thesis supervisor, a sufficient level of extramural funding (i.e., grants, contracts or clinical revenues) must be demonstrated.

Regarding award of research units, Polytechnic awards minimum of 44 units for the required PhD thesis research (with a minimum of 36 units for courses, a total of 90 units for courses plus research), and therefore charges tuition for the same. SGS, in contrast, does not award research units and therefore does not charge tuition for the required thesis research, but the financial support for the student stipend comes from NIH grants in which stipend is overheaded. Thus the total expense for a doctoral student is approximately the same. But by adhering to the strategy mentioned in Section A (page 3, bottom of paragraph 2) in which matters of bookkeeping are in accordance with the regulations and culture of the campus at which the student is registered, the potential conundrum will be avoided. Specifically, candidates whose thesis research advisers are Polytechnic faculty will be required to register at Polytechnic and will accumulate a total of 90 units; whereas those candidates whose thesis research advisers are Downstate faculty will be required to register at Downstate and will accumulate only the 46 course units. The same joint PhD will be conferred regardless of the campus at which the student registers; the research requirements for all graduate students in the program are identical. 18 units is the minimum number of biomedical engineering course units needed with the total course credit amount.

Each student will be required to register for all of the courses through the standard registration process at student's own institution, irrespective of where the courses are actually held. The Registrars at each institution will keep accounts of the number of units taken by their PhD in Biomedical Engineering students at the alternate institution. Those units will be tallied at the close of every two academic years, or every other June.

A single qualifying examination, scheduled within the two first two years, is required to advance to candidacy for the PhD degree. Students must submit a formal application to take the exam during registration of the selected semester. The application should include the names of three or more faculty who are willing/assigned to serve on qualifying examination committee. Prior to the examination, the student will submit to the examination committee a short paper that is related to the potential thesis project. The students are encouraged to submit this in the form of a grant application that would be appropriate for the field of interest (NSF, NIH) and the paper should be limited to 15 pages or less. The examination is not intended to describe preliminary results, but rather to inform committee members of the scientific areas most relevant to student's research. The paper must be presented to the members of the committee at least one week prior to the examination. During the examination, questions from the committee will not necessarily be limited to the student's presentation, but may cover other aspects of the student's academic training up to that point. The intent of the student paper is to focus committee's attention and to make the members aware of the areas of interest in which the student might be expected to have particular interest. The Committee will consist of at least three members, one of whom must be a member or designee of the executive committee. The examination will be graded as high pass, pass or fail by majority vote. In the case of failure, the right to a second examination is the discretion of the executive committee and the graduate dean or associate dean from biomedical engineering of the campus at which the student is enrolled. The results of each student's examination will be delivered to the Graduate School, in writing, no later than one week following the exam.

PROGRAM ADMISSION

PhD in Biomedical Engineering applications will be reviewed by an admissions committee composed of faculty from both SGS and Polytechnic. Requirements for acceptance to the program will include (1) academic excellence, (2) interests congruent with those of program faculty, and (3) positive recommendations from former research advisers. All viable candidates will be interviewed by admissions committee member and faculty members whose research interests match those of the candidate, either in person or by a conference call.

Bachelor's level students accepted into the PhD in Biomedical Engineering will be expected to register at the campus where the faculty research best matches their own interests. While this early commitment to a research area is dissimilar to other doctoral programs at Downstate, it is essential given the early tuition and stipend obligations at Polytechnic. Students with an MS who wish to enter the PhD in Biomedical Engineering must be accepted by a faculty thesis adviser before they will be allowed to enroll.

Several years ago, the School of Graduate Studies began a concerted effort to recruit more students from groups that have been underrepresented in biomedical science. Enrollment, applicant pool and minority recruitment at both Downstate and Polytechnic are discussed in detail later in this document.

Thesis Research

BME 998-9 PhD Thesis Research in Biomedical Engineering 0.0

Procedures for academic advising, and for supervision and evaluation of students' progress through degree completion.

Members of an Executive Committee of each program track will monitor the individual student's progression through the PhD in Biomedical Engineering, as in the other doctoral programs at Downstate and Polytechnic. At each stage of a student's career it is important to determine if they are progressing at a rate sufficient for success as a doctoral candidate. This includes the successful and timely completion of course work and examinations. In addition, research progress will be monitored by a series of committees. To accommodate the changing needs of each student based upon his or her research

project, the composition of the committees is designed for flexibility. The following schedule is suggested:

Year 1: For students entering at the bachelor's level, the appropriate PhD in Biomedical Engineering track's Executive Committee will assign a member to each first year student until he/she chooses a thesis adviser.

Year 2: The qualifying examination committee will be formed. This committee will consist of three members, one of whom must hold a PhD in engineering.

Year 3: The thesis/advisory committee will be formed. This committee will consist of six members, selection of which will be based primarily on the area of the student's research. All attempts should be made to include at least two members from the student's qualifying exam committee; one member should be from the track executive committee (or a designee); one member should have a PhD in engineering; two members should be from a department other than the one in which the thesis adviser is affiliated. While the sixth member, an outside examiner, is currently required by Downstate's SGS to be present at the thesis predefense, they may also become involved in the proposal defense, at the student and adviser's invitation.

Year 4: The thesis/advisory committee, including the external member, will monitor student progress during the thesis predefense. Internal members of the thesis/advisory committee monitor the thesis defense; attendance by the external member at the thesis defense is optional.

Below is a chronological description of the process by which a student will progress from thesis proposal to thesis defense.

- 1) Student submits written version of thesis proposal to the committee two weeks in advance of the Oral Proposal Defense.
- 2) Oral Proposal Defense. This is a formal presentation by the student before the program's students and faculty.
- 3) Chair of committee writes a letter to student containing the committee's determination of the proposal defense (Acceptable, Acceptable with Modifications or Unacceptable). The letter should describe what experiments are

required for completion of the thesis work. This is a "contract" with the student.

4) Student submits written thesis to committee, including to the outside examiner, two weeks in advance of the Predefense of the thesis.

5) Predefense. Student must defend written document and respond to questions regarding research. (The format is "oral." A formal presentation on the part of the student is discouraged; a brief, informal presentation may occur if desired by the chairman.)

6) Chair of committee writes a letter to student containing the committee's determination of what changes are required for the final document.

7) Student submits final document to committee members two weeks prior to the defense, or one week if agreed upon by all committee members.

8) Defense. First there is a formal, public presentation by the student, with questions from the audience. Following the public presentation, the student meets privately with the committee members for questions. A decision is made by the committee in camera.

GRADUATE COURSES

Course descriptions of biomedical engineering courses as well as CM courses associated with the BS in Biomedical Engineering Program are given below. Other courses that are not described below but are listed in the biomedical engineering program can be found in the description of courses from their respective departments.

BE 601 Molecular Immunology

2'l:0:0:3

Familiarizes students with the body of research that forms the foundation of our present understanding of the molecular basis and the cellular interactions that regulate the immune responses. The principal tool of learning is the reading and discussion of research papers in immunology by a small group of students supervised by a faculty member who is active in the specific research area. The topics to be covered include antibody structure, B-cell development, T-cell structure and development, T-cell-MHC interaction, MHC structure and antigen processing, complement chemistry, complement and Fc receptor structure and

function, transplantation immunogenetics, mucosal immunology and allergic reactions. *Prerequisites:* CM 950 or its equivalent and undergraduate biochemistry.

BE 610 Cellular and Molecular Neuroscience

2'l:0:0:3

A comprehensive overview of cellular neuroscience that consists of 20 lectures and two exams. Course is roughly divided into three parts: (1) the physiology and biophysics of neurons; (2) neuronal signal transduction, gene expression and transport of RNA and protein; and (3) synaptic transmission and plasticity. The textbook is *Fundamental Neuroscience* by Zigmond, Bloom, Landis, Roberts and Squire with supplementary readings provided from other textbooks as well as relevant journal articles. *Prerequisites:* CM 950 or its equivalent and undergraduate biochemistry.

BE 616 Transport Phenomena in Biological Systems

2'l:0:0:3

The goals of this course are to: (1) convey advanced concepts of fluid transport processes, mass transfer with chemical reaction, mixing and non-Newtonian flow and (2) apply concepts in biological systems such as blood flow in arteries and diffusion within fluid membranes. Fundamental concepts of momentum, energy and mass transport; transport in stationary and flow systems, steady-state and transient conditions. *Prerequisites:* CH 231 and CH 232.

BE 620 Biomedical Imaging I

2'l:0:0:3

Introduction of the mechanisms and concepts related to image acquisition and subsequent image processing and image formation in various biomedical-imaging modalities. Topics include computed tomography (CT) with x-rays, Single Photon Emission tomography (SPECT), positron emission tomography (PET) and magnetic resonance imaging (MRI). Prerequisite: CH 615 or the equivalent background (minimum grade C).

BE 621 Biomedical Imaging II 2½:0:0:3

Introduction of the mechanisms and concepts related to image acquisition and subsequent image processing and image formation in various biomedical imaging modalities. Building on material covered in Principles of Biomedical Imaging I, these courses focus on advanced topics such as functional magnetic resonance imaging (MRI), ultrasound imaging, bi-magnetic imaging and optical tomographic imaging (OTI). Prerequisites: CH 615 or the equivalent background (minimum grade C) and BE 620 (minimum grade B).

BE 625 Biosensors 2½:0:0:3

Discussion of various biosensors, which consist of bio-recognition systems, typically enzymes or binding proteins such as antibodies, immobilized onto the surface of physico-chemical transducers. Immuno-sensors, which use antibodies as their biorecognition system, are also discussed. Other biorecognition systems discussed are nucleic acids, bacteria, and whole tissues of higher organisms. Specific interactions between the target analyte and the complementary biorecognition layer that undergoes a physico-chemical change is ultimately detected and measured by the transducer. Various transducers, which can take many forms depending upon the parameters being measured—electrochemical, optical, mass and thermal changes are also part of the course. Prerequisites: CM 1004, CM 2214, CM 2614 and CM 941.

BE 630 Bio-optics 2½:0:0:3

Recent growth in the use of optics technology for biomedical research and health care has been explosive. New applications are made possible by emerging technologies in lasers, optoelectronic devices, fiber optics, physical and chemical sensors and imaging—all of which are being applied to medical research, diagnostics, and therapy. This sequence course on optics for biomedical students combines fundamental knowledge of the generation and interaction of electromagnetic waves with applications to the biomedical field. It is hoped that this approach will not only provide tools for researchers in bio-physics, but also familiarize researchers, technologists and premed students with cutting-edge

approaches. Prerequisite: an undergraduate course in physics that includes electricity, magnetism and waves such as PH 109.

BE 660 Drug Delivery 2½:0:0:3

Provides an integrated approach to the basic and clinical science of drug delivery. This course discusses the following: highlights of the historical development of drug delivery; kinds of drugs to be delivered, including genes and proteins; various targeting mechanisms; pharmacokinetics and pharmacodynamics of drug delivery systems, polymeric drug delivery systems; various devices developed for controlled delivery. Prerequisites: introductory undergraduate courses in biology, chemistry and physiology (minimum grade C).

BE 670 Materials in Medicine 2½:0:0:3

Focuses on the following: the basic principles behind human tissue response to artificial surfaces and materials; the general types of polymeric and metallic materials used in soft and hard tissue replacements; tissue engineering and drug delivery devices; current approaches directed toward the engineering of cell-based replacement for various tissues; techniques utilized to control the physiologic response to artificial surfaces; critical review of the current biomaterials literature; current research in the field; and evaluation of the design criteria which a material must meet for a given biological application and what is required for “biocompatibility.” Prerequisites: introductory undergraduate courses in biology, chemistry, physiology and engineering. Courses in biochemistry, molecular cell biology and immunology would be very helpful, but are not essential.

CM 792 Natural Polymers and Materials 2½:0:0:3

Introduction to natural and biomimetic polymers taught with an interdisciplinary view of biology, chemistry and macromolecular science. Topics covered in this course include: natural building blocks and methods by which nature carries out polymer synthesis and modification reactions; DNA; structural proteins; plant proteins; polysaccharides; polyesters; biosurfactants; polymers built from natural monomers and a wide variety of

renewable resources; uses of these polymers as fibers, films, rheological modifiers, flocculants, foams, adhesives and membranes; special applications of natural polymers in medicine and as biodegradable plastics. Prerequisites: CM 1004 and LC 1004.

CM 905 Enzyme-Catalysis in Organic Synthesis 2½:0:0:3

Provides students with a working knowledge of how to use biotransformations as a tool in organic chemistry. Students will learn about general enzymatic reaction types that carry out the cleavage and formation of C-O bonds, P-O bonds, C-N bonds, C-C bonds, reduction reactions, oxidation reactions and isomerizations. In addition, students will be taught about advanced principles that are currently being applied to the engineering of catalytic proteins. Prerequisites: CM 2214, CM 2614 and CM 3314.

CM 906 Combinatorial Chemistry 2½:0:0:3

Discussion of the development and practice of combinatorial chemistry and high throughput experimentation. The goals of the course include: knowledge of the origin, development and present day practice of combinatorial chemistry for preparation of libraries of chemical compounds; understanding of pharmaceutical models for high throughput discovery of drug compositions; the process of developing solid and liquid-phase methods for high throughput screening of compositions for particular applications; recent examples where the above principles have been applied to the discovery of new materials, including catalysts and materials for electronic devices. Prerequisite: CM 903.

CM 950 Principles of Biological Systems 5:0:0:6

Physiology is defined as the science that deals with the functions of the body. It logically follows, therefore, that a sound, comprehensive knowledge of human physiology should occupy a significant part of the academic training of personnel in medicine and related fields. The emphasis is on normal functions, but also considers the consequences of disease and injury, and deal with the body's potential for recovery and for compensa-

tion. Behavioral responses to environmental conditions are considered, but in this area our chief concern will be with the regulation and control of fundamental reflexes or neuro-endocrine mechanisms. Prerequisite: none, although some background of biochemistry and gross and cellular anatomy would be helpful.

CM 952 Molecular and Cellular Biology I 2½:0:0:3

Lectures, discussions and student presentations on the varying contributions of different molecular mechanisms to the control of gene expression. Topics include the biochemistry of nucleic acids, the basis of Central Dogma, the structure of prokaryotic genomes, bacterial genetics, the organization and structural arrangement of the eukaryotic genome, DNA replication, recombination, techniques of and strategies for cloning and analyzing genes, transcription in prokaryotes and eukaryotes, the operon concept and regulatory strategies for genetic expression, synthesis and processing of RNA in eukaryotes, mechanisms for protein synthesis and its regulation. Prerequisites: CM 950 or its equivalent and undergraduate biochemistry.

FACULTY

PARTICIPATING FACULTY FROM SUNY DOWNSTATE MEDICAL CENTER

Randall Barbour, Professor of Pathology, SUNY Downstate; Research Professor of Electrical Engineering, Polytechnic University
PhD, Syracuse University
Development of optical tomographic imaging methods for the evaluation of tissue function

John K. Chapin, Professor, Department of Physiology and Pharmacology
PhD, University of Rochester, School of Medicine and Dentistry
Emerging computer and electronic technologies are used to establish real-time control of a robotic prosthesis using signals derived from neuronal population recordings in motor cortex. The goal is to restore motor functions to paralysis patients by extracting "motor" commands from their brains, and using the "motor" commands to control robots, or their own limbs. A long-range goal is to combine motor prostheses with somatosensory prostheses that could substitute for the information normally provided by the skin. Similarly technology will make it possible to remotely control the navigational goals of animals that can carry sensors into otherwise inaccessible areas.

Miriam H. Feuerman, Associate Professor, Department of Biochemistry
PhD, University of California at Irvine
Molecular mechanisms that separate controlled normal growth from carcinogenesis; regulation of gene expression in liver regeneration and tumorigenesis

Andreas H. Hielscher, Assistant Professor, Department of Pathology, SUNY Downstate; Adjunct Professor, Department of Electrical Engineering, Polytechnic University
PhD, Rice University
A novel, fast-advancing, medical imaging modality called optical tomography (OT) uses near-infrared light to probe biological tissues and to obtain cross-sectional images of various body parts from measured transmitted light. Development of image reconstruction algorithms and instrumentation

Brehon C. Laurent, Assistant Professor, Department of Microbiology and Immunology
PhD, Massachusetts Institute of Technology
The control of two cellular processes in the context of chromatin structure: transcriptional initiation and progression through the mitotic cell division cycle

William T. McAllister, Professor and Chairman, Department of Microbiology and Immunology
PhD, University of New Hampshire
The structure and function of phage RNA polymerases. These enzymes are models for related enzymes such as DNA polymerases and reverse transcriptase. The work has practical applications in nucleic acid probes and detection, and the development of high-level expression systems for cloned genes

Josef Michl, Associate Professor, Department of Pathology; Associate Professor, Department of Anatomy and Cell Biology; Associate Professor, Department of Microbiology and Immunology
MD, Johannes Gutenberg Universitaet Mainz (Germany)
Cells involved in host defense mechanisms against infectious agents and tumors; the process of carcinogenesis in the exocrine pancreas in animals and humans using tissue culture and cell cloning, immunological, ultrastructural and biochemical as well as cell and molecular biological approaches and techniques

BIOMOLECULAR SCIENCE PROGRAM

Program Director: Michael Joesten

Advances in biology, particularly at the cellular and molecular level, are changing the world that we live in. The basic knowledge of the way nature functions to create and sustain life on earth is increasingly applied to the health care industry, to feeding an expanding world population, to producing cheap energy from renewable sources, to cleaning up the environment. Biology is the enabling science of the 21st century and will create numerous opportunities in the job market in the years to come.

The BS in Biomolecular Science lies at the interface between biology and chemistry and is designed to build upon the understanding of biology at the molecular level. The curriculum also provides a strong foundation in both mathematics and physics. This broadly based science education is a prerequisite for successful careers in industry and governmental laboratories, and for professional or graduate studies in the biological sciences, medicine and other health-related fields.

The BS in Biomolecular Science has three options, to meet the diverse needs of our students. The option in biomedical science is designed to provide students with the fundamental knowledge and skills needed for employment in the rapidly changing bio-related industries or to pursue advanced professional or graduate degrees. The curriculum is highly innovative, spans the boundaries between biology and chemistry and involves considerable exposure to research.

The option in biotechnology is oriented towards the need of students who plan to work for the fast growing biotechnology industry. The nature of the industry has dramatically changed in the last decade, with technologies based on human gene therapy taking their place along side the production of antibiotics, vaccines, hormones in technologies based on genetic engineering. This option provides a large choice of elective courses that would meet both the specific needs and interests of individual students. The option in chemistry inherits the rich

REQUIREMENTS FOR THE BACHELOR OF SCIENCE

Subject	OPTION		
	Biomedical Science	Biotechnology	Chemistry
Chemistry	33cr	33	36
Biology	26	18	8
Research*	8	8	8
Chemical & Biological Engineering	0	0	4
Computer Science	4	4	4
Humanities/Social Sciences	26	26	28
Mathematics	8	8	12
Physics	8	8	8
Technical electives	15	23	20
Total	128	128	128

A minimum of 128 credits is required for the BS in Biomolecular Science.

**Students registering for research are required to submit a written report prior to graduation. Students may elect to write an undergraduate thesis.*

traditions of Polytechnic in providing excellent education in chemistry, now combined with a fundamental knowledge of biology, to prepare students for employment in pharmaceutical and related companies. Graduates will also be prepared for positions at educational and/or research institutions and governmental laboratories. The research opportunities provided by this option will prepare students for pursuing graduate degrees in chemistry as well as degrees that border on biology.

GOALS AND OBJECTIVES

The goal of the BS in Biomolecular Science is to provide students with the fundamental knowledge and skills needed to advance to work in the rapidly changing bio-related industries or to pursue advanced professional or graduate degrees. This is accomplished through an innovative curriculum that spans the boundaries between biology and chemistry and through exposure to research. In this way, the program is designed to attract and train students who are adaptable and active learners.

BS/MS ACCELERATED HONORS OPTION

The BS/MS Accelerated Honors Option leads to the simultaneous awarding of a bachelor's and master's degree.

Depending on the student's preparation and objective, the two degrees may be completed in as few as four years of study. Each program is individually designed in cooperation with the departmental BS/MS adviser to allow varied transfer and AP credits, professional summer jobs, and other goals consistent with the Honors Option.

Possible BS/MS combinations include a BS in Biomolecular Science with an MS in Chemistry, Bioinformatics or Biomedical Engineering.

Incoming freshman with superior admissions qualifications are invited to participate in the Accelerated Honors Program. Later admission may be considered after students complete no more than one year at Polytechnic. Students must complete 16 to 20 credits each semester, maintain a 3.5 GPA average, and display a record free of course repetitions.

The required courses for the two degrees include all courses required for individual BS and MS degrees, except for Senior Research Project II (either BMS 4924 or CM 4924), and all curriculum footnotes apply. Required credits are the sum of the credits for the two degrees minus the 4 credits for Senior Research Project II. Students in this program must complete a Master's Thesis. (No Bachelor's Thesis is required.)

Acceleration may be achieved through

BIOMOLECULAR SCIENCE PROGRAM

summer course work, extra course loads, careful sequencing or credit by examination. Students may also achieve acceleration through advanced placement credit in such courses as biology, calculus, chemistry, computer science or physics.

UNDERGRADUATE COURSES

BMS 1004 Introduction to Cell and Molecular Biology 3:3:0:4

Fundamentals of biology. Physical, chemical and biochemical bases of life on various organizational levels, cellular morphology, complementarity of form and function, including reproduction, development and genetics.

BMS 2004 Introduction to Physiology 3:3:0:4

Fundamentals of biology, continued. Emphasis on evolutionary theory, phylogeny and comparative physiology including homeostasis, regulation, integration and coordination of organisms at the systems level. *Prerequisite: BMS 1004 or instructor's permission.*

BMS 2512 Biostatistics 2:0:0:2

Concise introduction to statistical methods used in biology, including probability, statistical distributions, regression, correlation and tests.

BMS 3114 Genetics 3:3:0:4

The genetics of bacteria, viruses and high organisms. Emphasis is placed on both the genetic and biochemical analyses of gene replication, heredity, mutation, recombination and gene expression. Comparisons of prokaryotic and eukaryotic genetics and regulation. Laboratory techniques used in the study of genetic phenomena in prokaryotes, eukaryotes and viruses. Emphasis placed on modern approaches to genetic research. Lab fee required. *Prerequisite: BMS 1004. Co-requisite: CM 2214.*

BMS 3214 Microbiology 3:3:0:4

Study of microbial organisms, especially bacteria and viruses. Microbial relationship to disease, infections and immunological processes. Mutation, transformation, transduction, induction and bioenergetic processes. Laboratory work includes experimental analysis of microbial structure and physiology by biochemical and cytochemical means. Influence of environment on nutrition, enzymes and metabolism of representative microbial species. Lab fee required. *Prerequisites: BMS 2004 and CM 1014 or instructor's permission.*

BMS 3314 Advanced Cell and Molecular Biology I 3:3:0:4

This course is designed as the first semester of a year-long course in which the molecular basis of cell function and current trends in molecular biology are explored. The lab component consists of a year-long project to locate, characterize, clone and express a gene. Lab fee required. *Prerequisites: CM 3314 and CM 2224 (see BMS 4324 for second semester).*

BMS 4011 Senior Seminar 1:0:0:1

Students present seminars based on current literature.

BMS 4314 Advanced Cell Physiology 3:3:0:4

Analysis of chemical and physical mechanisms of cellular function. Molecular constituents of biological systems, enzymes and reaction rates, energetics and regulation of metabolic processes, membrane transport, contractility and irritability. Laboratory studies include examination of cellular components in terms of their functional activities (enzymes, oxidative-phosphorylation, photosynthesis), kinetics of soluble and membrane-bound enzymes and membrane transport. Lab fee required. *Prerequisites: BMS 2004 and CM 2614.*

BMS 4414 Biophysics 4:0:0:4

Molecular basis of complex biochemical functions, membrane transport, intercellular and extracellular signaling, metabolism and energy transduction, DNA,

RNA and protein synthesis and control, macromolecular assemblies, special topics in biochemistry.

BMS 4324 Advanced Cell and Molecular Biology II 3:3:0:4

This course is for the second semester of a year-long course in which the molecular basis of cell function and current trends in molecular biology are explored. The lab component consists of a year-long project to locate, characterize, clone and express a gene. Lab fee required. *Prerequisite: BMS 3314.*

BMS 4814/4824/4834/4844 Topics in Biology each 4 credits as arranged

BMS 4914/492

4 Projects in Life Science each 4 credits. Investigations of problems in biology under supervision of faculty members. Library research, experimental studies and written reports required. Lab fee required. *Prerequisites: senior status or adviser's approval, CM 5010, CM 5040.*

BMS 4934 Life Science Internship 4 credits

Supervised projects carried out in hospital, community or industrial settings. Evaluated on basis of written and oral reports presented to faculty and outside project co-sponsors. Faculty conferences and visits required. Open to senior students on approval of departmental adviser. Pre-planned experiences provide students with significant exposure to relationships between theoretical information and practical applications. *Prerequisite: senior status or adviser's approval.*

GRADUATE COURSE

LS 561/562 Advanced Topics in Biology as arranged

From time to time, graduate-level courses may be offered in bioethics, bioinformatics, electron microscopy, environmental biology, topics in neurophysiology, topics in neurosciences and cytology.

Typical Course of Study for the Bachelor of Science in Biomolecular Science Option in Biomedical Science

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1054	Calculus I with Precalculus ¹	4	0	0	4
CM 1014	General Chemistry I	3	2	1	4
CS 1114	Introduction to Programming and Problem Solving	3	3	0	4
EN 1014	Writing & Humanities I ²	4	0	0	4
SL 1010	Freshman Seminar	1	0	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1154	Calculus II with Precalculus	4	0	0	4
BMS 1004	Biology I (Intro Cell & Molecular Bio)	3	3	0	4
CM 1024	General Chemistry II	3	2	1	4
EN 1204	Writing & Humanities	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

CM 2214	Organic Chemistry I	3	3	0	4
PH 1004	Introductory Physics I	4	1½	1	4
BMS 2004	Biology II (Intro Physiology)	3	3	0	4
HU 2104	Modern World History	4	0	0	4
CM 5040	Laboratory Safety	1	0	0	0
					16

Spring Semester

CM 2224	Organic Chemistry II	3	3	0	4
PL 2072	Bioethics	2	0	0	2
BMS 2512	Biostatistics	2	0	0	2
CM 2614	Physical Chemistry I	4	0	0	4
PH 2004	Introductory Physics II	4	1½	1	4
					16

JUNIOR YEAR

Fall Semester

BMS 3114	Genetics	3	3	0	4
CM 3314	Biochemistry I	4	0	0	4
HU/SS	Elective ³	4	0	0	4
	Elective ⁴	4	0	0	4
					16

Spring Semester

BMS 3314	Adv Cell & Molecular Bio I	3	3	0	4
CM 3324	Biochemistry II	4	0	0	4
CM 3514	Analytical Chemistry	3	3	0	4
CM 5011	Information Sources	1	0	0	1
	Elective ⁴	3	0	0	3
					16

SENIOR YEAR

Fall Semester

BMS 4324	Adv Cell & Molecular Bio II	3	3	0	4
BMS 4914	Senior Project Research	0	12	0	4
HU/SS	Elective ³	4	0	0	4
	Elective ⁴	4	0	0	4
					16

Spring Semester

BMS 4924	Senior Project Research	0	12	0	4
BMS 48xx	Topics in Biology	4	0	0	4
	HU/SS Elective ³	4	0	0	4
	Elective ⁴	4	0	0	4
					16

Total credits required for graduation:

128

See page 112 for footnotes.

Typical Course of Study for the Bachelor of Science in Biomolecular Science Option in Biotechnology

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1054	Calculus I with Precalculus ¹	4	0	0	4
CM 1014	General Chemistry I	3	2	1	4
CS 1114	Intro Progr & Prob Solving	3	3	0	4
EN 1014	Writing & Humanities I ²	4	0	0	4
SL 1010	Freshman Seminar	1	0	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1154	Calculus II with Precalculus	4	0	0	4
BMS 1004	Biology I (Intro Cell & Molecular Bio)	3	3	0	4
CM 1024	General Chemistry II	3	2	1	4
EN 1204	Writing & Humanities	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

CM 2214	Organic Chemistry I	3	3	0	4
PH 1004	Introductory Physics I	4	1½	1	4
BMS 2004	Biology II (Intro Physiology)	3	3	0	4
HU 2104	Modern World History	4	0	0	4
CM 5040	Laboratory Safety	1	0	0	0
					16

Spring Semester

CM 2224	Organic Chemistry II	3	3	0	4
PL 2072	Bioethics	2	0	0	2
BMS 2512	Biostatistics	2	0	0	2
CM 2614	Physical Chemistry I	4	0	0	4
PH 2004	Introductory Physics II	4	1½	1	4
					16

JUNIOR YEAR

Fall Semester

BMS 3114	Genetics	3	3	0	4
CM 3314	Biochemistry I	4	0	0	4
	HU/SS Elective ³	4	0	0	4
	Elective ⁵	4	0	0	4
					16

Spring Semester

BMS 3314	Advanced Cell & Molecular Biology I	3	3	0	4
CM 3324	Biochemistry II	4	0	0	4
CM 3514	Analytical Chemistry	3	3	0	4
CM 5011	Information Sources	1	0	0	1
	Elective ⁵	3	0	0	3
					16

SENIOR YEAR

Fall Semester

BMS 4914	Senior Project Research	0	12	0	4
	HU/SS Elective ³	4	0	0	4
	Elective ⁵	4	0	0	4
	Elective ⁵	4	0	0	4
					16

Spring Semester

BMS 4924	Senior Project Research	0	12	0	4
	HU/SS Elective ³	4	0	0	4
	Elective ⁵	4	0	0	4
	Elective ⁵	4	0	0	4
					16

Total credits required for graduation:

128

See page 112 for footnotes.

Typical Course of Study for the Bachelor of Science in Biomolecular Science Option in Chemistry

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1024	Calculus I ¹	2	0	0	4
CM 1014	General Chemistry I	3	2	1	4
CS 1114	Intro Progr & Prob Solving	3	3	0	4
EN 1014	Writing & Humanities I ²	4	0	0	4
SL 1010	Freshman Seminar	1	0	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1124	Calculus II	2	0	0	4
BMS 1004	Biology I (Intro Cell & Molecular Bio)	3	3	0	4
CM 1024	General Chemistry II	3	2	1	4
EN 1204	Writing & Humanities	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

CM 2214	Organic Chemistry I	3	3	0	4
PH 1004	Introductory Physics I	4	1½	1	4
BMS 2004	Biology II (Intro Physiology)	3	3	0	4
HU 2104	Modern World History	4	0	0	4
CM 5040	Laboratory Safety	1	0	0	0
					16

Spring Semester

CM 2224	Organic Chemistry II	3	3	0	4
MA 2012	Linear Algebra I (½ semester)	4	0	0	2
MA 2132	Ordinary Differential Equations (½ semester)	4	0	0	2
CM 2614	Physical Chemistry I	4	0	0	4
PH 2004	Introductory Physics II	4	1½	1	4
					16

JUNIOR YEAR

Fall Semester

CM 3314	Biochemistry I	4	0	0	4
CM 4413	Polymer Science	3	0	0	3
CBE 2124	Chemical & Biological Processes	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					15

Spring Semester

CM 3324	Biochemistry II	4	0	0	4
CM 3514	Analytical Chemistry	3	3	0	4
CM 5011	Information Sources	1	0	0	1
	HU/SS Elective ³	4	0	0	4
	Elective ⁵	4	0	0	4
					17

SENIOR YEAR

Fall Semester

CM 4914	Senior Project Research	0	12	0	4
	HU/SS Elective ³	4	0	0	4
	Elective ⁶	4	0	0	4
	Elective ⁶	4	0	0	4
					16

Spring Semester

CM 4924	Senior Project Research	0	12	0	4
	HU/SS Elective ³	4	0	0	4
	Elective ⁶	4	0	0	4
	Elective ⁶	4	0	0	4
					16

Total credits required for graduation:

128

See page 112 for footnotes.

**Footnotes for Typical Course of Studies for the Bachelor of Science in Biomolecular Science
Options in Biomedical Science, Biotechnology and Chemistry**

1. Students who are placed by examination or by an advisor into MA 914 must defer registration for MA 1054 or MA 1024.

2. Students who are placed by examination or by an advisor into EN 1080 must subsequently register for EN 1034, rather than EN 1014.

3. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II Elective courses in different disciplines, and one from Level III Advanced Elective courses.

4. Electives for the Option in Biomedical Sciences: Two courses must be chosen from the following list or must be approved by an advisor, subject to the courses being offered in a given semester. Graduate courses may only be taken by students with junior standing and a C+ average or better, unless otherwise approved by the advisor. The remaining courses are free electives.

CBE 2124	Chemical & Biological Processes	4 cr
BMS 2314	Physiology	4 cr
BMS 3214	Microbiology	4 cr
BMS 4414	Biophysics	4 cr
BMS 48XX	Topics in Biology	4 cr
BE 650	Tissue Engineering	3 cr
BE 660	Drug Delivery	3 cr
BE 670	Materials in Medicine	3 cr

5. Electives for the Option in Biotechnology: Three courses must be chosen from the following list or must be approved by an advisor, subject to the courses being offered in a given semester. Graduate courses may only be taken by students with junior standing and a C+ average or better, unless otherwise approved by the advisor. The remaining courses are free electives.

CBE 2124	Chemical & Biological Processes	4 cr
BMS 4324	Advanced Cell and Molecular Biology II	4 cr
BMS 48XX	Topics in Biology	4 cr
CM 4314	Biomaterials	4 cr
CM 4413	Polymer Science	3 cr
BE 655	Recombinant DNA Technology	3 cr
CM 625	Biosensors	3 cr
CM 905	Enzyme Catalysis in Organic Synthesis	3 cr
CM 906	Combinatorial Chemistry	3 cr
BI 751	Chemical Foundations of Bioinformatics	3 cr
BI 753	Bioinformatics I: Sequence Analysis	3 cr
BI 754	Bioinformatics II: Protein Structure	3 cr

6. Electives for the Option in Chemistry: Two courses must be advanced undergraduate CM, BMS or CBE courses, or graduate CM courses, or must be approved by an advisor, subject to the courses being offered in a given semester. Graduate courses may only be taken by students with junior standing and a C+ average or better, unless otherwise approved by the advisor. The remaining courses are free electives.

NOTES:

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 biology or chemistry courses at other schools.

BUSINESS AND TECHNOLOGY MANAGEMENT PROGRAM

Program Director: Barry S. Blecherman

GOALS AND OBJECTIVES

The Bachelor of Science in Business and Technology Management (BTM) [formerly Technology and Information Management] Program prepares students to be the next generation of managers in fields dominated by technological innovation and information intensity. Students completing this program will be prepared to succeed in positions such as technology project leaders, new economy entrepreneurs, technology and IT analysts on Wall Street, customer relationship managers and in other roles in large and small companies that require a cross-functional understanding of both technology and the motivational, financial, innovative and international challenges that accompany it. BTM students will also be well prepared for advanced studies in the management of technological and informational intense environments; they will be able to succeed in both studies of the practical aspects of management (MS Management, MBA) and in the theoretical analysis of a doctoral program.

This program provides a rigorous training in the qualitative, quantitative and innovative aspects of technology and information management. All classes are designed to provide a broad managerial background with specific application of the ideas and practices relevant for the world of technological goods and services.

The art and science of management demands that its practitioners be able to communicate ideas effectively and efficiently. Therefore, this program's courses emphasize spoken and written presentations, in individual, team and classroom settings, as central components of the learning experience.

PEDAGOGY

Management courses are taught using a variety of pedagogical methods. These include:

- Theory-led teaching
- Case-method education
- Project-based and team-based teaching

Teaching based on exposition of theory is often appropriate for management classes. Case-method teaching emphasizes a variety of real-world business experiences and attempts to lead the students to draw general principles from the many examples, in much the same way that a computer screen or a photograph creates an image from a variety of small dots or pixels. Project-based and team-based education is experiential; students learn by doing, much as they would in a natural sciences laboratory class. It is very common in management courses for all pedagogical approaches to be employed.

COURSE DISTRIBUTION

The BTM Program requires 128 credits for graduation. Key characteristics of this curriculum include:

- 10 credits in courses in mathematics
- 34 credits in courses in humanities and social sciences
- 8 credits in science and engineering, taken during students' freshman year
- 4 credits in computer science
- 4 credits in a technical elective
- 8 credits in restricted electives chosen from math, science, social sciences and humanities
- 60 credits in management

Courses for the BS in BTM are taken in a 4x4 manner (four courses per semester, each 4 credits) for eight semesters; deviations from this template occur in the freshman year, when a calculus course and a management course of 2 credits each are taken; and in the fifth semester of the program, when two 2-credit courses in project management and business ethics are required.

Course Numbering

BTM courses are numbered using the following schema:

- The first digit of a course number corresponds to the year in which a BTM student would take the course (1 = Freshman, etc.)
- The second digit reflects the primary nature of the course material. Courses numbered with a second digit of:
- "0" are focused primarily on process-

- es in management
- "1" are oriented toward Organizational Behavior
- "2" are quantitative in nature
- "3" describe a firm's relationships with external forces
- "4" study innovation
- "5" are capstone courses
- The third digit in a course number serves only to differentiate different courses
- The fourth digit reflects the number of credits

Thus, MG 3304 Introduction to Supply Chain Management is a 4-credit junior-year course focusing on external relationships.

Areas of focused study

Students in this degree program may focus their study in Technology Innovation and Strategy or in Technology Finance. Candidates who choose the first path will complete MG 3304 Supply Chain Management in their sixth semester of study and MG 4004 Management Strategy in Technology Sectors in their seventh semester. Students electing the Technology Finance track of study will take MG 3214 Advanced Corporate Finance and 4½ credits of study in Financial Engineering at these points in their careers as students.

Graduation Requirements

To remain in good standing, candidates for the degree BS BTM must satisfy the following requirements, in addition to the University requirements for a minimum term and cumulative 2.0 GPA in all courses:

- An average of C (2.0) or better in all MG courses must be maintained
- A course in which the grade of I is received may not be used to satisfy any prerequisites until the incomplete is resolved.

Honors Capstone

Students who earn a 3.6 GPA or better in MG courses through their junior year of study qualify for the honors senior project capstone courses. These students are also free to not elect this project sequence.

Transfer Students

Courses at other schools may or may not be granted transfer credit based on evaluation of the content and level of material covered. Periodic re-evaluation 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.

Transfer students must present their records for evaluation at least two weeks before the regular registration period for their first semester.

Minor in Management

Students may obtain an undergraduate minor in management by completing 14 credits of MG courses. An overall GPA of at least 2.0 must be maintained in these classes. At least 8 of the 14 credits must be taken by students while enrolled at Polytechnic.

Information

Curricula and prerequisite changes, new courses, special sections and other special announcements will be posted in the Department of Management office suite and on the program's website at www.ite.poly.edu/bsmngt. Students are responsible for keeping informed and are encouraged to visit the BS BTM website often.

UNDERGRADUATE COURSES**MG 1002 Foundations of Management**
4:0:0:2

Half-semester, introductory course in the principles and practices of management. Management is viewed as a system of tasks, including environmental scanning, planning, organizing, leading and controlling. Within each of these major tasks is a series of processes, which show how to do what has to be done. Management is both a science and an art; both aspects of management are covered in this course. Major emphasis is placed on management history, philosophy, and the theory and practice of management planning, decision making, organizing, motivating and leading.

MG 2004 Management of Information Technology and Systems
4:0:0:4

Provides foundation for understanding the role and potential contributions of infor-

mation technologies and systems in business organizations—what they are, how they affect the organization and its employees, and how they can make businesses more competitive and efficient. The focus of the course is on the current state of IT in organizations, challenges and strategic use of IT, IT infrastructure and architecture, building, implementing and managing IT applications, and emerging issues such as intelligent systems, business process re-engineering, knowledge management, and group support systems.

MG 2014 Operations Management
4:0:0:4

A firm has the opportunity to create competitive advantage through proficient management of its operations. To do so, the firm must first recognize and establish the strategic role of its operations within the organization. Then, at the more detailed operational level, the firm must execute effectively and efficiently. This course examines the strategic role that the operations function can play, and offers specific tools and techniques that the firm can use during implementation. *Prerequisite: 4 credits of calculus.*

MG 2104 Organizational Behavior
4:0:0:4

Focuses on the study of human behavior in innovative organizations. Emphasis is on teams, leadership, communication theory, and organizational culture and structure. The course includes analyses of organizational behavior problems through the use of case studies, and by participation in experiential learning.

MG 2204 Financial Accounting 4:0:0:4

Provides a solid foundation in the construction and interpretation of financial statements. Topics include: accounting terminology, financial statement preparation and analysis, liquidity and credit risk ratios, depreciation calculations, revenue recognition, accrued liabilities and asset valuation. Also covered are the effects of equity transactions, cash flows, and various accounting methods on financial statements.

MG 2304 Marketing 4:0:0:4

An undergraduate introduction to marketing. We discuss the fundamentals of marketing like the marketing mix, the role of

the customer, marketing research and survey techniques. In addition, emerging paradigms like relationship marketing and Internet marketing will also be introduced.

MG 3002 Project Management 4:0:0:2

Half-semester course provides students with practical and best practice project management theory, concepts and (hands-on) practical experience so that they may effectively contribute in and lead multicultural team projects framed for the new global economy. The practical component includes a team-based project that runs throughout the duration of the course.

MG 3024 Management of Data Communications and Networking
4:0:0:4

Introduces the fundamentals of modern telecommunications and networking such as components of data communication, data transmission, Open System Interconnection (OSI), TCP/IP and other models, data link and network layers, and local area networks (LANs). The course focuses on managerial issues related to the management of data communications and networking technologies. *Prerequisite: MG 2004.*

MG 3204 Introduction to Finance
4:0:0:4

An introduction to business finance for BTM majors. It emphasizes the financing and investment decisions of the financial manager, with special emphasis placed on examples from technological environments. Included are topics such as time value of money, asset valuation, risk analysis, financial statement analysis and capital budgeting. *Prerequisites: 6 credits of calculus. Co-requisite: MG 2204.*

MG 3214 Advanced Corporate Finance
4:0:0:4

This course builds on the principles of basic corporate finance covered in MG 3204. It prepares students with an understanding of financial theory and how modern finance is used by firms for strategic and tactical decision-making. The critical issue of how these decisions impact the value of a firm and the returns of assets is addressed. Major topics include: bond valuation, the CAPM model, portfolio design and modeling,

and option pricing using the Black-Scholes model. There is a strong emphasis on the use of spreadsheets as a financial modeling tool. *Prerequisites: MA 2054 and MG 3204.*

MG 3304 Introduction to Supply Chain Management 4:0:0:4

An undergraduate level introduction to supply chain management. The underlying objective is to introduce key supply chain management concepts and examine relevant business practice. This will enable the student to develop skills that are useful in analyzing marketing, logistics, operations and channel management issues. *Prerequisites: MG 2004 and MG 2304. Co-requisite: MA 2054, MA 2122 or MA 3012.*

MG 3404 Innovation Management 4:0:0:4

Examines the key managerial features of technology-enabled innovation and new product development. This course focuses on accessing innovative capabilities via R&D, acquisition, alliances, joint ventures and innovation-friendly cultures and organizations. The key perspective underlying this course is managerial. Although the innovation activities studied are overwhelmingly technology-enabled ones, success is largely determined by managerial factors. The interplay between the technology and management leading to innovation in a major concern of the discussion and work comprising this course.

MG 4004 Management Strategy in Technology Sectors 4:0:0:4

An overview of the process of implementing a successful management strategy in an information and technology intensive environment. Fundamental topics that are covered include: the development of strategic vision, objectives and plans, the implementation of strategy and the evaluation of performance, industry and competitive analysis, SWOT analysis, and competitive advantage and sustained advantage. Advanced concepts discussed in this course include: strategic positioning in global markets, Internet strategy, strategy in diversified firms, and the interactions between organizational structure and strategy and between ethics and strategy. *Prerequisites: MG 3204 and MG 3404.*

MG 4014 Introduction to E-Business 4:0:0:4

Since its introduction, the Internet has changed how businesses work. In addition to creating new opportunities, the Internet has also revolutionized existing businesses and entire industries. This course provides an undergraduate level introduction to e-business. The main objectives of this course are to: (1) provide a hands-on introduction to the emerging area of e-Business, (2) discuss the major business concepts and issues in this domain and (3) develop high quality content based on team discussion and individual/group research. *Prerequisites: MG 3204, MG 3002, MG 3304 and MG 3404.*

MG 4204 Management Science 4:0:0:4

Teaches the student to create mathematical models of managerial problems. Types of models discussed include: linear programming, integer linear programming, non-linear programming, queuing models, decision tree models, game theoretic models, simulation models, inventory models and more. Each model is discussed in the context of the assumptions necessary for modeling and the robustness of the model's managerial recommendations. *Prerequisites: 6 credits of calculus. Co-requisite: MA 2054, MA 2122 or MA 3012.*

MG 4404 Entrepreneurship 4:0:0:4

Discusses the current theories and practices related to starting and managing small firms, with emphasis on firms in technology and information intensive environments. Particular attention is paid to the critical issues of: (1) identifying opportunities that provide competitive advantage; (2) the development of a solid business plan; (3) the marketing of a new venture; (4) small business operations, including human resource and process management; (5) ethical and social issues in small firms; and (6) the financial management of small firms. *Prerequisite: senior status as a BTM major.*

MG 4504 Global Perspectives on Technology Management: A Capstone Project Course 4:0:0:4

Provides students with a knowledge of the current theories and practices related to managing international and multinational firms. Students in this class will

study the ways in which international management differs from the management of a firm residing solely within domestic boundaries. Topics covered include: planning, organizing, HR management, communication and negotiation, and co-ordination and control of international endeavors. Case studies are used extensively to focus the class on technological examples of problems in international management. Students will develop a term project that either: (1) develops a business plan for a technological international venture, (2) creates a case study of a technological firm's challenges in international management or (3) analyzes an technological industry's position vis-à-vis international management. *Prerequisite: senior status as a BTM major.*

MG 4514 Honors Capstone Project in Technology and Information Management I 4:0:0:4

A qualified honors student or several such students work with a faculty member (and perhaps graduate students as well) on an advanced topic in technology and information management. This effort may be directed toward the development of theory, the development of case material, the development of a business plan and business strategy for a new venture, or another project of this caliber. *Prerequisites: senior status, 3.6 GPA or better through the junior year in major; all courses specified by the project adviser.*

MG 4524 Honors Capstone Project in Technology and Information Management II 4:0:0:4

A qualified honors student or several such students work with a faculty member (and perhaps graduate students as well) on an advanced topic in technology and information management. This effort may be directed toward the development of theory, the development of case material, the development of a business plan and business strategy for a new venture, or another project of this caliber. *Prerequisites: senior status, 3.6 GPA or better through the junior year in major; all courses specified by the project adviser including MG 4514.*

Typical Course of Study for the Bachelor of Science in Business and Technology Management

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1024	Calculus I or	4	0	0	4
MA 1054	Calculus Bus & Life Sci I				
EN 1014	Writing & Humanities I ²	4	0	0	4
CS 1114	Intro. Prog & Problem Solving	3	3	0	4
	Science/Engineering Elective ³				4
SL 1010	Freshman Seminar	1	1	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1252	Calculus Bus & Life Sci IIA (½ semester)	4	0	0	2
MG 1002	Foundations of Management	2	0	0	2
EN 1204	Writing & Humanities II	4	0	0	4
	Technical Elective				4
	Science/Engineering Elective ³				4
					16

SOPHOMORE YEAR

Fall Semester

MG 2204	Financial Accounting	4	0	0	4
MG 2004	Mngt. of Info. Tech. & Systems	4	0	0	4
MG 2104	Organizational Behavior	4	0	0	4
LA/TC/DM	Elective				4
					16

Spring Semester

EC 2524	Math Microeconomics	4	0	0	4
MG 2304	Marketing	4	0	0	4
MG 2014	Operations Management	4	0	0	4
MA 2054	Applied Data Analysis	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

MG 3204	Introduction to Finance	4	0	0	4
MG 3024	Mngt. of Data Comm. & Network	4	0	0	4
MG 3002	Project Management	2	0	0	2
PL 4052	Business Ethics	2	0	0	2
HI 2104	Modern World History	4	0	0	4
					16

Spring Semester

MG 3404	Innovation Management	4	0	0	4
MG 3304	Intro. Supply Chain Mngt. or	4	0	0	4
MG 3214	Advanced Corporate Finance Restricted Elective ⁵				4
	HU/SS Elective ⁴	4	0	0	4
					16

SENIOR YEAR

Fall Semester

MG 4004	Mgmt. Strategy in Tech. Sectors ⁵ or	4	0	0	4
FE	3 FE Electives ⁷ (1½ credits each)	4½			4½
MG 4404	Entrepreneurship ⁶ Restricted Elective ⁵	4	0	0	4
	HU/SS Elective ⁴	4	0	0	4
					16

Spring Semester

MG 4504	Global Perspect. on Tech Mngt.	4	0	0	4
MG 4014	Intro. to E-Business	4	0	0	4
MG 4204	Management Science ⁶ HU/SS Elective	4	0	0	4
					16

Total credits required for graduation:

128

- Students who are placed by examination or by an adviser into MA 914 must defer registration for calculus.
- Students who are placed by examination or by an adviser into EN 1080 must subsequently register for EN 1034, rather than EN 1014.
- Science/Engineering Electives are CM 1004, EG 1004, BMS 1004 and PH 1004.
- Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. BTM students cannot take EC 2504 or EC 2514 for credit.

- Restricted Electives are courses in math, science, humanities and social sciences.
- Students with a 3.6 GPA or better in major at the end of junior year may substitute MG 4514 Honors Capstone Project I (4 credits) for MG 4004 or MG 4404. They may also substitute MG 4524 Honors Capstone Project II (4 credits) for MG 4204.
- Technical Electives can be chosen from computer science, engineering, mathematics, chemistry, physics and bimolecular sciences
- FE Electives can be chosen from: FE 603, FE 611, FE 613, FE 615, FE 617 and FE 621

CHEMICAL AND BIOLOGICAL ENGINEERING PROGRAM

Academic Directors:

Walter Zurawsky (undergraduate)

José Pinto (graduate)

Chemical and biological engineers rely heavily on science, engineering methods, experience and ingenuity to develop the processes and equipment required for economical production of new and useful products. Chemical and biological engineers have contributed to the development of virtually every material common to modern life. In addition to bulk chemicals and petroleum products, they are involved with the production of plastics, pharmaceuticals, fertilizers and foodstuffs, synthetic rubber and rocket propellants, to name a few. Their influence has been felt in developing fuel cells, automatic controls, water desalination plants, missiles and artificial kidneys.

Chemical and biological engineers may choose from a 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 in chemical and biological engineering are virtually unlimited.

The foundations of chemical and biological engineering are the sciences, with emphasis on chemistry, biology, mathematics, physics and the engineering sciences (including thermodynamics, fluid mechanics, kinetics and heat and mass transfer). Courses include the analysis, design and control of equipment, operations and processes. Through this course of study, students develop the knowledge and analytical skills necessary to bridge the gap between scientific advances and large-scale production of products.

UNDERGRADUATE PROGRAM

The undergraduate program in chemical and biological engineering is a modern version of the traditional chemical engineering curriculum that was put forth by the department in May 2003. It aims to provide a solid foundation in science and the engineering sciences. An integrated set of chemical and biological engineering courses is built upon this foundation.

Thorough instruction is given in chemistry, biology, physics, mathematics and engineering science, which are basic to the understanding of physical, chemical and biological operations and processes. Courses in engineering science include engineering thermodynamics, reaction kinetics, process dynamics, fluid mechanics, heat transfer and mass transfer.

The undergraduate program leads to a Bachelor of Science in Chemical and Biological Engineering and is accredited by the Accreditation Board for Engineering and Technology (ABET).

GOALS AND OBJECTIVES

The objectives of the BS degree in Chemical and Biological Engineering are to produce graduates who:

1. Are well grounded in the fundamentals of chemical and biological engineering
2. Understand how to apply these fundamentals to the analysis and design of chemical and biological processes
3. Understand the social, economic and ethical problems inherent in the practice of chemical and biological engineering
4. Are committed to a lifetime of learning

With these attributes, graduates will be poised to become valuable members of the chemical and biological engineering profession and society as a whole and they will be prepared to work in industry or government or pursue advanced degrees. The department is committed to upgrading class offerings and engineering tools to continuously assure that students stay abreast of the latest developments in the field.

CURRICULUM

Design is an essential part of the chemical and biological engineering education and is incorporated into many of the courses. Generally, as students progress through the curriculum and learn more fundamental engineering science, more design components are introduced into the courses and the complexity of the design problems increases. Elements of design are contained in many courses and culminate in senior process design course. In this course students design chemical processes and must include

engineering, safety and economic considerations in their designs.

The chemical and biological 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.

REQUIREMENTS FOR THE BACHELOR OF SCIENCE

Polytechnic requires a 2.0 GPA or better for graduation. Students must also meet the academic standards of the department. For students to advance to their senior year courses, a 2.5 GPA must be maintained in freshman, sophomore and junior CBE courses. 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 students are permitted to enroll in chemical engineering courses.

GRADUATE PROGRAMS

Graduate programs in chemical engineering are designed to introduce students to advanced designs, research and development. The department offers graduate programs leading to a Master of Science in Chemical Engineering and Doctor of Philosophy in Chemical Engineering. (The department is in the process of modifying this program to one in chemical and biological engineering.) A BS degree in Chemical Engineering or a related field of science or 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. 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. Students must have had a course in differential equations. The program leading to a master's in chemical engineering may be used as either a terminal course for development and

CHEMICAL AND BIOLOGICAL ENGINEERING PROGRAM

advanced design or as a research degree giving preliminary graduate training for a doctorate in chemical engineering. The PhD in Chemical Engineering program provides advanced graduate study and research for qualified students interested in research and development.

GOALS AND OBJECTIVES

The objective of the MS degree in Chemical Engineering is to provide an understanding of the fundamental principles of chemical engineering subjects. The mathematical and computer training of the student is enhanced, and advanced design concepts are also emphasized. The MS program enables the student to develop laboratory and research skills and conduct an in-depth study of a specialized chemical engineering topic.

The objective of the PhD degree in Chemical Engineering is to provide advanced knowledge of chemical engineering fundamentals and research. The student also gains enhanced knowledge in a selected minor area. Research skills are refined, and the candidate performs basic research that advances the understanding of a specific chemical engineering discipline. The participating members of the department plan programs of study individually with each candidate. Systematic study toward a doctorate is carried out under a guidance committee appointed by the Office of Research and Graduate Studies. The program is planned to give students a thorough chemical engineering background accompanied by study in a minor field chosen by the candidate.

SPECIAL MOT TRACK:

Bio-Pharma Track

The Bio-Pharma MOT Track deals with the effective management of technology and innovation in the bio-pharma sectors. Jointly sponsored by the Department of Management and Othmer Department of Chemical and Biological Sciences and Engineering, this track covers the diverse array of firms that comprise the modern bio-pharma arena. The track also provides a broad and business-oriented overview of emerging technologies that are changing the nature of competition in bio-pharma. Finally, the Bio-Pharma Track introduces participants to the key managerial and competitive implications of developments that are significantly affecting the structure and future of bio-pharma value creation.

The Bio-Pharma curriculum is as follows:

First Semester

MG 865 Managing Innovation
MG 609 Managerial Accounting & Finance
MG 603 Organizational Behavior & Management in Innovative Corporations

Second Semester

MG 963 Information Technologies, Systems & Management in Organizations
MG 607 Marketing
CBE 771/MG 771 Bio-Pharma Sectors: Structure, Organization & Management

Third Semester

MG 672 e-Business Decision Making
MG 608 Managerial Economics
CBE 768/MG 772 Managing Technological Innovation & Emerging Technologies in the Bio-Pharma Sectors

Fourth Semester

MG 950 MOT Project Course Capstone
CBE 769/MG 773 Emerging Trends in Innovation & Technology in the Bio-Pharma Sectors
MG Elective Course I**
(select one from the list below)
MG Elective Course II**
(select one from the list below)

Elective Course Portfolio

MG 781 Selected Topics in Networking & Information Technologies**
MG 784 Negotiation in Technology-Intensive Sectors**
MG 785 High-Technology Leadership**
MG 786 High Technology Entrepreneurship
MG 787 Intellectual Property for Technology & Information Managers**
MG 788 Modern Supply Chain Management: Integration Through Technology**
MG 789 Special Elective Topics for MOT and TIM**
MG 797 Financing for Value Creation**
MG 820 Project Management & Assessment for Technology Managers*

* variable credit (11?2/3 unit) course

** half-semester courses offered in third or fourth semesters

REQUIREMENTS FOR THE MASTER OF SCIENCE

Candidates for the MS in Chemical Engineering are to plan their programs in accordance with the following list of requirements for full-time study:

FULL-TIME STUDENTS

1. Required Subjects		12
Course No.	Course Title	Units
CH 615	Applied Mathematics in Chemical Engineering	3
CH 633	Transport Phenomena	3
CH 773	Chemical Engineering Thermodynamics	3
CH 781	Chemical Reactor Analysis & Design	3
CH 991/992	Departmental Seminar	0

2. Electives: four courses 12

At least two electives must be chosen from CH 600-CH 940, while the other two may be chosen from another science or engineering department with the approval of the graduate adviser in chemical engineering.

3. CH 997 Master's Thesis 12

Total 36

Part-time students can choose between the above program and the Guided Study Option, which includes the following requirements:

PART-TIME STUDENTS

1. Required subjects: as above 12

2. Electives: six courses 18

At least two electives must be chosen from CH 600 - CH 940, while the other four 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 6

Total 36

To meet graduation requirements, students must have an overall B average in all courses (excluding MS Thesis or Guided Study Project) and must not obtain more than two grades of C in required subjects.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY

Students must pass a comprehensive qualifying examination in chemical engineering and present a doctoral dissertation. The qualifying exam is given once a year. Additional details on the qualifying examination should be obtained from the graduate adviser.

Each candidate for the doctorate must complete a minimum of 90 units 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 PhD 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 MS thesis and at Polytechnic University. A minimum of 24 graduate units beyond the bachelor's degree (not including PhD or

MS 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 Polytechnic. The minor must meet the approval of the graduate adviser in chemical engineering. Attendance is required at departmental 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 two grades of C in required subjects.

Candidates for the degree Doctor of Philosophy in Chemical Engineering are to plan their programs in accordance with the following requirements:

1. Required Subjects 12

Course No.	Course Title	Units
CH 615	Applied Mathematics in Chemical Engineering	3
CH 633	Transport Phenomena	3
CH 773	Thermodynamics	3
CH 781	Chemical Reactor Analysis & Design I	3
CH 991*	Departmental Seminar	0

* CH 991 must be taken for two years.

2. Electives: seven courses, of which at least two must be in chemical engineering subjects. 21

To be chosen in conference with the graduate adviser in Chemical Engineering.

3. Minor: three courses 9

A minor must be taken in another science or engineering department with the approval of the graduate adviser in chemical engineering.

4. CH 989 PhD Thesis 48

Up to 12 units of Master's Thesis can be included here.

Total 90

UNDERGRADUATE COURSES

CBE 1124 Introduction to Chemical and Biological Engineering 4:0:0:4

This course introduces and develops design and analysis from a broad view through real-world examples. Simple material and energy balances are introduced along with the concept of mathematical modeling. Graphical analysis as a

design tool is introduced along with basic concepts of error, uncertainty and data fitting. Dimensional analysis and the concept of scaling are developed. *Prerequisites: CM 1004 and EG 1004.*

CBE 2124 Analysis of Chemical and Biological Processes 4:0:0:4

This course prepares students to formulate and solve material and energy balances on chemical and biological process systems and lays the foundation for subsequent courses in thermodynamics, unit operations, kinetics, and process dynamics and control. More fundamentally, it introduces the engineering approach to problem solving: breaking a process down into its components, establishing the relations between known and unknown process variables, assembling the information needed to solve for the unknowns and, finally, obtaining the solution using appropriate computational methods. *Prerequisites: CM 1004 and MA 1022.*

CBE 3102 Mathematical Methods for Chemical and Biological Engineers 2:0:0:2

This course examines a set of essential linear and nonlinear mathematical methods needed to the solution of engineering problems described by sets of algebraic equations, ordinary differential, as well as partial differential equations. Emphasis is placed in understanding the fundamental mathematical ideas through their effective application in complex engineering problems. Chemical and biological engineering problems that are examined include but are not limited to the following areas: complex reaction networks representative of industrial catalytic reactions or metabolic transformations within a cell, transient phenomena in chemical and biological reactors, mass transfer operations across membranes or in microelectronic operations. Students are also exposed to modern concepts such as chaos and complexity. *Prerequisites: CBE 2124, MA 2122, MA 2132 or equivalent.*

CBE 3134 Physical Rate Processes 4:0:0:4

Introduction to conservation of mass, momentum and energy in open systems. Newtonian fluids in laminar and turbulent flow. Differential equations for conservation of mass and momentum. Differential equations for heat transfer by conduction and convection. Use of those

differential equations to analyze chemical and biological systems. *Prerequisites: MA 2132 and CBE 2124.*

CBE 3153 Chemical and Biological Engineering Thermodynamics 3:0:0:3

Thermodynamics of flow systems. Properties of fluids with advanced equations of state. Properties of non-ideal mixtures. Activity coefficient models for nonelectrolyte and electrolyte solutions. Phase equilibrium calculations at low and elevated pressures by computer procedures. Chemical reaction equilibria. *Prerequisites: CBE 2124 and CM 2514.*

CBE 3224 Chemical and Biological Reactor Engineering 4:0:0:4

This course provides students with the fundamentals of thermodynamics and kinetics of chemical and biological reactions and the development of skills to analysis and design reactor systems. Typical topics include homogeneous and heterogeneous reactors of various types, catalyzed and non-catalyzed reactors and the design of single and cascaded chemical and bio-reactors. Students are given computer procedures for the design of reactors and the corresponding energy interactions. *Prerequisites: CBE 3102, CBE 3134 and CBE 3153.*

CBE 3234 Chemical and Biological Engineering Separations 4:0:0:4

Introduction to the many aspects of mass transfer. Topics range from diffusion, convection and mass transfer coefficients to the analysis and design of separation processes such as distillation, absorption and extraction. Analytical and computer techniques are stressed. *Prerequisites: CBE 3134 and CBE 3153.*

CBE 4113 Engineering Laboratory I 1:6:0:3

Introduction to and performance of experiments in unit operations, transport processes and unit processes. Students analyze and design their experiments to meet stated objectives; results are presented in written and oral form. *Prerequisite: CBE 3234.*

CBE 4143 Process Dynamics and Control 3:0:0:3

Introduction to system dynamics and process control. Dynamic models of

CHEMICAL AND BIOLOGICAL ENGINEERING PROGRAM

chemical processes are developed. The design and tuning of feed—back and feed—forward controllers are discussed and students are introduced to multiple input—multiple output systems and large system control issues. *Prerequisites: CBE 3102 and CBE 3224.*

CBE 4163 Chemical and Biological Process Design I 3:0:0:3

This course provides students with the skills necessary to synthesize and design chemical and biological processes with considerations of site and process selections, process economics, materials of construction, data requirements and acquisition flow-sheeting and subsystems. Students are given computer procedures and case studies to gain experience in process simulation and analysis. *Prerequisites: CBE 3153 and CBE 3234.*

CBE 4173 Polymeric Materials 3:0:0:3

Processing, structure, properties and applications of polymers as engineering materials, including renewable-resource based biopolymers. Fundamentals of processing-morphology-property correlations in materials. Basic concepts of viscoelasticity, fracture behavior and thermal and electrical properties of engineering polymeric materials. *Prerequisite: CBE 3134.*

CBE 4213 Engineering Laboratory II 1:6:0:3

Continued experiments in unit operations, transport processes and process control. Students analyze and design their experiments to meet stated objectives. Their results are presented in written and oral form. *Prerequisites: CBE 4113 and CBE 4143.*

CBE 4263 Chemical and Biological Process Design II 3:0:0:3

This course provides students with the skills to optimally design industrial processes synthesizing their knowledge from previous chemical and biological engineering courses. Students are given more advanced computer procedures and work on case studies to gain further experience in process simulation and analysis. Design projects are conducted in a team environment similar to that found in industry. *Prerequisites: CBE 4143 and CBE 4163.*

CBE 481X/482X Chemical Engineering Project up to 4 credits

Independent work in areas of interest in chemical engineering selected by students and faculty supervisors. Not open to honors or senior thesis students. X = 1, 2, 3 or 4 and designates the number of credits. *Prerequisite: adviser's approval.*

CBE 491X/492X Bachelor's Thesis in Chemical Engineering up to 4 credits

Original investigations of problems in chemical engineering with a faculty supervisor. A thorough search of the literature is required. Special apparatus constructed as required for experimental work. X = 1, 2, 3 or 4 and designates the number of credits. *Prerequisite: adviser's approval.*

CBE 4954 Chemical Engineering Internship 4 credits

Supervised, creative engineering experiences of at least two months' duration, typically taken during the summer, culminating in written and oral reports presented to industrial and faculty supervisors. Faculty visitations and conferences during internships are arranged. *Prerequisites: senior standing and adviser's approval.*

GRADUATE COURSES

CH 615 Applied Mathematics in Chemical Engineering 2½:0:0:3

Mathematical formulation of chemical engineering problems in terms of ordinary, partial differential and differential 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 633 Transport Phenomena 2½:0:0:3

Fundamental concepts of momentum, energy and mass transport applied to stationary and flow systems under both steady-state and transient conditions. Topics include conservation equations in both differential and integral form, creeping and inviscid flow, convective heat and mass transfer, coupled transport and boundary layers. *Prerequisites: CH 615, CBE 3134 and CBE 3234, or equivalent.*

CH 637 Engineering Principles of Drug Delivery 2½:0:0:3

Fundamental concepts in drug delivery from an engineering perspective. Biological organisms are viewed as highly interconnected networks where the surfaces/interfaces can be activated or altered 'chemically' and 'physically'. Topics include drug delivery mechanisms (passive, targeted), therapeutic modalities, principles of controlled release and quantitative understanding of drug transport, characteristics of delivery molecules and assemblies (polymer based, lipid based), significance of biodistributions and pharmacokinetic models, consideration of toxicity issues. *Prerequisites: CBE 3134 and CBE 3234 or equivalent.*

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_x, SO_x, CO, etc.) and of aerosols and other particulates. *Prerequisite: adviser's approval.* Also listed under CE 758.

CBE 768 Managing Innovation and Emerging Technologies in the Bio-Pharma Sectors 2½:0:0:3

Introduction to technological innovation and emerging technologies that are changing the nature of competition in the bio-pharma sectors. Concentrates on modern approaches for research and discovery of new molecules and on development of processes to manufacture them in large quantities. Explores the two major routes for this discovery activity and manufacturing processes: the "chemical" route and the "biological" route. Provides a blend of conceptual overviews, essential technical and scientific basics, competitive, regulatory and management implications of the developments studied and specific cases studied and industry examples. Also listed under MG 772.

CBE 769 Emerging Trends in Innovation and Technology in the Bio-Pharma Sectors 2½:0:0:3

Deals with selected important trends and issues that are having a major influence on the management of innovation and technology in the bio-pharma sectors.

Covers a range of topics and comprises written papers, team presentations, readings and invited speakers. Intended to be integrative, and demands application of the knowledge gained in the Management of Technology Program as a whole. Actual topics explored may vary from year to year. Also listed under MG 773.

CBE 771 The Bio-Pharma Sectors: Structure, Organization and Management 2½:0:0:3

Introduction to effective management in the modern bio-pharma sectors. Investigates how key bio-pharma firms are organized and managed at both the strategic and operational levels. Particular attention is paid to various forms of technology and innovation management occurring in the bio-pharma arena. Also listed under MG 771.

CH 773 Chemical Engineering Thermodynamics 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: CBE 3152 or equivalent.*

CH 781 Chemical Reactor Analysis and Design 2½:0:0:3

Kinetics of complex homogenous and heterogeneous reactions: determination of kinetic parameters, effects of transport processes; catalyst deactivation. Analysis and design of reactors; ideal reactors, effects of nonideal flow; fixed-bed, fluidized-bed and multiphase reactors. *Prerequisite: CBE 3224 or equivalent.*

CH 821 Process Optimization 2½:0:0:3

The Mathematical programming approach. Tree and Network representations. Review of the basic concepts in optimization. Kuhn-Tucker optimality conditions. Modeling techniques for formulating nonlinear models. Non-linear programming algorithms. Review of linear programming. Mixed-integer programming techniques. Modeling of continuous and discrete decisions. *Prerequisites: CH 615 or instructor's permission.*

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. *Prerequisites: CBE 3134 and CBE 3234 or instructor's permission.*

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. *Prerequisite: 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. Modeling 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 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.*

CH 900/901 Selected Topics in Chemical Engineering variable credit

Topics of special interest in chemical engineering announced in advance of each semester's offerings.

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 prob-

lems 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 are required to submit three unbound copies of their reports to advisers one week before the last day of classes. *Prerequisite: degree status.*

CH 991/992 Departmental Seminars no credit

Recent developments in chemical and biological sciences and engineering are presented by engineers and scientists from industry and academia. Two semesters are required for MS candidates and four semesters for PhD candidates.

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

Theses for the 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 are required to submit four unbound copies to advisers before the seventh Wednesday prior to commencement. *Prerequisite: degree status.*

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

Theses for the PhD degree 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, worthy of publication in recognized journals, have been made to chemical engineering. Candidates are required to take oral examinations on thesis subjects and related topics. Doctoral degree candidates must submit five unbound thesis copies to advisers before or on the seventh Wednesday prior to commencement. *Prerequisites: doctoral qualifying examination and PhD research proposal.*

Typical Course of Study for the Bachelor of Science in Chemical and Biological Engineering

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1012	Calculus IA1 (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
CM 1004	General Chemistry	3	2	1	4
EN 1014	Writing & Humanities I ¹	4	0	0	4
EG 1004	Intro. Engineering & Design	1	3	2	4
SL 1010	Freshman Seminar	1	1	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1112	Calculus IIA (½ semester)	4	0	0	2
MA 1122	Calculus IIB (½ semester)	4	0	0	2
BMS 1004	Intro. to Cell & Molec. Biology	3	3	0	4
CBE 1124	Intro. to Chem. & Bio. Eng. Design	4	0	0	4
EN 1204	Writing & Humanities II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

MA 2012	Linear Algebra I (½ semester)	4	0	0	2
MA 2132	Ordinary Diff. Equ. (v semester)	4	0	0	2
PH 1004	Introductory Physics I	4	2	1	4
CM 2234	Industrial Organic Chemistry	4	0	0	4
CBE 2124	Anal. of Chem. & Bio. Processes	4	0	0	4
					16

Spring Semester

MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi. Calculus B (½ semester)	4	0	0	2
CS 1114	Intro. to Program. & Prob. Solving	3	3	0	4
CM 2514	Chem. & Bio. Equilibria	4	0	0	4
PH 2004	Introductory Physics II	4	1½	1	4
					16

JUNIOR YEAR

Fall Semester

CM 3314	Biochemistry I	4	0	0	4
CBE 3103	Math. Methods. for Chem. & Bio. Engineers	2	0	0	2
CBE 3152	Chem. & Bio. Eng. Thermo	3	0	0	3
CBE 3134	Physical Rate Processes	4	0	0	4
HI 2104	Modern World History	4	0	0	4
					17

Spring Semester

CBE 3234	Chem. & Bio. Eng. Separations	4	0	0	4
CBE 3224	Chem. & Bio. Reactor Eng. HU/SS Elective ³	4	0	0	4
	Sequence Elective I ⁴				4
					16

SENIOR YEAR

Fall Semester

CBE 4113	Engineering Laboratory I	1	6	0	3
CBE 4143	Process Dynamics & Control	3	0	0	3
CBE 4163	Chem. & Bio. Eng. Proc. Design I	3	0	0	3
	Sequence Elective II ⁴				4
	HU/SS Elective ³	4	0	0	4
					17

Spring Semester

CBE 4123	Engineering Laboratory II	1	6	0	3
CBE 4173	Polymeric Materials	4	0	0	3
CBE 4263	Chem. & Bio. Eng Proc. Design II	4	0	0	3
	Engineering Elective ⁵				3
	HU/SS Elective ³	4	0	0	4
					16

Total credits required for graduation:

130

1. Students who are placed by examination or by an adviser into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1012.

2. Students who are placed by examination or by an adviser into EN 1080 must subsequently register for EN 1034, rather than EN 1014.

3. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II Elective courses in different disciplines and one from Level III Advanced Elective courses.

4. A list of approved Sequence Electives is available from the department.

5. Engineering Electives must be engineering courses unless the Sequence Electives are in engineering, then the electives may be a non-engineering technical course.

TRANSFER STUDENTS must substitute an engineering elective for EG 1004.

CHEMISTRY PROGRAM

Program Directors:

Bruce A. Garetz (undergraduate)

Mary K. Cowman (graduate)

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

Classical divisions of chemistry are (1) organic chemistry, dealing primarily with compounds of carbon; (2) inorganic chemistry, concerned with all other compounds; (3) analytical chemistry, concerned with quantitative determinations of composition; and (4) physical chemistry, which seeks understanding of matter, including chemical bonds and molecular interactions. These classical fields have increasingly overlapped, and several interdisciplinary fields are now of great importance: biochemistry, electrochemistry, photochemistry, polymer chemistry, solid-state chemistry and chemical physics.

The Othmer Department of Chemical and Biological Sciences and Engineering offers a full complement of undergraduate and graduate courses in various aspects of modern chemistry. Graduates are prepared for positions at educational institutions, research institutes, industrial organizations and government laboratories.

Staff members conduct and supervise research at undergraduate, graduate and postdoctoral levels. This research is combined with teaching so that courses at all levels are taught by chemists highly competent in their respective fields.

Undergraduates participating in optional research activities are stimulated and well-prepared for graduate school or professional positions. The department offers programs leading to a Bachelor of Science in Biomolecular Science, a Master of Science in Chemistry and a Doctor of Philosophy in Materials Chemistry.

GOALS AND OBJECTIVES

The goals of the Master of Science program are to advance students' knowledge and experience beyond the BS level and equip them with the needs of a changing industrial environment.

The goal of the PhD program is to offer candidates an opportunity to learn various aspects of materials chemistry especially associated with polymers and biological materials.

UNDERGRADUATE PROGRAM

The BS degree requirements are described in the Biomolecular Science Program section of this catalog. Note, in particular, the option in chemistry.

GRADUATE PROGRAMS

Admission to graduate studies in chemistry requires a solid 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 taken differential equations and modern physics. All applicants are required to take the Graduate Record Examination (general and chemistry). Applicants for whom English is a second language must score at least 550 on the TOEFL. Chemistry graduate students cannot take CM 5011, CM 5024 or CM 5040 for graduate credit.

Students in this program are trained and given the appropriate knowledge to function at the mid-managerial level of the chemical industry and other organizations involved in chemically related work. Certain students in this program can be expected to continue their efforts toward the doctoral degree. Many students in this program may already be employed in chemistry related institutions and will gain the knowledge to move ahead in these organizations. The MS program will allow graduate credit

for both courses and special studies that may involve research as arranged with advisers in the program.

REQUIREMENTS FOR THE MASTER OF SCIENCE

A total of 36 units past the bachelor's degree is required with an overall GPA 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:

Course No.	Course Title	Units
CM 601	Inorganic Chemistry	4½
CM 703	Chemical Physics I	4½
or		
CM 704	Chemical Physics II	4½
CM 802	Applied Spectroscopy	4½
or		
CM 907	Organic Spectroscopy	4½
CM 903	Organic Chemistry I	4½
or		
CM 904	Organic Chemistry II	4½

Upon 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 to write a thesis are required to take 3 to 6 units of guided studies (CM 871, CM 872) with the submission of a written report.

Students in the master's program must participate in seminars for two semesters (CM 973, CM 974); those not preparing 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 5040 Chemical Laboratory Safety. Students are strongly encouraged to take CM 5011 Information Sources for the Chemical Sciences.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY

The research aspect of the PhD program is essential, and students are expected to take on a student/mentor relationship with a faculty member. This is an outstanding opportunity since the faculty participating in this program are internationally known for their research. With solid training in research, graduates will be in a position to move into the academic world as professors in their own right, as well to take leadership positions in research institutes, industrial organizations, and government laboratories. In graduating from this program, students join the many generations before them who have received the doctoral degree in chemistry from Polytechnic—a fellowship of excellence and filled with people who have made distinguished careers in the chemical sciences.

Programs of study are planned individually. Students select a research adviser after interviewing a minimum of five faculty members. They must take the preliminary examination—which can include both a written and an oral component—during their first or second year as determined by the graduate adviser, based on the student’s prior graduate experiences at the time of admission. Students then select a dissertation committee made up of at least four members—including a research adviser, major adviser, minor adviser and at least one outside expert in the field—who monitors the student’s progress through the rest of the program. When all thesis research is completed, students schedule an oral defense of the thesis. The dissertation committee makes the final judgment on awarding a PhD.

A total of 90 units past the baccalaureate degree level is required. At least 45 units must be for dissertation research (33 units of research for holders of an MS based on research and thesis acceptable to department). A GPA of B or better is mandatory in all courses (not including dissertation research) submitted for a PhD and a grade of A or B is required for the dissertation.

Currently, the department offers a PhD with a major in materials chemistry. Minors are also required and may be in biochemistry, inorganic chemistry, organic chemistry, physical chemistry, polymer chemistry and, additionally, in other departments or areas such as polymer science and engineering. The program includes the following courses, for

which students must maintain a B average or better:

1. Required Courses: in the doctoral curriculum, required courses are listed below.

Course No.	Course Title	Units
CM 601	Inorganic Chemistry	4½
CM 703	Chemical Physics I	4½
or		
CM 704	Chemical Physics II	4½
CM 802	Applied Spectroscopy	4½
or		
CM 907	Organic Spectroscopy	4½
CM 903	Organic Chemistry I	4½
or		
CM 904	Organic Chemistry II	4½

These courses are offered in two consecutive terms so that full-time students entering in the fall can complete the sequence in two terms. In addition to the 18 units of required courses listed, PhD students must take CM 5040 Chemical Laboratory Safety and fulfill the seminar and other requirements described in the catalog.

2. Minor Requirements: the department offers a minor concentration in biochemistry, inorganic, organic and 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. Students select courses to fulfill minors in consultation with a minor adviser.

3. Students must participate in seminar for four semesters, twice as a lecturer.

4. Students must present research in a dissertation.

5. All doctoral students must take CM 5040 Chemical Laboratory Safety prior to registering for thesis research.

6. Students are strongly encouraged to take CM 5011 Chemical Literature.

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

8. 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 a Master of Science upon satisfactory completion with a B average of course requirements and 12 units of research toward doctoral dissertations, as certified by the chair of the guidance committee. Students are certified as having earned a Master of Science on application to the Office of the Dean of Engineering and Applied Sciences and after completion of preliminary examinations.

UNDERGRADUATE COURSES

CM 1004 General Chemistry for Engineers 3:2:1:4

See course description in the Department of Introductory Design and Science section in Part 2 of this catalog.

CM 1014 General Chemistry I 3:2:1:4

Chemical equations, chemical conservation laws, stoichiometry, thermochemistry, properties of gases, atomic structure, periodic table, chemical bonding and molecular structure. Required course for students in the Biomolecular Science program.

CM 1024 General Chemistry II 3:2:1:4

States of matter, chemical thermodynamics and equilibria, kinetics, acid-base chemistry, electrochemistry, introduction to organic chemistry, natural and synthetic polymers. Required course for students in the Biomolecular Science program.

CM 2214 Organic Chemistry I 3:3:0:4

Chemistry of organic molecules: structure, nomenclature, properties and reactions of carbon compounds with emphasis on aliphatic compounds. Introduction to reaction mechanisms and stereochemistry. Includes laboratory involving methods for preparation, isolation and purification of typical organic compounds. Experiments chosen to illustrate basic techniques. Lab fee required. *Prerequisite: CM 1004 or CM 1024.*

CM 2224 Organic Chemistry II 3:3:0:4

Continuation of CM 2214 with emphasis on finding the principles of organic chemistry in industrial practice and biochemical mechanisms. Includes laboratory stressing complex preparation, purification, characterization and identification of organic compounds by chemical and physical means. Introduction to instrumental methods of analysis and identification. *Prerequisite: CM 2214.*

CM 2234 Industrial Organic Chemistry 4:0:0:4

This course demonstrates the basic ideas of organic chemistry using industrial processes and important commercial materials. Covers the petroleum-based foundations of organic materials and shows how these petroleum-derived molecules ultimately lead, via important chemical reactions and intermediates, to the commercial products produced by the chemical industry. Course demonstrates how the principles of organic chemistry are intertwined with the many changes that characterize the chemical industry. The material presented in this course is couched in a historical context. *Prerequisite: CM 1004 or equivalent.*

CM 2514 Chemical and Biological Equilibria 4:0:0:4

Chemical thermodynamics with applications to solution, phase and chemical equilibria; chemical and biological kinetics. *Prerequisites: CM 1004, MA 1122, PH 1004*

CM 2614 Physical Chemistry I 4:0:0:4

Chemical thermodynamics with applications to solutions, phase and chemical equilibria. Molecular motion and transport properties. *Prerequisites: CM 1004 or CM 1024 and MA 1122 and PH 1004.*

CM 3114 Inorganic Chemistry 3:3:0:4

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. *Prerequisite: CM 2514 or CM 2614.*

CM 3314 Biochemistry I 4:0:0:4

Survey of modern biochemistry with emphasis on current areas of research. Structure-function relationships in proteins. Enzymes and their mechanisms of action. Bioenergetics principles and energy production. Biochemical theories and techniques. *Prerequisites: CM 2214 and CM 2614 or CM 2514 or instructor's permission.*

CM 3324 Biochemistry II 4:0:0:4

Continuation of Biochemistry I. Principles of intermediary metabolism, energetics, membrane structure and transport; structure and function of DNA and RNA, principles of molecular biology, the immune system, hormonal regulation, cancer. *Prerequisite: CM 3314 or instructor's permission.*

CM 3514 Analytical Chemistry 3:3:0:4

Theories and applications of instrumentation techniques in modern analytical chemistry, including spectroscopy (UV-VIS absorption, infrared absorption, fluorescence, Raman scattering, nuclear magnetic resonance), chromatography (gas, liquid), and other techniques (mass spectroscopy, electrophoresis). The accompanying laboratory part focuses on practical skills. *Prerequisite: CM 2514 or CM 2614.*

CM 3614 Physical Chemistry II 2:6:0:4

Chemical kinetics. Molecular structures and interactions, and their relationship to the bulk properties of matter. Laboratory component comprises and introduction to the experimental quantitative methods of analytical and physical chemistry, including volumetric, calorimetric and optical techniques. Computer analysis of data and report writing. *Pre-requisite: CM 2514 or CM 2614.*

CM 4314 Biomaterials 4:0:0:4

Natural macromolecules, including polypeptides, polysaccharides, lignin, biodegradable polymers, and special characterizations of these biopolymers. *Prerequisite: CM 4414.*

CM 4413 Polymer Science 3:0:0:3

This course gives students a broad perspective of polymer science and its application in everyday life. The course has three major components: a survey of polymers, polymer synthesis and aspects of polymer physics. *Prerequisites: CM 2214 and CM 2614 or CM 2514.*

CM 4414 Polymer Chemistry 3:3:0:4

An introduction to polymer science. The course includes principles of various polymerization methods, characterization and physical chemistry of polymers. Includes laboratory. *Prerequisites: CM 2214 and CM 2514 or CM 2614.*

CM 4914/4924 Undergraduate Research in Chemistry each 4 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 8 credits of thesis during senior year. Research (lab) fee required. *Prerequisites: CM 5010 and CM 5040.*

CM 5714 Molecular Modeling and Simulation 3:3:0:4

See listing under "Undergraduate and Graduate Courses."

UNDERGRADUATE AND GRADUATE COURSES**CM 5011 Information Sources for the Chemical Sciences** 1:0:0:1

A hands-on introduction to methods and tools for searching. Includes both electronic (CD-ROM and online) as well as print databases. Students may emphasize topics related to their research. Required of all BS students in chemistry. Graduate students are encouraged to take this course; no credit counts toward degree requirements in chemistry graduate programs.

CHEMISTRY PROGRAM

CM 5024 Environmental Chemistry 4:0:0:4

Chemical properties of pollutants in air, water, soil and hazardous wastes. Effects of chemical pollutants on health. *Prerequisites: CM 2214 and CM 2614 or instructor's permission. This course does not fulfill requirements for a regular MS or PhD in Chemistry.*

CM 5040 Chemical Laboratory Safety 1:0:0:0

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.

CM 5714 Molecular Modeling and Simulation 3:3:0:4

Principles and applications of modern molecular modeling and simulations methods, using commercially available software packages on powerful computer workstations. Algorithms for visualization and prediction of structural and physical properties of molecules and molecular aggregates based on the principles of quantum, classical and statistical mechanics, which will be reviewed in a mathematically simplified form. An accompanying laboratory part. *Prerequisites: completion of core undergraduate courses in mathematics and science (grade C or better) in CM, CH, ME, EE, CS, PH, CE or equivalent.*

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 PhD degree in chemistry.

CM 615 Advanced Topics in Inorganic Chemistry 2½:0:0:3

Advanced topics in inorganic chemistry.

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 750 Special Topics in Physical Chemistry 2½:0:0:3

Advanced or specialized topics in physical chemistry.

CM 5714 Molecular Modeling and Simulation 3:3:0:4

See listing under "Undergraduate and Graduate Courses."

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 2214 and CM 2614 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 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 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 minor field requirements in polymers or biochemistry. *Pre-/Co-requisite: CM 941 or instructor's permission.*

CM 792 Natural Polymers and Materials 2½:0:0:3

Introduction to natural and biomimetic polymers taught with an interdisciplinary view of biology, chemistry and macromolecular science. Topics covered in this course include: natural building blocks and methods by which nature carries out polymer synthesis and modification reactions; DNA; structural proteins; plant proteins; polysaccharides; polyesters; biosurfactants; polymers built from natural monomers and a wide variety of renewable resources; uses of these polymers as fibers, films, rheological modifiers, flocculants, foams, adhesives and membranes; special applications of natural polymers in medicine and as biodegradable plastics. *Prerequisites: CM 1004 or CM 1024 and BMS 1004.*

ANALYTICAL CHEMISTRY**CM 802 Applied Spectroscopy** 3¼:0:0:4½

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.

CM 850 Special Topics in Analytical Chemistry 2½:0:0:3

Advanced or specialized topics in analytical chemistry.

**ORGANIC CHEMISTRY
CM 903 Organic Chemistry I**

3¼:0:0:4½

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 3¼:0:0:4½

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 instructor's permission.*

CM 905 Enzyme-Catalysis in Organic Synthesis 2½:0:0:3

Provides students with a working knowledge of how to use biotransformations as a tool in organic chemistry. Students will learn about general enzymatic reaction types that carry out the cleavage and formation of C-O bonds, P-O bonds, C-N bonds, C-C bonds, reduction reactions, oxidation reactions and isomerizations. In addition, students will be taught about advanced principles that are currently being applied to the engineering of catalytic proteins. *Prerequisites: CM 2214, CM 2614 and CM 3314.*

CM 906 Combinatorial Chemistry 2½:0:0:3

Discussion of the development and practice of combinatorial chemistry and high throughput experimentation. The goals of the course include: knowledge of the origin, development and present day practice of combinatorial chemistry for preparation of libraries of chemical compounds; understanding of pharmaceutical models for high throughput discovery of drug compositions; the process of devel-

oping solid and liquid-phase methods for high throughput screening of compositions for particular applications; recent examples where the above principles have been applied to the discovery of new materials, including catalysts and materials for electronic devices. *Prerequisite: CM 903.*

CM 907 Organic Spectroscopy 3¼:0:0:4½

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, CM 904 or instructor's permission.*

CM 940 Special Topics in Organic Chemistry 2½:0:0:3

Topics selected from current research or literature and approaches to problem solving. *Pre-/Co-requisite: 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: instructor's permission.*

CM 945 Advanced Topics in Biochemistry 2½:0:0:3

Selections from the following topics: protein and nucleic acid chemistry; intermediary metabolism; metabolic regulation. *Prerequisite: CM 941 or instructor's permission.*

CM 950 Principles of Biological Systems 5:0:0:6

Physiology is defined as the science that deals with the functions of the body. It logically follows, therefore, that a sound, comprehensive knowledge of human physiology should occupy a significant part of the academic training of personnel

CHEMISTRY PROGRAM

in medicine and related fields. The emphasis is on normal functions, but also considers the consequences of disease and injury, and deal with the body's potential for recovery and for compensation. Behavioral responses to environmental conditions are considered, but in this area the chief concern will be with the regulation and control of fundamental reflexes or neuro-endocrine mechanisms.

CM 952 Molecular and Cellular Biology I *2½:0:0:3*

Lectures, discussions and student presentations on the varying contributions of different molecular mechanisms to the control of gene expression. Topics include the biochemistry of nucleic acids, the basis of Central Dogma, the structure of prokaryotic genomes, bacterial genetics, the organization and structural arrangement of the eukaryotic genome, DNA replication, recombination, techniques of and strategies for cloning and analyzing genes, transcription in prokaryotes and eukaryotes, the operon concept and regulatory strategies for genetic expression, synthesis and processing of RNA in eukaryotes, mechanisms for protein synthesis and its regulation. *Prerequisites: CM 950 or its equivalent and undergraduate biochemistry.*

GENERAL COURSES

CM 751 Chemical Foundation for Bioinformatics *2½:0:0:3*

An intensive review of those aspects of organic chemistry and biochemistry necessary to begin research in bioinformatics and to enter graduate courses in biology. Covalent bonding, quantum mechanical basis of bond formation, three-dimensional structure of molecules, reaction mechanisms, catalysis, polymers, enzymes, thermodynamic and kinetic foundations, metabolic pathways, sequence and structure of macromolecules. This course makes extensive use of computer approaches to convey the essential computational and visual nature of material to be covered. *Prerequisites: general chemistry, general physics, organic chemistry and calculus.*

CM 752 Biological Foundation for Bioinformatics *2½:0:0:3*

An intensive review of those aspects of biochemistry, molecular biology and cell biology necessary to begin research in bioinformatics and to enter graduate courses in biology. Areas covered include cell structure, intracellular sorting, cellular signaling (receptors), Cytoskeleton, cell cycle, DNA replication, transcription and translation. This course makes extensive use of computer approaches to convey the essential computational and visual nature of the material to be covered. *Prerequisites: CM102, general chemistry, general physics, organic chemistry, calculus or instructor's permission.*

CM 753 Bioinformatics I: Sequence Analysis *1½:2:0:3*

Computer representations of nucleic acid and protein sequences, pairwise and multiple alignment methods, available databases of nucleic acid and protein sequences, database search methods, scoring functions for assessment of alignments, nucleic acid to protein sequence translation and codon usage, genomic organization and gene structure in prokaryotes and eukaryotes, introns and exons, prediction of open reading frames, alternative splicing, existing databases of mRNA, DNA protein and genomic information. An overview of available programs and of resources on the web. Lab is an integral part of this course.

CM 754 Bioinformatics II: Protein Structure *1½:2:0:3*

Protein folding representations, databases of protein folding classes, secondary structure prediction, tertiary structure prediction via computer folding experiments threading, and homology model building, prediction of post translation modification sites, active and binding sites in proteins, representations of contiguous and non-contiguous epitopes on protein surfaces at the sequence level, representations of functional motifs at the three dimensional and at the sequence level. Lab is an integral part of this course. *Prerequisite: CM 753.*

CM 755 Bioinformatics III: Functional Prediction *1½:2:0:3*

Functional classifications of proteins, prediction of function from sequence and structure, Orthologs and paralogs, representations of biological pathways, available systems for the analysis of whole genomes and for human-assisted and automatic functional prediction. Lab is an integral part of this course. *Prerequisite: CM 754.*

CM 756 Chemoinformatics *1½:2:0:3*

Review of Database Theory, Chemical Structure Representation; connection tables, line notations, structure diagrams, Representations of Chemical Reactions, Structure manipulation: Graph Theory, Structure Analysis: ring perception, structural fingerprints, symmetry perception, Molecular Modeling Algorithms, Genetic Algorithms, Simulated Annealing, QSAR historical approaches, Structural Search of Chemical Databases, Commercial Chemical Information Databases, Combinatorial Chemistry and diversity assessment.

CM 757 Special Topics in Informatics in Chemical and Biological Sciences

Presentation at intervals of various advanced or specialized topics in chemo- or bioinformatics.

CM758/9 Guided Studies in Informatics in Chemical and Biological Sciences

As arranged

CM 760 Research in Informatics in Chemical and Biological Sciences

As arranged

Original research, which serves as basis for master's degree. 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 have passed required oral examinations. Research credits registered for each semester realistically reflect time devoted to research. *Prerequisites for MS candidates: degree status and consent of graduate adviser and thesis director.*

CM 871/872 Guided Studies in Chemistry
As arranged

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 0:0:1¹/₄:1¹/₂

Chemical topics of current interest presented by participating students, staff and 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 PhD candidates before completion of PhD preliminary examinations in materials 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 have passed required oral examinations. Research credits registered for each semester realistically reflect time devoted to research. A maximum of 6 units may be counted toward a PhD in Materials Chemistry. Research charge. *Prerequisites for MS candidates: degree status, consent of graduate adviser and thesis director and CM 5040.*

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 a PhD. Minimum research registration requirements for holders of an MS degree based on research and thesis acceptable to department, 33 units; for other students, 45 units. Registration required each semester consecutively until students have completed adequate research projects and acceptable theses and have passed required oral examinations. Research fees required. *Prerequisites: completion of PhD preliminary examination in chemistry, consent of thesis director and CM 5040.*

CIVIL ENGINEERING PROGRAM

Program Advisers:

Roger P. Roess (undergraduate)

Magued G. Iskander (graduate)

UNDERGRADUATE PROGRAM

The Department of Civil Engineering develops engineering graduates capable of contributing to and advancing the practice of civil engineering and its sub-disciplines. Through its research programs, the department strives to be at the forefront in selected areas in the development of new knowledge and applications in civil engineering. Through its educational programs, graduates will be well rounded in state-of-the-art techniques and will develop the skills needed to apply them in a complex profession. Among these skills are the abilities to communicate effectively in written and verbal form and understand the context of civil engineering projects in a complex society.

GOALS AND OBJECTIVES

The general goals of the Bachelor of Science in Civil Engineering are that undergraduates should have sufficient exposure to all major sub-disciplines in order to (1) allow them to choose a career path intelligently, (2) elect a program of depth in at least two sub-disciplines and (3) continue in a Master of Science program in any civil engineering sub-discipline.

Specific program objectives have been established to reinforce these general goals. Graduates of the undergraduate civil engineering program should:

- Have a solid foundation of knowledge in the major sub-disciplines of civil engineering: structural and geotechnical engineering, environmental and water resources engineering, transportation engineering and construction management
- Have the opportunity to develop depth of knowledge in at least two of these sub-disciplines within the scope of their undergraduate education
- Be capable of professional practice at the entry level in any civil engineering sub-discipline or to pursue graduate work in any of the sub-disciplines

- Develop design knowledge and skills in at least three sub-disciplines of civil engineering
- Develop good oral and written communications skills
- Develop a basic understanding of the societal context in which civil engineering occurs and a thorough appreciation for their responsibilities as professionals to society.

REQUIRED COURSES

The undergraduate curriculum provides a solid foundation in all major sub-disciplines through required courses.

Four courses provide the engineering science and professional underpinnings for all sub-disciplines: CE 2114 Statics and Dynamics, CE 2124 Mechanics of Materials, CE 2214 Fluid Mechanics and Hydraulics and CE 1003 Fundamentals of Civil Engineering. Structural engineering is covered in CE 3133 Structural Analysis and CE 3144 Steel Design. The required environmental and water resources sequence includes CE 3223 Environmental Engineering I, and CE 4243 Water Resource Engineering I. CE 3324, Traffic Engineering I, introduces the student to highway and traffic engineering. CE 4413 Construction Management provides a thorough overview of this important sub-discipline.

Design is covered in many of these courses, giving students exposure to design in the various sub-disciplines. Courses CE 2214, CE 3144, CE 3223, CE 4243, CE 3153 and CE 3324 all have significant design content. Most elective courses also have strong design components and all students are required to complete a 5-credit senior design project (CE 4812, CE 4823) during their senior year. An introduction to design is provided by EG 1004 in the freshman year. Thus, students have progressive design exposure in each year of the program.

Undergraduate elective courses are provided in structural, geotechnical, environmental, water resources, construction management and transportation engineering. These allow students to gain signifi-

cant depth in these areas. Selected students with sufficient grade-point averages may take beginning graduate courses in these areas. Special topics courses are provided in each major sub-discipline and are offered as needed.

Communications skills are emphasized throughout the curriculum. The humanities and social sciences portions of the curriculum provide a strong focus on developing writing and verbal skills. The freshman engineering program also includes substantial emphasis on oral presentations and written report assignments. CE 1003, Fundamentals of Civil Engineering, includes numerous written assignments, class debates and oral presentations. All courses with associated laboratories require written laboratory or project reports; many design courses require formal submittal of design reports, some with oral presentations. The senior design project experience includes many verbal and written progress reports, and is formally presented and defended as part of final submittals.

Humanities and social science courses also contribute to students' understanding the societal context of their profession. CE 1003, Fundamentals of Civil Engineering, reinforces this with specific civil engineering references and provides a focused treatment of professional ethics. These aspects are also highlighted in other courses in the civil engineering curriculum.

ACCREDITATION

The BS in Civil Engineering is accredited by the Accreditation Board for Engineering and Technology (ABET).

CURRICULUM

The curriculum for the BS in Civil Engineering is described in the tables that follow. Table 1 summarizes the curriculum and its requirements in subject area categories. Table 2 summarizes elective courses available in civil engineering by sub-discipline. A typical four-year course of study for civil engineering majors is shown on the full-page chart in this section.

TABLE 1: CURRICULUM FOR THE BS (CIVIL ENGINEERING)

Course No.	Course Title	Credits	Sem1
Required Courses in Mathematics²			
MA 1054	Calculus I with Precalculus	4	F1
MA 1154	Calculus II with Precalculus	4	F2
MA 2012	Linear Algebra I	2	So1(a)
MA 2132	Ordinary Differential Equations	2	So1(b)
MA 2212	Data Analysis I	2	So1(a)
MA 2222	Data Analysis II	2	So1(b)
Total mathematics credits required:		16	
Required Courses in Physical Sciences			
CM 1004	General Chemistry for Engineers	4	F1
PH 1004	Introductory Physics I	4	F2
PH 2004	Introductory Physics II	4	So1
Total physical science credits required:		12	
Mathematics or Science Electives:		4	
Required Courses in Freshman Engineering and Computer Science			
EG 1004	Introduction to Engineering & Design	4	F1
CS 3xx2	Computer Systems and Problem-Solving	2	J1
Total freshman engineering and CS credits required:		6	
Required Courses in Civil Engineering			
CE 1003	Fundamentals of Civil Engineering	3	F2
CE 2114	Statics & Dynamics	4	So1
CE 2214	Fluid Mechanics & Hydraulics	4	So2
CE 2124	Mechanics of Materials	4	So2
CE 3133	Structural Analysis	3	J1
CE 3223	Environmental Engineering I	3	J2
CE 3144	Steel Design	4	J2
CE 3153	Geotechnical Engineering	3	J2
CE 4243	Water Resource Engineering I	3	J1
CE 3324	Traffic Engineering I	4	J1
CE 4163	Structural Materials	3	S2
CE 4413	Construction Management	3	S2
CE 4812	Civil Engineering Design Project I	2	S1
CE 4823	Civil Engineering Design Project II	3	S2
CE	Civil Engineering Elective ³	3	S1
CE	Civil Engineering Elective ³	3	S2
CE	Civil Engineering Elective ³	3	S2
Total civil engineering credits required:		55	
Required Courses in Humanities and Social Sciences⁴			
EN 1014	Writing & the Humanities I	4	F1
EN 1204	Writing & the Humanities II	4	F2
HI 2104	Contemporary World History	4	So1
	Level II Elective ⁵	4	So2
	Level II Elective	4	J1
	Level III Elective ⁶	4	J2
Total humanities and social science credits required:		24	
Other Electives			
	Sequence Elective I ⁷	4	J2
	Sequence Elective II	4	S1
	Technical Elective ⁸	3	S1
Total Other Electives:		11	
Total credits required for BS in Civil Engineering:		128	

Footnotes for Table 1:

1. Semester Codes: F=freshman, So= Sophomore, J=Junior, S=Senior, 1=Fall, 2=Spring, (a)(b) refer to half-semester courses with (a) being first half, (b) second half.

2. The Department of Civil Engineering prefers all of its students to take the MA 1054/1154 calculus sequence. This sequence includes two additional hours of pre-calculus review which the department believes is helpful, even for students with an excellent math background. Students may choose to take a placement exam to be placed in MA 1014/1124 (Calculus I, II), or may be advance-placed based upon AP test results.

3. Civil engineering electives are technical electives, which must be taken from among civil engineering (CE) courses. A list of civil engineering elective courses is found in Table 2.

4. Students must take a placement examination in English. They may be placed in a remedial writing program for native English speakers, or ESL (English as a Second Language) or in a special EN 1034 Writing and the Humanities ESL.

5. Level II electives are elective courses in the humanities or social sciences that have a prerequisite of EN 1014 (or EN 1034), EN 1204 and/or HI 2104. The two Level II elective courses must be taken in two different disciplines. These courses generally have course numbers 2xxx, with an appropriate subject prefix.

6. Level III electives have a prerequisite of a Level II elective. These courses generally have course numbers 3xxx with an appropriate subject prefix.

7. By vote of the faculty, the requirement for sequences was dropped for students enrolling September 2003 or later. For such students, sequence electives may be taken as technical electives.

8. Technical electives can be taken as any math, science or engineering course for which students have appropriate prerequisites.

TABLE 2: ELECTIVE COURSES IN CIVIL ENGINEERING*

Course No.	Course Title	Semester
CE 4043	Sustainable Cities	Spring
CE 4173	Foundation Engineering	Fall
CE 4183	Reinforced Concrete Design	Fall
CE 4193	Timber & Masonry Structures	Spring
CE 4253	Water Resource Engineering II	Spring
CE 4263	Environmental Geotechnology	Spring
CE 4273	Environmental Engineering II	Fall
CE 4333	Traffic Engineering II	Spring
CE 4613	Selected Topics in Structural & Geotech. Eng.	Either
CE 4623	Selected Topics in Env. & Water Res. Eng.	Either
CE 4633	Selected Topics in Transportation Eng.	Either
CE 4643	Selected Topics Construction Management	Either
CE 4710	Readings in Civil Engineering	As arranged

All courses are 3 credits; Readings courses have variable credit.

TRANSFER STUDENTS AND CREDITS

Potential transfer students should refer to the University guidelines in this catalog. The Department of Civil Engineering has established additional requirements and

interpreted the University guidelines as indicated in this section.

The 128-credit curriculum is fulfilled through a combination of transfer credits, credits by examination and courses taken while at Polytechnic. Transfer credits in mathematics, chemistry, physics, humanities and social sciences are evaluated by the Office of Academic Affairs with the guidance of faculty from appropriate departments. Transfer credits in civil engineering and other technical areas are evaluated by the faculty of the Department of Civil Engineering.

The length of time for a transfer student to complete the BS in Civil Engineering depends upon three factors:

1. The total number of transfer credits awarded
2. The particular courses required to complete degree requirements
3. Enrollment status (part-time or full-time)

Transfer Notes:

Transfer students should be aware that they can be awarded transfer credits for courses only in which a C grade or better has been earned, and then only for courses that are applicable towards the BS in Civil Engineering as described in this catalog.

There is a residency requirement that must also be fulfilled. To earn a BS, all students must complete a minimum of 30 credits of course work at Polytechnic at the junior or senior level (courses numbered CE 3XXX or CE 4XXX). These credits must include the design project, CE 4812 and CE 4823.

PART-TIME STUDENTS

Students may register as part-time students (less than 12 credits per semester). Such students must be advised, however, that the department no longer offers many undergraduate courses in the evening and that part-time students will have to take most of their courses during the day. Part-time students should maintain close contact with their academic advisers to work out the details of course sequence in the most efficient and effective manner.

UNDERGRADUATE MANUAL

Curriculum changes may occur before the publication of a new catalog. The Department of Civil Engineering maintains an Undergraduate Manual, which details the most current curriculum at all times.

CIVIL ENGINEERING PROGRAM

PREVIOUS CURRICULA

It is a generally accepted rule that students are subject to the requirements of the catalog that was in effect when they initially enrolled at the Polytechnic. Academic advisers work with students to make sure that they fulfill the proper requirements.

MASTER OF SCIENCE PROGRAM IN CIVIL ENGINEERING

The Master of Science in Civil Engineering allows students to specialize in one of the following six areas of concentration:

- Structural Engineering
- Geotechnical Engineering
- Environmental and Water Resource Engineering
- Highway and Traffic Engineering
- Construction Management and Engineering
- Urban Systems Engineering and Management

Students may also elect to follow a general program by taking courses across several areas of concentration.

The Department of Civil Engineering also offers graduate programs in transportation planning, management and engineering (see the Transportation section in this catalog), environmental science and engineering (see Environmental Science and Engineering section in this catalog), construction management (see the Construction Management section of this catalog) and urban systems engineering and management (see Urban Systems Engineering and Management section in this catalog).

GOALS AND OBJECTIVES

The degree MS in Civil Engineering prepares graduates to practice their profession at an advanced level. Specific objectives of the program are to provide the skills and knowledge necessary to:

- Specialize in one of the primary sub-disciplines of civil engineering or to achieve depth across a number of the sub-disciplines
- Design and analyze civil engineering infrastructure
- Understand civil engineering materials, technologies and processes as applied to modern civil engineering infrastructure

- Obtain civil engineering project management skills
- Provide a basis for continued, lifelong learning in the civil engineering profession

ADMISSION

Students seeking admission to the MS program should hold a bachelor's degree in civil engineering from a program accredited by the Accreditation Board for Engineering and Technology (ABET) and have a 2.75 GPA or better. Applicants lacking a BS from an ABET-accredited program in civil engineering (including those possessing undergraduate degrees in other engineering disciplines, engineering science, engineering technology, architecture or from a foreign university) will have their qualifications reviewed by a graduate adviser. Admission may be granted and may include the requirement for additional undergraduate courses to make up deficiencies. These additional courses are not counted toward the MS degree, nor are undergraduate courses included in the computation of graduate grade-point averages.

Applicants from universities outside the United States should take the Graduate Record Examination (GRE advanced tests) and achieve a minimum grade of 550 on the quantitative section and 550 on the verbal section. They must also take the Test of English as a Foreign Language (TOEFL) and achieve a minimum grade of 550. In some cases, the department head may waive the GRE and/or TOEFL after a graduate adviser examines the student's transcripts and interviews the candidate.

Foreign candidates who meet all other admission requirements but who fail to satisfy the TOEFL requirement may be required to take one or more remedial courses in English before admission.

GRADE REQUIREMENTS

To earn an MS degree from Polytechnic, students must maintain a B average (3.0 GPA) or better in (1) all graduate courses taken at Polytechnic, (2) all graduate courses taken in the Department of Civil Engineering and (3) all graduate guided studies (readings, project, thesis).

Poor scholastic performance (under 3.0 GPA) may lead to a student being placed on graduate probation. If students' grades do not improve, they may be disqualified from further graduate study in the department. Students may repeat a

course with their adviser's approval. When a course is repeated, the latest grade counts toward the GPA. In the rare case where a course is repeated more than once, only the first grade is dropped from the GPA computation.

ADVISING

Graduate students are assigned a faculty adviser. It is important that students maintain frequent contact with their adviser throughout the course of their studies.

Students must meet with their academic adviser prior to each registration and at any other time they need advice or consultation. Students must have a detailed program of study formally approved by their adviser prior to registration. Advisers also handle requests for waivers of certain degree requirements, where warranted. Such waivers must be approved in writing and must be entered into the student's departmental file. Where specific courses are waived, the approval of the course instructor is also required. When 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, projects, theses) are assigned advisers for each such activity. The guided studies adviser may or may not be the same as the student's academic adviser, depending upon the subject matter selected. To register for any guided study activity, a student must submit written proposals for the topic(s) to be covered to an appropriate project adviser before registration. To register, students must obtain the written approval of the project adviser and the academic adviser.

While academic advisers consult with and advise students, it is the student's responsibility to ensure that all degree requirements are fulfilled and to submit all proper forms and applications when required.

TRANSFER CREDITS

The residency requirement for MS degrees is 27 units. Students may transfer up to 9 units of acceptable courses toward an MS degree, subject to their academic adviser's approval. To be transferred, the course(s) must be relevant to the student's program and from an acceptable institution. A grade of B or better is required for granting of transfer credit. Courses graded on a pass/fail basis are not considered for transfer unless accompanied by a

detailed written evaluation by the course instructor. All transfer requests must be accompanied by an official transcript from the transferring institution. Applications for transfer credits are accepted only after the student has earned 12 units at Polytechnic.

Validation credits by examination may not be used toward any civil engineering graduate degree program.

GRADUATE MANUAL

The Department of Civil Engineering publishes an annual Graduate Student Manual. As changes in curricula sometimes occur more frequently than the catalog is printed, students should consult the manual each year to be informed of the most recent changes.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE IN CIVIL ENGINEERING

All students must complete the following three core requirements:

Students must complete at least four of the following six core courses (12 units):

CE 602	Materials Engineering	3 units
CE 607	Instrumentation, Monitoring, and Condition Assessment of Civil Infrastructure	3 units
CE 767	Environmental Impact Assessment	3 units
CE 784	Introduction to Urban Systems Eng	3 units
CE 825	Project Management for Construction	3 units
CE 828	Risk Analysis	3 units

Students must complete either a Master's Project or Master's Thesis (3 or 6 units):

CE 996	Project for the MS in Civil Engineering	3 units
	or	
CE 997	Thesis for the MS in Civil Engineering	6 units

Students must complete at least four courses in their area of concentration, or, if selecting a general program, a minimum of at least two courses in three areas of concentration (12 or 18 units). Note that areas of concentration may involve some courses that are required within the concentration.

Depending upon the choice of a project or thesis and the choice of a single or multiple areas of concentration, the student may have up an additional 9 units of course work to complete the 36 units required for a degree. These are technical electives. One technical elective (3 units) may be selected outside the civil engineering department from a related technical discipline, such as mathematics, com-

puter science, etc. Remaining electives must be selected from the courses given by the Department of Civil Engineering. Table 3 summarizes these requirements.

TABLE 3: MS IN CIVIL ENGINEERING REQUIREMENTS

Students Selecting a Single Area of Concentration Core Courses	12 units (min.)
Project or Thesis:	3 or 6 units
Courses Within Concentration:	12 units (min.)
Technical Electives:	6 or 9 units
Students Selecting a General Program Core Courses:	12 units (min.)
Project or Thesis:	3 or 6 units
Courses in 3 Concentration Areas:	18 units (min.)
Technical Elective	0 or 3 units

36 units required for MS degree.

Tables 4 through 9 show the courses and requirements for each of the areas of concentration. For students following a general program, requirements within concentrations do not apply; such students must, however, satisfy all course pre-requisites. All courses in Tables 4 through 9 are 3 units.

TABLE 4: STRUCTURAL ENGINEERING CONCENTRATION

Required for concentration:

CE 601	Theory of Structural Analysis
CE 616	Finite Element Analysis

Select at least two from:

CE 603/4	Selected Topics in Structural Engineering I, II
CE 606	Bridge Engineering
CE 613	Stability of Structures
CE 614	Steel Structures
CE 618	Concrete Structures
CE 619	Earthquake and Wind Eng.

TABLE 5: GEOTECHNICAL ENGINEERING CONCENTRATION

Required for concentration:

CE 842	Foundations and Ground Improvement
CE 866	Advanced Foundation Design

Select at least three from:

CE 840	Geotechnics and Geomaterials
CE 843	Urban Geotechnology
CE 849	Environmental Geotechnics
CE 860	Selected Topics in Geotechnical Engineering
CE 867	Excavation Support Systems

TABLE 6: ENVIRONMENTAL/WATER RESOURCE ENGINEERING CONCENTRATION

Required for concentration:

CE 723	Groundwater Hydrology and Pollution
CE 737	Environmental Chemistry and Microbiology I

Select at least two from:

CE 735	Special Topics in Water Resource and Hydraulic Engineering
CE 739	Environmental Chemistry and Microbiology II
CE 742	Water and Wastewater Treatment I

CE 743	Water and Wastewater Treatment II
CE 745	Water and Wastewater Treatment Laboratory
CE 747	Analysis of Stream and Estuary Pollution
CE 753	Hazardous/Toxic Waste Management

TABLE 7: HIGHWAY AND TRAFFIC ENGINEERING CONCENTRATION

Required for concentration:

TR 681	Traffic Studies and Characteristics
TR 683	Intersections: Design and Control

Select at least two from:

TR 605	Travel Demand Forecasting
TR 607	Urban Transportation Planning and Congestion Management
TR 609	Transportation Economics and Finance
TR 682	Freeways and Rural Highways
TR 684	Arterials and Networks
TR 852	Public Transportation Systems and Operations
TR 810	Introduction to Intelligent Transportation Systems

TABLE 8: CONSTRUCTION MANAGEMENT AND ENGINEERING CONCENTRATION*

Select at least 4 from:

CE 826	Construction Cost Estimating
CE 827	Contracts and Specifications:
CE 829	Construction Operation Analysis
CE 830	Information Systems in Project Management
CE 831	Engineering for Construction I
CE 832	Engineering for Construction II

Any course in the EXEC 21 Construction Management certificate program. (See Construction Management section of this catalog.)

TABLE 9: URBAN SYSTEMS ENGINEERING AND MANAGEMENT CONCENTRATION**

Required for Option:

CE 781	Infrastructure Planning, Engineering, and Economics
CE 785	Concepts and Implementation of Infrastructure Management Systems

Select at least 2 from:

CE 775	Environmental Systems Management
CE 786	Infrastructure Monitoring and Performance Assessment
CE 871	Construction and the Law
CE 873	Infrastructure Financing: the Art of The Deal
TR 810	Introduction to Intelligent Transportation Systems

Footnotes for Tables 4 - 9:

* Students in the Construction Management concentration must select CE 825 (Project Management for Construction) and CE 828 (Risk Analysis) among their core courses.

** Students in the Urban Systems Engineering and Management concentration must select CE 784 (Introduction to Urban Systems Engineering) and CE 607 (Instrumentation, Monitoring, and Condition Assessment of Civil Infrastructure) among their core courses.

DOCTORAL PROGRAM IN CIVIL ENGINEERING

The Department of Civil Engineering currently offers two doctoral degree programs: PhD in Civil Engineering and PhD in Transportation Planning and Engineering. Requirements for the Civil Engineering degree are detailed here. For information on the Transportation Planning and Engineering program, see the "Transportation" section of this catalog.

GOALS AND OBJECTIVES

The PhD in Civil Engineering is a research-oriented degree intended for those whose goal is career in basic civil engineering research and/or teaching at the university level or in private research organizations. Specific objectives of the doctoral program are to develop the skills and knowledge necessary to:

- Specialize within one of the sub-disciplines of civil engineering
- Perform independent fundamental research in one of the sub-disciplines of civil engineering
- Produce a piece of fundamental research that meaningfully advances the state-of-the-art of one of the sub-disciplines of civil engineering, and is publishable in a first-tier refereed civil engineering-related journal

AREAS OF CONCENTRATION

Students pursuing the PhD in Civil Engineering must choose to specialize in one of the following sub-disciplines of civil engineering:

- Structural materials and engineering.
- Geotechnical and geo-environmental engineering.
- Environmental and water resources engineering.
- Construction management and engineering.
- Highway and traffic engineering.
- Urban infrastructure systems engineering and management.

Other focus areas are possible, and can be developed with the assistance of faculty advisers. All subject areas must be, of course, relevant to the degree sought, and there must be a faculty member who is willing and able to guide the student's research.

PROGRAM ADMINISTRATION

There are four graduate program coordinators in the Department of Civil Engineering:

- Graduate Program Coordinator for Civil Engineering (MS& PhD)
- Graduate Program Coordinator for Environmental Engineering/Environmental Science (MS)
- Graduate Program Coordinator for Urban Systems Engineering and Management (MS)
- Graduate Program Coordinator for Transportation (MS & PhD)

The graduate coordinators form the departmental Graduate Committee. All PhD applications are reviewed by the Committee, and admissions decisions are made by the Committee and implemented by the appropriate graduate coordinator.

For each registration, the student's program must be approved by the Academic Adviser, and signed by the appropriate graduate coordinator.

ADMISSION CRITERIA

Admission to the PhD in Civil Engineering requires an MS in Civil Engineering or equivalent with a GPA of 3.5 or better (on a 0-4 scale).

Admission to PhD programs does not require GRE's (Graduate Record Examination), but applicants are encouraged to take these examinations. If these examinations are taken, the student must submit the results for consideration.

Foreign applicants must take the TOEFL examination and submit the results for consideration.

In the criteria above, the "equivalent" can be achieved in several ways. The candidate may have an MS degree with a different title that covers substantially the same material. In more general terms, the applicant must demonstrate that he/she has the equivalent of all undergraduate and master's level course work to be able to pursue doctoral level work in the major area chosen, as well as in a minor area within the umbrella of civil engineering. Further, "equivalence" is evaluated based on the totality of the student's undergraduate and graduate record, not on a course-by-course basis. Thus, an applicant who wishes to pursue doctoral work in the area of Environmental Engineering, for example, must have all of the undergraduate and master's level course background expected in Environmental Engineering, but does not have to demon-

strate such a background in structures.

Because admission to a PhD program requires an appropriate MS (or equivalent), those applicants who have not yet achieved a master's degree would normally be admitted as MS students. They are expected to earn an MS degree while completing their major and minor course requirements. In rare cases, an applicant with only a BS degree may be directly admitted into the PhD program with the written approval of the department head.

DOCTORAL COMMITTEES

Every PhD student is assigned an academic adviser, who is assigned by the department head upon admission. Any member of the civil engineering faculty can be an academic adviser to a graduate student. In cases where a student is being supported on a research contract, the principal investigator of the contract would normally be appointed as the academic adviser for the student. Where a student has a particular research interest and is working with a particular faculty member, the student may request that the faculty member be appointed as his/her academic adviser. In rare cases where a PhD student enters the program without a prior selection of a major area of study, the initial academic adviser will be the Graduate Coordinator of the appropriate program area.

In the course of fulfilling their academic requirements, PhD candidates, they will deal with two advisory committees:

Academic Advisory Committee: The student's Academic Adviser works out an appropriate program of courses to fulfill major and minor requirements for the PhD. The Academic Advisory Committee generally will consist of the Academic Adviser and one faculty member for each minor area of study. The Academic Advisory Committee guides the PhD student's work through the successful completion of a qualifying examination. A letter signed by the academic adviser and approved by the department head is placed in the student's file indicating the composition of the Academic Advisory Committee.

Dissertation Committee: The Dissertation Committee is formed immediately after the student passes the qualifying examination. It consists of a major adviser, a dissertation adviser, and a minor adviser for each minor the student has pursued. Additional faculty members may also be

on the Dissertation Committee. The dissertation committee may be the same as the Academic Advisory Committee, or may be different. The Dissertation Committee guides the student's course and research work after the student has passed the qualifying examination. The Dissertation Committee must be formally assigned with the approval of the department head and is filed with the Office of Graduate Studies.

The major adviser must be a full-time faculty member of the Department of Civil Engineering. The major and dissertation advisers may be the same individual where appropriate.

DOCTORAL DEGREE REQUIREMENTS

To earn a doctoral degree in either Civil Engineering, the following requirements must be met:

- 60 units of graduate work (not including the PhD dissertation) in relevant major and minor areas of study beyond the bachelor's degree, with an average grade of B or better (cumulative average of 3.0 or better on a 0-4 scale).
- Completion and successful defense of a 30-unit dissertation related to the major area of study. Dissertations must consist of original research that meaningfully advances the state-of-art in the subject area of the research, and should result in the publication of at least one paper in a strictly peer-reviewed technical journal appropriate to the subject. A grade of B or better must be achieved for the dissertation.
- Completion of two minor areas of study, each consisting of between 9 and 12 units of graduate work. At least one minor area must be outside the sub-disciplines of Civil Engineering.
- Residency requirements for the PhD in Civil Engineering include the 30-unit dissertation plus a minimum of 12 units of applicable graduate course work taken at the Polytechnic.

In satisfying the 60-unit course requirement, the student must satisfy all requirements for the major and minor areas selected, or their equivalent.

In satisfying these basic PhD requirements, students must also satisfy one of the two following conditions:

- 48 units of appropriate graduate course work, not including individual

guided studies (readings, projects, theses, etc.) beyond the bachelor's degree, with an average grade of B or better (cumulative average of 3.0 or better on a 0-4 scale).

- 24 units of appropriate graduate course work, not including individual guided studies (readings, projects, theses, etc.) beyond the master's degree, with an average grade of B or better (cumulative average of 3.0 or better on a 0-4 scale).
- Satisfying condition 2 requires that the department accept the student's MS degree in toto without regard to its specific content. This requires a recommendation from the department's Graduate Committee, and the approval of the department head.

TRANSFER CREDITS

Transfer credits for PhD students can be awarded on a course-by-course basis, or an MS degree from another institution may be accepted for transfer in toto. In the former case, a maximum of 48 units of appropriate graduate work may be transferred. The latter requires a recommendation from the department's Graduate Committee, and the approval of the department head. Transfer credits are generally awarded at the time of admission, and must be approved by the academic adviser, the appropriate graduate coordinator and the department head.

QUALIFYING EXAMINATIONS

Departmental qualifying examinations for the PhD in Civil Engineering are given once per year, usually in May or June. If sufficient demand exists, a second qualifying examination may be scheduled in December or January.

Every PhD student must pass a qualifying examination in the major area of study and in any in-department minor areas of study before becoming a candidate for the PhD Further:

- No student may register for dissertation units until the Qualifying Examination is passed.
- A dissertation committee cannot be formed until the student passes the Qualifying Examination.

A student may take the Qualifying Examination twice. A third attempt is permitted only with the written recommendation of the Academic Advisory Committee and the approval of department head. In no case may a student take

the examination more than three times.

Students normally take the Qualifying Examination (for the first time) after successfully completing most of their course requirements in the major and in-department minor areas of study.

The Qualifying Examination consists of a six-hour written portion (generally given in two 3-hour blocks on the same day) and an oral portion of approximately one hour. Both written and oral portions of the examination focus on the student's major and in-department minor. The oral portion may also explore higher-level skill areas required to successfully conduct independent research. Students are deemed to have passed the examination based upon an overall evaluation of results of both the written and oral portions. While some students may not be invited to the oral examination if they have done poorly in the written portion, invitation to the orals does not imply that the student has "passed" the written portion of the exam.

The Qualifying Examination is either "passed" or "failed." A letter indicating the result of each examination is placed in the student's graduate file. In rare cases, a student may be deemed to have "conditionally passed" the Qualifying Examination. This occurs in cases where the student does extremely well in all areas except for a single subject area in which weakness has been noted. Such a student must follow a prescribed preparation plan for strengthening their knowledge and skills in the area of weakness, and must pass a special examination on the area of weakness within one calendar year. A student who has "conditionally passed" the Qualifying Examination may register for dissertation credits, and may form a Dissertation Committee.

While each student may face a different Qualifying Examination, based upon the major and in-department minor areas of study, the exam is considered to be a departmental exam. All departmental faculty members in each sub-discipline will participate in submitting written problems in the sub-discipline, in the grading process, and in the oral examination. All departmental faculty members are welcome to observe any oral examination and to ask appropriate questions. Each student's Academic Advisory Committee will have the opportunity to review the entire exam before it is administered, and may suggest changes if it deems that the examination as presented is not an equitable test of the student's abilities.

CIVIL ENGINEERING PROGRAM

Recommendations on the results of the examination are submitted by each student's Academic Advisory Committee, augmented by any departmental faculty in the sub-disciplines tested. The departmental faculty, acting as a whole, votes to accept or reject such recommendations at a meeting scheduled for this purpose.

DISSERTATION PROPOSAL

Following passage of the Qualifying Examination and the appointment of a Dissertation Committee, the PhD candidate must submit a written dissertation proposal outlining the subject of the proposed research. This proposal should be between 15-20 pages long, and should address the following specific items:

- Description of the topic.
- Literature review sufficient to insure that the work contemplated is original.
- Methodology(ies) to be employed in the research.
- Data and/or laboratory needs, and their availability to the student.
- Anticipated outcomes.

The Dissertation Proposal must be submitted within one semester of full-time study, or before 9 units of dissertation credit are completed.

The Dissertation Proposal is orally presented and defended before the Dissertation Committee and any other interested departmental faculty. The date of the oral defense and copies of the draft Dissertation Proposal must be made available to departmental faculty at least two weeks (14 calendar days) prior to the defense.

When the Dissertation Proposal is formally accepted, the Dissertation Adviser enters a letter into the student's graduate file indicating this, together with a copy of the proposal. While the Dissertation Committee has reasonable flexibility in modifying the proposal as appropriate during the course of the research, any significant change in focus area or methodology requires that an amended Dissertation Proposal be written and formally accepted following the same procedure noted herein.

DISSERTATION DEFENSE

The culmination of the student's PhD work is the oral presentation and defense of the final draft dissertation. A defense is generally scheduled after the Dissertation Committee has reviewed the draft disser-

ation and determined that it is complete and of sufficient quality to be presented and defended.

The defense is organized and scheduled by the Dissertation Committee. All University faculty members are invited to observe and ask appropriate questions at all Polytechnic dissertation defenses. Therefore, the date of the defense must be announced University-wide at least one month prior to the event, and copies of the draft dissertation must be made available to any faculty member who requests one in a timely fashion and in no case less than two weeks prior to the defense.

UNDERGRADUATE COURSES

GENERAL COURSES

CE 1003 Fundamentals of Civil Engineering 2:3:0:3

This course introduces the student to the profession and practice of civil engineering. The course has five primary components: (1) a review of the principal sub-disciplines of civil engineering and their relationship to urban and regional infrastructure, (2) a review of professional ethics and the responsibilities of engineers to their profession and to the general public; this includes a detailed study and discussion of the American Society of Civil Engineers (ASCE) and National Society of Professional Engineers (NSPE) codes of practice, and the use of case studies for illustration and discussion; (3) a study of civil engineering measurements and the use of surveying tools and instruments; this will include an overview of GIS and GPS systems in civil engineering, (4) the use of AutoCAD as a tool for computer-based drawings, and (5) the use of spreadsheets to develop analytic algorithms to solve simple engineering problems. *Co-requisite: EG 1004 or equivalent.*

CE 4043 Sustainable Cities 3:0:0:3

The purpose of this course is to provide an overview of the issues that need to be addressed in making a city sustainable, beginning with a definition of what is intended by the concept of sustainability, and a discussion of what is the essence of a city. Students will be asked to become familiar with the major challenges in making a city sustainable, and to provide, as part of their homework assignments, a paper addressing a topic covered by the

course through research and, where appropriate, proposing solutions.

CE 4034 Introduction to Urban Infrastructure Systems Management 4:0:0:4

Course provides a descriptive overview of the key infrastructure systems and technologies that must be managed, operated and maintained. Part of a two-course elective sequence with LA 3024, offered by the Department of Humanities and Social Sciences. Systems treated include bridges and structures, water supply, solid and liquid waste handling and disposal, transportation, power, communications and information systems, health and hospitals, police and fire protection. The course also treats the financial, political, administrative, legal and institutional settings of these systems and technologies. Innovative methods using intelligent monitoring and control systems are also discussed. A portion of the course features distinguished guest lecturers who are experts in some of the systems and technologies included. The course includes a case study on a selected urban project integrating the different dimensions of urbanism. This project is pursued throughout the courses of this sequence.

STRUCTURAL AND GEOTECHNICAL ENGINEERING

CE 2114 Statics and Dynamics 4:0:0:4

A thorough treatment of basic statics and dynamics. Subjects include: vector treatment of static and dynamic equilibrium of particles and rigid bodies; equivalent force and couple systems; distributed force systems; static analysis of trusses, frames and machines; friction and impending motion. Newton's Laws are also treated. *Co-requisite: PH 1004 or equivalent.*

CE 2124 Mechanics of Materials 3½:1½:0:4

Basic principles of stress and deformation in axial, torsion and bending members are introduced. Elastic stability of compression members and an introduction to mechanics of fracture and fatigue is included. Stress analysis laboratories are conducted in which students work individually and in groups on stress analysis measurement projects. *Prerequisites: PH 1004, CE 2114 or equivalents.*

CE 3133 Structural Analysis 3:0:1:3

In-depth coverage of structural analysis techniques. Topics covered include: analysis of statically determinate structures; deflection calculations using energy methods; analysis of statically indeterminate structures using superposition; influence lines; slope deflection, moment distribution and matrix analysis of structures. Computer applications are included. *Prerequisite: CE 2124 or equivalent.*

CE 3144 Steel Design 3:3:0:4

A thorough treatment of steel design principles and techniques. Topics included: design of tension and compression members, beams, beam-columns, slabs and footings; design of bolted, riveted and welded connections for steel structures. The course includes a design laboratory in which students, working alone and in groups, develop design projects. *Prerequisite: CE 3133 or equivalent.*

CE 3153 Geotechnical Engineering 2:3:0:3

Introduction to soil mechanics and foundation engineering, including origin of soils; phase relationships; classification of soils; permeability; effective stress; seepage; consolidation; shear strength; slope stability; and bearing capacity. *Prerequisites: CE 2124 and CE 2214 or equivalents.*

CE 4163 Structural Materials 2:3:0:3

This course covers the mechanical behavior and durability of structural materials. Properties of steel, concrete, wood, asphalt, and fiber composites are discussed. Material processing, optical metrology and stress analysis laboratories are conducted in which students work independently and in groups on material preparation and evaluation topics. *Prerequisite: CE 2124 or equivalent.*

CE 4173 Foundation Engineering 2:3:0:3

Introduction and development of foundation engineering, including site exploration; soil sampling; interpretation of boring logs; bearing capacity of footings; settlement of structures; lateral earth pressure; design of retaining walls, braced excavations and sheet pile walls; design of deep foundations. *Prerequisite: CE 3153 or equivalent.*

CE 4183 Reinforced Concrete Design 2:3:0:3

Detailed treatment of reinforced concrete design: Material properties, ACI load factors, and design strength; shear and diagonal tension in beams; reinforced concrete columns; two-way slabs; footings; shear walls; torsion. *Prerequisite: CE 3133 or equivalent.*

CE 4193 Timber and Masonry Structures 3:0:0:3

Properties and classification of structural lumber; design of timber connectors; design and construction 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 un-reinforced masonry structural elements. *Prerequisite: CE 3144 or equivalent.*

ENVIRONMENTAL AND WATER RESOURCE ENGINEERING

CE 2214 Fluid Mechanics and Hydraulics 3½:1½:0:4

The basic principles of fluid mechanics with beginning applications to hydraulic design. Topics covered include fluid properties, hydrostatics, continuity, energy and momentum equations. Additional topics cover laminar and turbulent flow, boundary layer drag, dimensional analysis, Euler's equation, two-dimensional ideal fluid flow, pipe flow, pumps, turbines, fluid measurements, pipe networks, open channel flow and reservoir balance. *Prerequisite: CE 2114 or equivalent.*

CE 3223 Environmental Engineering I 3:3:0:3

Introduction to water and wastewater treatment. Stream assimilation and public health. Introduction to air pollution and solid waste management. Laboratory analysis of water and wastewater samples and treatment process tests. *Prerequisite: CE 2214 or equivalent.*

CE 4243 Water Resource Engineering I 3:0:0:3

This course provides a detailed overview of water resources engineering, including both analysis and design elements. Topics covered include: open channel flow; pipe networks; reservoir balances; hydrologic techniques; surface water and ground water supplies; water demand and development of water resources for multiple purposes. *Prerequisite: CE 2214 or equivalent.*

CE 4253 Water Resource Engineering II 3:0:0:3

This course covers feasibility-level planning and design for water resources projects, including water conveyance works; concrete dams and assorted waterways; pumping stations; hydroelectric, irrigation, navigation and flood mitigation projects. Subjects considered include layouts, dimensions and capacities of facilities, hydraulic and structural forces and stability analysis. *Prerequisite: CE 4243 or equivalent.*

CE 4263 Environmental Geotechnology 2:3:0:3

Intended to benefit students who are about to enter the consulting industry. It is difficult to separate environmental and geotechnical concerns in the urban environment. This course teaches students what environmental concerns to expect when planning construction projects, investigating sites and overseeing construction. The course covers methods for addressing these concerns. Topics covered include clay mineralogy, soil/water/contaminant interactions, interfacial tension and capillarity and remediation techniques. *Prerequisite: CE 3153 or equivalent.*

CE 4273 Environmental Engineering II 2:3:0:3

Detailed coverage of water and wastewater treatment unit operations; includes a laboratory on processes and process design. Experiments are performed to evaluate laboratory-scale conventional water and waste treatment processes. Lectures cover detailed theory, design and advanced concepts. *Prerequisites: CE 2214 and CE 3223 or equivalents.*

HIGHWAY AND TRANSPORTATION ENGINEERING

CE 3324 Traffic Engineering I 4:0:0:4

A basic overview of the traffic engineering profession. Traffic stream parameters and characteristics are presented, along with study techniques for their measurement, analysis, and interpretation. Characteristics of road users, vehicles, roadways, and traffic control devices are treated in detail, as is their impact on traffic stream behavior. Functional and geometric characteristics of roadways are introduced with design applications. Traffic operations and control techniques are treated. Detailed coverage of isolated signal design and timing, both pre-timed and actuated, is included. Signal coordination on arterials and in networks is introduced. *Prerequisite: Junior status or instructor's permission.*

CE 4333 Traffic Engineering II 3:0:0:3

A second semester of traffic engineering for undergraduate students: The focus is on highway capacity and level of service analysis on uninterrupted and interrupted flow facilities. Additional analysis of signalized and unsignalized intersections is also included using current computer software packages. Facility types include freeways, freeway weaving areas and ramp junctions, rural and suburban multi-lane highways, two-lane rural highways and suburban and urban arterials. *Prerequisite: CE 3324 or instructor's permission.*

CE 3344 Introduction to Transportation I 4:0:0:4

First course in the Transportation Sequence. Focuses on the fundamental conceptual elements of a transportation system, and how to analyze and design particular transportation systems. Covers basic material about transportation systems, the context within which they operate and a characterization of their behavior. Transportation of freight and travelers is included. *Prerequisite: junior status.*

CE 4354 Introduction to Transportation I 4:0:0:4

Second course in the Transportation Sequence. Deals with some of the more engineering-oriented aspects of the transportation field. Functional designs of transportation systems—including highway geometry, parking facilities, rail facilities, airports, stations and terminals—are discussed. An overview of traffic control systems and their application is included. Traffic signal systems hardware and software are discussed. Intelligent Transportation Systems (ITS), the application of information technologies to the monitoring and control of transportation systems, is covered. *Prerequisite: CE 3344.*

CONSTRUCTION MANAGEMENT AND ENGINEERING

CE 4413 Construction Management 3:0:0:3

The participants, processes and techniques required to maintain the life-cycle of a construction project are covered: planning of construction operations, including estimating and economic evaluation of alternatives; analysis of construction bid processes, contracting and related issues of ethics in project engineering; productivity, safety and quality on a constructed project; time scheduling of the project, including CPM and PERT; trends in computer analysis of project information. Students will prepare and formally present team projects. *Prerequisite: senior status or instructor's permission.*

CE 4423 Information Systems in Construction Management 3:0:0:3

Development of a strong understanding of contemporary tools for managing the vast array of information in the project life-cycle. Information is reviewed both from the perspective of knowledge acquisition and knowledge representation. The course focuses on the concepts of Fully Integrated and Automated Project Processes (FIAPP), and the relationships of 3D computer models, simulation, cost estimating, scheduling, procurement and information technology. Emphasis is given to the implementation of 3D computer models and relational databases and information systems for processing and automating project information. The class

makes heavy use of computer applications related to civil engineering and construction management. *Prerequisite: Senior status or instructor's permission.*

Additional construction management courses are listed in the "Construction Management" section of this catalog. Most of these are available to civil engineering students as electives.

SELECTED TOPICS, READINGS AND PROJECTS

CE 4613 Selected Topics in Structural and Geotechnical Engineering 3:0:0:3

Topics of current interest in structural and geotechnical engineering. The specific subject of each offering is generally unique. The course may feature a detailed look at a single topic or a series of focused topical presentations. *Prerequisite: instructor and adviser approval.*

CE 4623 Selected Topics in Environmental and Water Resources Engineering 3:0:0:3

Topics of current interest in environmental and water resources engineering. The specific subject of each offering is generally unique. The course may feature a detailed look at a single topic or a series of focused topical presentations. *Prerequisite: instructor and adviser approval.*

CE 4633 Selected Topics in Transportation Engineering 3:0:0:3

Topics of current interest in transportation engineering. The specific subject of each offering is generally unique. The course may feature a detailed look at a single topic or a series of focused topical presentations. *Prerequisite: instructor and adviser approval.*

CE 4643 Selected Topics in Construction Management 3:0:0:3

Topics of current interest in construction management. The specific subject of each offering is generally unique. The course may feature a detailed look at a single topic or a series of focused topical presentations. *Prerequisite: instructor and adviser approval.*

CE 4710 Readings in Civil Engineering *variable credit (1-4)*

Individually guided study in a subject area related to the civil engineering curriculum. Topic must arise from a regular course and must extend and go beyond what is covered in the traditional curriculum. The student must have the prior approval of the instructor with which he/she is to work and a topic approved by that instructor before registering for a readings course. A readings course shall require a written report on the subject of the student's readings before a grade is given. A student may take this course more than once.

CE 4812 Civil Engineering Design Project I *1½:0:1½:2*

The first semester of the two-semester senior capstone design experience in civil engineering. In the first semester, a project involving integration of the civil engineering subdisciplines will be described and presented. Working groups will be established. All groups may work on a single project or several may be prescribed, depending upon the semester. Lectures will be devoted to particulars of the project and will present specific design applications that may not have been included in other courses. During the first semester, each group will be expected to prepare and present a complete professional proposal for design and construction of the project, including a detailed cost estimate. *Prerequisites: CE 3144 and CE 3153 or equivalents. Co-requisites: CE 3223 and CE 4243 or equivalents.*

CE 4823 Civil Engineering Design Project II *2:3:0:3*

The second semester of the two-semester senior capstone design experience in civil engineering. Lecture sessions will be used to present periodic topical material of relevance to the project(s) assigned and to allow student groups to present progress reports on their work. Each group will be expected to prepare a complete design report addressing all assigned aspects of the project, with functional design drawings and specifications and a refined construction cost estimate. All projects will be verbally presented and defended. *Prerequisite: CE 4812. Co-requisites: CE 4163 and CE 4413.*

GRADUATE COURSES

CORE COURSES

CE 602 Materials Engineering *2½:0:0:3*

Materials composition and production of cementitious materials; polymeric composites and metals; mechanical properties subject to short-term and long-term loads, impact and fire; fatigue and fracture; transport properties, chemical degradation and long-term durability. *Prerequisite: graduate status.*

CE 607 Instrumentation, Monitoring, and Condition Assessment of Civil Infrastructure *2½:0:0:3*

A systematic approach to planning and executing instrumentation, monitoring and condition assessment programs; strain measurements; civil engineering sensors (static, dynamic, optical); environmental measurements; mechatronic sensors; signal conditioning, information measurements and error analysis; business aspects; advanced measurement systems.

CE 767 Environmental Impact Assessment *2½:0:0:3*

An examination of legal and technical requirements in the preparation of environmental impact statements. Considerations include legal and technical requirements, the procedure and the interdisciplinary nature of the analysis. Topics include overall impact evaluation, categories of impacts, problem definition, quantification of impact, methods used in analysis, field evaluations, mitigations, hearing procedures and management. Practical examples and case studies are used.

CE 784 Introduction to Urban Systems Engineering *2½:0:0:3*

A descriptive overview of the key infrastructure systems and technologies that must be managed, operated and maintained. Systems treated include buildings and structures, water supply, solid and liquid waste handling and disposal, transportation, power, communications and information systems, health and hospitals, police and fire protection. Course treats the financial, political, administrative, legal and institutional settings of

these systems and technologies. A portion of the course features distinguished guest lecturers who are experts in some of the systems and technologies included.

CE 825 Project Management for Construction *2½:0:0:3*

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 and project life-cycle activities. Also listed under MG 825.

CE 828 Risk Analysis *2½:0:0:3*

A thorough investigation of the ever-increasing importance of risk analysis in project management. Analysis of qualitative and quantitative risk. Techniques in probability analysis, sensitivity analysis, simulation of risk and utility theory. Computational methods for calculating risk. An exposure to the complexity of real-world corporate and public problems through case investigations.

CONSTRUCTION MANAGEMENT

CE 798/799 Special Topics in Infrastructure Systems and Construction I/II *2½:0:0:3*

Contemporary 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. Other topics include, but are not limited to, intelligent buildings and other modern constructed works, temporary structures for construction and problems in construction engineering, new approaches in construction management and integration and automation of construction processes.

CE 826 Construction Cost Estimating *2½:0:0:3*

Estimates and costs from the viewpoint of contractor or construction engineer, details of estimating with emphasis on labor, material, equipment and overhead costs. Also listed under MG 826.

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CE 827 Contracts and Specifications

2½:0:0:3

Principles of contract law as applied to the construction industry and legal problems in preparing and administering construction contracts. Also listed under MG 827.

CE 829 Construction Operations

Analysis

2½:0:0:3

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/time-lapse 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 adviser's approval.*

CE 830 Information Systems in Project Management

2½:0:0:3

Development of a strong understanding of contemporary tools for managing the vast array of information in the project life-cycle. Information handling is reviewed from the perspectives of both knowledge acquisition and knowledge representation. The course focuses on the concepts of fully integrated and automated project processes and the interrelationships of 3D computer models, simulation, cost estimating, scheduling, procurement and information technology (emphasis is given on the implementation of 3D computer models and relational databases as information systems for project information handling and project automation). *Prerequisite: degree in civil engineering or adviser's approval.*

CE 831 Engineering for Construction I: Methods and Technologies

2½:0:0:3

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 adviser's approval.*

CE 832 Engineering for Construction II: Design

2½:0:0:3

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 instructor's permission.*

The following courses are part of the Exec- 21 Executive Construction Management Certificate Program. They are open only to students with at least two years of practical experience in construction management.

CE 870 Managing and Leading in the 21st Century

2½:0:0:3

Today's mega projects require the formation of large multidisciplinary teams including engineers, constructors and financial, legal and business experts. Success in this challenging environment requires up-to-date and proven leadership and management skills. Learn these skills from two of the nation's premier corporate managers. Covers the basic components of management planning organizing, directing, controlling and decision-making. Defines the engineering and construction team and discusses leadership styles. Addresses the management of change, external factors that shape decisions, the development of a personal leadership profile and, ultimately, 21st century leadership requirements. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 871 Construction and the Law

2½:0:0:3

Construction industry executives need not be legal experts, but they must be aware of the legal issues affecting their industry and their bottom line. A leading construction law expert uses the case

study method to lead students through the concepts of design and construction law. Focuses on the interface of legal, business and technical issues and their resolution. Includes the design and organization of construction documents; the legal aspects of bidding, subcontracting, bonds, insurance, mechanic's liens, etc.; and the legal implications of delays, changes and changed conditions. Alternative dispute resolution (ADR) methods are introduced. Student participation and interaction is encouraged. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 872 How to Succeed in Construction

2½:0:0:3

A former chairman and CEO of an international construction firm leads students through the how-to's of running a successful, large and complex construction company. Analyzes how the industry actually works, including contractual relationships with clients in all types of projects, from design/build to privatization; the business fundamentals of running a construction company, covering issues such as surety and insurance; various types of construction organizations, domestic and international; and company culture—the inner workings of a business that can mean the difference between success and failure. Also, step-by-step breakdown of how to run a construction company: secure business; evaluate and estimate project costs; deal with contractors; manage self-perform work; handle financial, accounting and control issues; and deliver quality services while saving time and money. Finally, through case studies, focuses on applying sound business practices to risk management. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 873 Infrastructure Financing

2½:0:0:3

Increasingly, in infrastructure financing, the emphasis is on identifying a revenue-producing stream. Taught by investment bankers experienced in financing multi-billion dollar projects, this course examines what it takes to structure a deal from a credit perspective, legally and financially—for both domestic and international projects, examining the peculiarities and uniqueness of our capital markets—what drives them; how, historically, they have

been accessed to finance transportation projects; and the dramatically changing nature of financing these projects. In the international sector, covers new and innovative financing techniques. Uses recent case studies to provide hands-on experience in applying tools and techniques for analyzing project finance requirements for credit evaluation, forecasting and enhancing the efficiency of decision-making. Covers use of taxable and non-taxable bonds. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 874 International Engineering and Construction 2½:0:0:3

A world-renowned construction executive who successfully led his firm into the international marketplace gives a total overview of the international engineering and construction industry, from a historical perspective to a vision of the future. Covers networking/marketing and partnering skills that are unique to the international arena; parochialism and barriers to overseas involvement; education, R&D and technology transfer; delivery systems such as design-bid-build, design/build, turnkey, BOO, BOT and partnering; and guidelines for establishing an overseas office. As a final project, student teams will prepare a presentation for a board of directors to justify the establishment of an international engineering or construction office in a developing country. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 875 Project: Employer-Focused Residency 2½:0:0:3

Students can choose an employer-focused residency to replace one core or elective course. With the help of their employers, students identify a management or engineering problem specifically related to the work performed by their firms and develop innovative management and engineering techniques to rectify the problem. An Exec21 faculty adviser will supervise the project, providing guidance, conducting periodic review meetings and approving the final report. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 876 Capital Program Management/Program Development 2½:0:0:3

Drawing upon their considerable experience in major projects with the Port Authority of NY & NJ and the New York MTA, two veteran industry executives will examine capital program management and development from the public sector point of view. Analyzes how the public sector looks at a project and develops it and the internal workings of an organization in determining how a project is selected, funded and managed. Explains privatization and why it is chosen, from the public sector point of view. Uses case studies of three existing projects—a resource recovery plant, a cogeneration project and the JFK light rail DBOM project—to examine various contracting strategies. Concepts of risk allocation, funding and project finance (consolidated bonds, special project bonds), DBOM contracts and various privatization models are explored. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 877 Dispute Avoidance and Resolution 2½:0:0:3

Learn about dispute avoidance and resolution from a nationally recognized expert who is both an engineer and an attorney. Analyzes basic causes for construction disputes and introduces methods for dispute avoidance through proper risk allocation, management and control, as well as other techniques such as partnering. Uses the case study method to address litigation and provides an understanding of the process of arbitration and other alternative dispute resolution (ADR) methods such as negotiation, mediation, mini-trials and dispute review boards. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

CE 879 Advanced Construction Systems 2½:0:0:3

This course will cover estimation, control of cost of construction systems, requirements of plans and specifications and calculation of cost by trade crewing and histogram development. Use of three-dimensional computer models will be discussed, as well as time-cost trade-off analyses using construction animation and simulation. Topics include: piles and pile-driving equipment, concrete, mason-

ry and steel construction techniques. *Prerequisite: permission from both the faculty adviser and the Exec21 program director.*

ENVIRONMENTAL AND WATER RESOURCE ENGINEERING

CE 722 Hydrology 2½:0:0:3

Hydraulic cycle. Meteorological considerations. Analysis of precipitation, runoff, unit hydrographs, flood routing and reservoir storage. Principles of groundwater hydrology. Introduction to frequency analysis of floods and droughts. *Prerequisites: adviser's approval and undergraduate calculus and fluid mechanics.*

CE 723 Groundwater Hydrology and Pollution 2½:0:0:3

Characteristics of confined and unconfined flow of water through porous media; groundwater and well hydraulics; quality of groundwater; environmental influences; groundwater pollution; management aspects of groundwater and groundwater modeling. *Prerequisite: CE 722 or equivalent or instructor's permission.*

CE 735/736 Selected Topics in Water Resources and Hydraulic Engineering I/II 2½:0:0:3

Topics in water resources and hydraulic engineering of current interest. Some examples include Topics vary with each offering and are disseminated prior to the semester of offering. *Prerequisite: instructor's permission.*

CE 737 Environmental Chemistry and Microbiology I 1½:1½:0:3

Introduction to the chemistry and microbiology of polluted and natural waters, including applications of principles developed.

CE 739 Environmental Chemistry and Microbiology II 1½:1½:0:3

Advanced topics in chemistry and microbiology of polluted and natural wastewater treatment. *Prerequisite: CE 737 or equivalent*

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CE 742 Water and Wastewater Treatment I 2½:0:0:3

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-requisite: CE 737.*

CE 743 Water and Wastewater Treatment II 2½:0:0:3

Continuation of CE 742. Topics include sedimentation, adsorption, aerobic and anaerobic biological treatment, sludge treatment and disposal. *Prerequisite: CE 742. Co-requisite: CE 739.*

CE 745 Water and Wastewater Treatment 1:2:0:3

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 and aerobic and anaerobic biological treatment systems. Warburg analysis of waste. *Co-requisite: CE 743.*

CE 747 Analysis of Stream and Estuary Pollution 2½:0:0:3

Dispersal and decay of contaminants introduced into lakes, streams, estuaries and oceans. Effects of pollutants on chemical quality and ecology of receiving waters

CE 752 Air Pollution 2½:0:0:3

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 2½:0:0:3

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 2½:0:0:3

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: adviser's approval.* Also listed under CH 752.

CE 770 Solid Waste Management 2½:0:0:3

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 Selected Topics in Environmental and Water Resources Eng I/II 2½:0:0:3

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, hydro-economic models, finite difference and finite element models, synthetic hydrology, desalinated and recycled water systems and others. *Prerequisite: instructor's permission.*

GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

CE 840 Geotechnics and Geomaterials 2½:0:0:3

Index properties of soil, mechanical behavior, shear strength, stress-strain characteristics, drained and undrained soil behavior, permeability, seepage, groundwater flow and control, consolidation of soils. *Pre-requisite: undergraduate soil mechanics.*

CE 842 Foundations and Ground Improvement 2½:0:0:3

Foundation engineering practice, foundation rehabilitation, emerging ground improvement technologies. Selection and

design analysis of appropriate ground improvement techniques for different foundation problems. Construction, monitoring and performance evaluation. *Prerequisites: undergraduate soil mechanics and foundations.*

CE 843 Urban Geotechnology 2½:0:0:3

Case histories on geotechnical design, construction and rehabilitation in the urban environment. Special construction problems and innovative solutions; unforeseen ground conditions, performance monitoring, remedial planning and implementation, geotechnical design and construction issues from a practicing engineer's perspective. *Prerequisite: CE 842 or instructor's permission.*

CE 849 Environmental Geotechnology 2½:0:0:3

Clay mineralogy, soil-water interaction processes, chemical transport through soils, hydraulic conductivity, diffusion and attenuation mechanisms, water disposal systems, design of land fills, seepage barriers and cut-off walls; geo-environmental site characterization techniques; soil remediation techniques. *Prerequisite: undergraduate soil mechanics.*

CE 860 Selected Topics in Geotechnical Engineering 2½:0:0:3

Current topics of special interest, such as ground improvement, geotechnical earthquake engineering, site characterization and remediation. Topics vary with each offering and are disseminated prior to registration. *Prerequisites: CE 840 and CE 841.*

CE 866 Advanced Foundation Design 2½:0:0:3

Advanced analysis of foundations, shallow foundations, bearing capacity, settlement, deep foundations, axial and lateral loading of piles, wave equation analysis, drilled piers and design and construction issues. *Prerequisites: undergraduate soil mechanics and foundations.*

STRUCTURAL MATERIALS AND ENGINEERING

CE 601 Theory of Structural Analysis and Design 2½:0:0:3

Theories of structural analysis and their 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: undergraduate structural analysis.*

CE 603/604 Selected Topics in Structural Analysis I/II 2½:0:0:3

Special topics of current interest offered at irregular intervals by advance announcement. Graduate advisers may approve repeat registration for different topics. *Prerequisite: adviser's approval.*

CE 606 Bridge Engineering 2½:0:0:3

Types of bridges; geometric design of bridges; construction materials and construction techniques; simplified bridge analysis; special problems in the design of steel and reinforced concrete bridges; bridge inspection policies; bridge rehabilitation procedures; bridge management systems; effects of wind and earthquakes on long-span bridges. *Prerequisites: undergraduate structural analysis and steel design.*

CE 613 Stability of Structures 2½:0:0:3

Stability concepts. Investigation of buckling structural configurations composed of beams, plates, rings and shells. Effects of initial geometric imperfections, load eccentricities and inelastic behavior. Application of energy measures and numerical techniques. *Prerequisite: adviser's approval.*

CE 614 Steel Structures 2½:0:0:3

Compression members; elastic and inelastic buckling of columns and plates. Lateral supported beams; 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 semi-rigid mechanisms of continuous beams and rigid frames. Elastic/plastic design criteria. *Prerequisite: undergraduate steel design.*

CE 616 Finite Element Methods 2½:0:0:3

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. *Prerequisite: adviser's approval.*

CE 618 Concrete Structures 2½:0:0:3

Design principles and construction methods for reinforced and pre-stressed concrete structural elements; response of members subject to axial loading, shear and flexure; design of columns, deep beams and shear walls; design and detailing for connection regions; design of pre-tensioned and post-tensioned beams and slabs; effect of short-term and long-term deformations. *Prerequisite: graduate status.*

CE 619 Earthquake and Wind Engineering 2½:0:0:3

Characteristics of wind and earthquake loads; atmospheric motions and boundary layer; response of structures to wind forces; code treatments of wind loads on structures; calculation of lateral forced from seismic events; lateral force resisting systems; diaphragm and center of rigidity; response spectrum and time-history; ductility; concrete and steel frame structures; braced frames; shear walls; dual systems; story drift; detailing requirements. *Prerequisite: graduate status.*

CE 782 Forensic Engineering 2½:0:0:3

Focuses on the direct application of engineering principles to the proper performance of civil engineering structures. Emphasizes lessons learned by analyzing structural failures and resulting outstanding practicing professional engineers.

HIGHWAY AND TRAFFIC ENGINEERING

For courses in this area, please consult the "Transportation" section of this catalog.

URBAN INFRASTRUCTURE SYSTEMS MANAGEMENT AND ENGINEERING

CE 781 Infrastructure Planning, Engineering and Economics 2½:0:0:3

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, meets local and regional needs and takes advantage of opportunities for development. Financial and economic analyses, including sensitivity and risk analysis. Mathematical models for evaluation of alternatives and optimization. Impacts of projects: environmental, social, regional economic growth, legal and institutional and public involvement.

CE 783 Infrastructure Rehabilitation: A Practical Approach 2½:0:0:3

Upgrading the nation's aging infrastructure will be a top national priority well into the 21st century. A preeminent civil engineer who has overseen major rehabilitation projects focuses on the direct practical application of engineering principles required to address today's infrastructure rehabilitation needs. Emphasizes conceptual thinking, brainstorming techniques, team evaluation of alternative solutions, verbal and written communication and intensive classroom participation.

CE 785 Concepts and Implementation of Infrastructure Management Systems 2½:0:0:3

Review of state-of-the-art performance monitoring and system condition assessment methodologies as part of infrastructure management systems. Emphasis is placed on information technologies as applied to remote sensing and data base development for urban systems management. Infrastructure tools, such as GIS and dedicated databases for condition

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assessment are presented in a laboratory environment. Invited experts participate in such areas as transportation, water distribution and utilities.

CE 786 Infrastructure Monitoring and Performance Assessment

2½:0:0:3

Introduction to the physical nature of infrastructure materials and systems. Concept of performance is introduced from the point of view of strength and durability. Lectures and laboratory demonstrations identify the mechanism of degradation and cover techniques for condition assessment and quality assurance.

CE 990 Case Study in Urban Systems Engineering and Management

3 units

A comprehensive independent case study involving a specific urban infrastructure engineering and management project under the guidance of a faculty adviser and generally in coordination with a participating infrastructure agency. Case studies are submitted as formal reports and must be formally presented and defended.

GENERAL COURSES

CE 598 Selected Topics in Civil Engineering I

2½:0:0:3

Special topics in current areas of civil engineering that cover more than one sub-disciplinary category. Open to undergraduate students with exceptional records on approval of the undergraduate adviser.

CE 599 Selected Topics in Civil Engineering II

2½:0:0:3

Special topics in current areas of civil engineering that cover more than one subdisciplinary category. Open to undergraduate students with exceptional records on approval of the undergraduate adviser.

GUIDED STUDIES AND RESEARCH

CE 901 Readings in Civil Engineering

3 units each

Individual study of selected literature in civil engineering under the guidance of a faculty adviser. Acceptable written report or successful completion of an examination is required. Only one registration permitted, except with the permission of the department head. *Prerequisite: instructor's permission.*

CE 996 Project for the MS in Civil Engineering

3 units

Analytical, design or experimental studies in civil engineering under the guidance of a faculty adviser and following departmental guidelines. A written report is required. *Prerequisites: degree status and project adviser's approval.*

CE 997 Thesis for the MS in Civil Engineering

3 units each

Original investigation or design in the student's principal field of study prepared under close supervision of a faculty adviser. Candidates must successfully defend theses orally. Registration for a minimum of 6 units is required. *Prerequisites: degree status and thesis adviser's approval.*

CE 999 Dissertation for the PhD in Civil Engineering

3 units each

Independent original investigation demonstrating creativity and scholarship worthy of publication in a recognized engineering journal. Candidates must successfully defend dissertations orally. Registration for a minimum of 30 units is required prior to the defense. Registration must be continuous (excluding summer semesters), unless a formal leave of absence is requested and approved. Registration for 3-18 units per semester is permitted. In the final semester of work, registration for ? unit is permitted with the approval of the department head. *Prerequisites: degree status, successful completion of doctoral qualifying examinations and approval of the dissertation adviser.*

Typical Course of Study for the Bachelor of Science in Civil Engineering

FRESHMAN YEAR

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
MA 1054	Calculus I with Precalculus ¹	4	0	0	4
CM 1004	General Chemistry	3	2	1	4
EN 1014	Writing & Humanities I ²	4	0	0	4
EG 1004	Intro. Engineering & Design ³	1	3	2	4
SL 1010	Freshman Seminar	1	1	0	0
					16

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
MA 1154	Calculus II with Precalculus	4	0	0	4
PH 1004	Introductory Physics I	4	1½	1	4
EN 1204	Writing & Humanities II	4	0	0	4
CE 1004	Fundamentals of Civil Engineering	2	3	0	3
					15

SOPHOMORE YEAR

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
MA 2012	Linear Algebra I (½ semester)	4	0	0	2
MA 2132	Ordinary Diff. Equ. (½ semester)	4	0	0	2
HI 2104	Modern World History	4	0	0	4
PH 2004	Introductory Physics II	4	1½	1	4
CE 2114	Statics & Dynamics	4	0	1	4
					16

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
MA 2212	Data Analysis I (½ semester)	4	0	0	2
MA 2222	Data Analysis II (½ semester)	4	0	0	2
CE 2214	Fluid Mechanics & Hydraulics	3½	1½	0	4
CE 2124	Mechanics of Materials	3½	1½	0	4
	HU/SS Elective ³	4	0	0	4
					16

JUNIOR YEAR

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
	Math/Science Elective ⁴				4
CS 3xx2	Computer Systems & Problem-Solving ⁵				2
CE 3324	Traffic Engineering I	4	0	0	4
CE 3133	Structural Analysis	3	0	1	3
	HU/SS Elective ³	4	0	0	4
					17

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
CE 3144	Steel Design	3	3	0	4
CE 3153	Geotechnical Engineering	2	3	0	3
CE 3223	Environmental Engineering I	3	3	0	3
	Technical Elective I ⁶	3	0	0	3
	Sequence Elective I ⁷				4
					17

SENIOR YEAR

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
CE 4243	Water Resources Engineering I	3	0	0	3
CE 4812	Design Project I	1½	0	1½	2
	Technical Elective II				3
	Sequence Elective II				4
	HU/SS Elective ³				4
					16

		Hours/Week			
Course No.	Course Title	Class	Lab.	Rec.	Cr.
CE 4163	Materials Engineering	2	3	0	3
CE 4413	Construction Management	3	0	0	3
CE 4823	Design Project II	2	0	3	3
	Technical Elective III				3
	Technical Elective IV				3
					15

Total credits required for graduation: 128

1. The Department of Civil Engineering prefers all of its students to take the MA 1054/1154 calculus sequence. This sequence includes two additional hours of pre-calculus review which the department believes is helpful, even for students with an excellent math background. Students may choose to take a placement exam to be placed in MA 1014/1124 (Calculus I, II), or may be advance-placed based upon AP test results.

2. Students who are placed by examination or by an adviser into EN 1080 must subsequently register for EN 1034, rather than EN 1014. Some students with an ESL background may be placed in EN 1034, which is equivalent to EN 1014 with additional hours.

3. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II Elective courses (course numbers 2xx4) in different disciplines (prefixes) and one from Level III Advanced Elective courses (course numbers 3xx4, with a level II prerequisite).

4. The math/science elective may be selected from among any course in mathematics, chemistry, physics or biomedical science for which the student has the appropriate prerequisites.

5. This course is currently under development, and will be given for the first time during the 2005-2006 academic year.

6. Technical electives: there are four technical electives in the CE curriculum. Three must be chosen from among civil engineering (prefix CE) courses; the fourth may be taken from among any math, science or engineering course for which the student has the appropriate pre-requisites.

7. Every student must select an 8-credit, two-course sequence from the approved list. The list included elsewhere in this catalog, and may be obtained from the department or on the University's website. This requirement has been eliminated for students enrolling in September 2003 or later; such students may treat these credits as additional technical electives.

COMPUTER ENGINEERING PROGRAM

Program Director: Peter Voltz

The Department of Electrical and Computer Engineering offers a Computer Engineering Program for the degrees Bachelor of Science and Master of Science. The BS in Computer Engineering is administered in cooperation with the Department of Computer and Information Science.

COMPUTER ENGINEERING PROFESSION

As the use of digital computers became pervasive in all branches of human endeavors, the discipline of computer engineering developed to encompass the work of designing computers and devising ways to use them has improved the efficiency and quality of almost all activities in business, industry, government, education and entertainment. Computer engineering draws heavily on electrical engineering topics, including electronic circuit design and analysis of physical communication and control systems; and on computer science topics, including logic design, system architecture, computer software and algorithms.

Computer engineering is a rapidly growing profession and computer engineers are in the midst of exciting times with unlimited opportunities in all walks of life. For instance, computer engineers interact with and design large supercomputers as well as the ubiquitous personal and portable computers. Furthermore, computer engineers play a key role in networking computers with other computers and intelligent devices. Computer engineers are also involved in projects as varied as designing specialized computer hardware to reconstruct the human genome to monitoring and controlling industrial plants and the environment, computer graphics, robotics and the design of biomedical devices and computer networks. Finally, computer engineers design and develop hardware and embedded software-hardware systems.

The Computer Engineering Program

provides an outstanding and up-to-date education in computer systems with an emphasis on both hardware and software. To achieve this goal, the department incorporates into the educational experience the latest trends in the marketplace and in technology, combining traditional disciplines of electronics, communications, control and computer programming with newer courses such as Encryption, Circuit Design, Parallel Machines, Image Processing, Java Programming, Wireless Networks, Local Area Networks and ASIC (Applications Specific Integrated Circuit) and VLSI (Very Large-Scale Integrated).

A strong design faculty has been developed through sponsored research programs, many of which are coordinated in Polytechnic's Center for Advanced Technology in Telecommunications (CATT).

Additional information about computer engineering careers can be found online at www.iee.org/organizations/eab/sloancareers/sloancareers.htm.

UNDERGRADUATE PROGRAM

The Bachelor of Science program in Computer Engineering gives students a broad-based background in computer engineering, preparing them for immediate employment in industry and government or for graduate study.

GOALS AND OBJECTIVES

The undergraduate program achieves the following objectives for students:

- Instills in them a broad-based understanding of the fundamental technical subject areas associated with computer engineering
- Requires them to achieve technical depth in at least one area of specialization and allows them to take electives in other areas
- Develops their problem-solving skills with modeling, analysis, design and computer simulation as tools
- Provides them with a broad educa-

tional component that complements the technical content of the computer engineering discipline, including multidisciplinary experience, humanistic and societal issues, with particular emphasis on the development of effective oral and written communication skills.

The BS program includes analysis and design courses in the major areas of computer engineering that build on fundamental courses in mathematics and science. Many of the computer engineering courses include hands-on laboratory components. A variety of electives are available to undergraduates to provide depth and specialization, many in commercially viable areas such as high-speed networks, data bases, embedded control systems, image processing and archiving and privacy/security.

Since most current engineering design is computer facilitated, the department includes computer-aided design (CAD) programs in many undergraduate courses to emphasize possibilities for large-scale design, corrections for unmodelled complexities, trade-offs among performance criteria and real-time simulations. The senior design project challenges each student to integrate analytical and design concepts from earlier courses to design a device or system to meet specified performance requirements.

The program recognizes that communication and interpersonal skills are essential to a successful career in any profession. Students in the program are required to take courses in history, writing and literature, as well as elective courses in the areas of humanities and social sciences. Those skills are also developed in team projects in design courses.

The Computer Engineering Program keeps abreast of market changes through the CATT Industrial Affiliates Program, hiring of professors and part-time adjunct teachers who have industrial experience, frequent contacts with alumni, review of professional journals and

encouraging faculty to work in industry part-time or while on sabbatical. Where possible, classroom work challenges students to apply their knowledge to current design situations.

Industry's need for the systems approach in engineering is also reflected in the curriculum through senior projects in areas such as control and robotics, advanced hardware design, imaging and embedded controllers. The economic aspects of engineering are addressed by allowing undergraduates to choose electives such as macro/micro economics, psychology and ethics. Cost evaluation is required in the design projects for EG 1004 Introduction to Engineering Design. Senior projects emphasize time management and planning.

Exceptional undergraduate students are given the opportunity for advanced study in two programs: (1) the BS/MS Honors Program, which requires students to work on a research project equivalent to 6 or 9 credits hours, and (2) the summer junior research internship program, which allows undergraduates to work on research projects with graduate students and their advisers.

Up-to-date information about program requirements, course offerings, senior project topics and research projects is available online from the Department of Electrical and Computer Engineering at www.ece.poly.edu.

UNDERGRADUATE DEGREE REQUIREMENTS

The BS program in Computer Engineering gives students broad-based preparation for a career in computer engineering in any of its specialization and readies them for immediate employment in industry, business and government, or for further graduate education. The program is accredited by the Accreditation Board for Engineering and Technology (ABET).

The table at the end of this section outlining the Typical Course of Study for a BS shows a typical semester-by-semester program for students who enter as freshmen in fall 2005 or later. The notes identified by superscript numbers are an essential part of the table. Students are responsible for making themselves aware of changes that might be made in this program after the publication date of this catalog. Those changes are posted outside the department's advising offices and on the

department's Web page. (Students who started their studies before fall 2005 should consult the department's Web page for program and course requirements applicable to them.)

CONCENTRATIONS FOR THE BS IN COMPUTER ENGINEERING

Each BS student in computer engineering is required to take two elective courses that are associated with a specified concentration area. Students may enrich the quality of a concentration by taking additional electives in related areas and/or doing a senior project on a topic in the concentration area. Students should also note that some concentration courses have other elective courses as prerequisites. Students who plan to enroll in the MS Electrical Engineering Program should include EE 3054 as an elective in the BS program.

A 2.7 GPA or better is required to take 6XX-level graduate courses.

The following list shows possible concentration areas and course groupings. Students should consult departmental posting and its Web page for up-to-date information on concentrations.

Concentrations I and II:

Computer Architecture

CS 3254 Intro to Parallel & Distributed Systems
CS 613 Computer Architecture I

Electronics

EE 3124 Fundamentals of Electronics II
EL 644 VLSI System & Architecture Design

Software Engineering

CS 4531 Software Engineering
CS 3234 Data Base Systems
CS 391 Java and Web Designs
CS 905 Intro. to Java Programming

Security

CS 392 Computer Security
CS 393 Network Security

Communications

EE 3054 Signals & Systems
EE 3404 Fundamentals of Communications Theory
EL 501 Wireless Personal Communication Systems
EL 601 Principles of Digital Communications: Modulation & Coding
EL 930 Wireless Information Systems Lab

Networking

EL 501 Wireless Personal Communication Systems
EL 537 Internet Architecture & Protocols
EL 604 Wireless & Mobile Networking Protocols
EL 638 High-speed Networks

Signal Processing

EE 3054 Signals and Systems
EL 512 Image Processing
EL 514 Multimedia Information Processing & Communications Lab

Systems/Control

EE 3064 Feedback Control
EL 625 Linear Systems

SENIOR DESIGN PROJECT

The two-semester Senior Design Project allows students to focus on an application area of computer engineering. In the first semester students choose to concentrate in either the hardware or software aspect of computer engineering. They develop skills using specialized laboratory equipment and computer design packages, are introduced to techniques for planning projects and making effective presentations, and they learn to balance design requirements such as performance, safety, reliability and cost-effectiveness.

In the final semester, students design, build or simulate and test a device or system to meet prescribed engineering specifications.

Informal and formal written and public oral presentations help prepare students for professional careers. Design project students frequently work in groups or pairs to develop interaction skills essential to good engineering.

GRADUATION REQUIREMENTS

The University requires a 2.0 GPA 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 in writing, mathematics and programming; course credits by transfer and advanced placement; and credit by examination.

To graduate, students must (1) have a C- grade or better in CS 1114, 1124, 2134 and 2204 and in EE 2013 and 2024 and (2) have a technical GPA of 2.0 based on all courses prefixed EE, CS or EL. Seniors may elect graduate courses labeled EL 5XX, but not CS 5XX. To enroll in other graduate courses, seniors must have a 2.7 GPA or better in related courses and adviser approval.

Students are expected to meet the degree requirements in effect at the time when they first enrolled in a Polytechnic program. Those requirements apply as long as a student remains in good stand-

ing and less than eight years have elapsed since entering the program. The period for unchanged requirements is proportionately less for a transfer student.

GOOD STANDING, PROBATION AND DISQUALIFICATION

Students who fail to meet University GPA requirements or other conditions of adequate progress toward completing a degree are put on probation. (See the "General University Requirements" section in this catalog for more details.) Students on final probation may not register for courses in one semester until grades are available from their previous semester's courses, and they are limited to a reduced number of credits per semester. Students who improve their academic performance are removed from probation and returned to good standing. Continued poor academic performance can lead to final probation and, eventually, disqualification from the University.

To remain in good standing in the Undergraduate Computer Engineering Program, students must (1) maintain, term-by-term and cumulatively, a technical GPA (based on EE, EL and CS courses) and a University GPA of at least 2.0; (2) fail no courses; (3) earn a C- or better in each of the five courses specified above; (4) fulfill all course pre-/co-requisites; and (5) remove any incomplete I grades within 30 days of the last day of final exams. Occasionally an adviser may permit a third enrollment in a course for which a C- grade is required. In such cases, the student must earn a C or better in that course. Students facing difficulties, whether educational or personal, should consult their instructor or a departmental adviser at the earliest possible time. Students who do not meet program conditions are placed on departmental probation.

Probation conditions may require students to (1) repeat courses, including courses where they received transfer credits and courses where they received a C grade or less at Polytechnic; (2) specify their credit load and permissible withdrawals; or (3) take other remedial programs. Students who do not meet departmental probation requirements, fail twice to earn the required grade in any one course or do not conform to the University Student Code of Practice are

subject to being disqualified from working toward a bachelor's in computer engineering or taking any further computer engineering courses. Actions taken depend on individual cases. Students who are disqualified may appeal in writing. Students may also apply for readmission after two terms (fall, spring or summer) have passed if they show evidence of an improved chance of success.

DUAL UNDERGRADUATE MAJORS

With departmental permission, students may earn a single bachelor's degree in electrical and computer engineering. This degree requires a total 142 credits rather than the usual 128 required for individual bachelor's degrees.

PART-TIME UNDERGRADUATE STUDY

In order to accommodate the need of some students to complete part of their studies on a part-time basis, some basic courses are offered in the evening (starting at 6PM or later). However, part-time students will have to take most of their courses during the day to complete their 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

Transfer credits for courses taken at other schools are based on evaluation of content and level. Students completing the same program at another school, but in different years, may receive different amounts of transfer credits. They should consult with a 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. Transfer credits are awarded only for courses completed with C grades or better.

Qualified students from two-year pre-engineering programs, such as those at liberal arts and community colleges, may fulfill the requirements for the BS 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 at

the beginning of their pre-engineering program.

Graduates of technology programs may be able to fulfill the requirements for the BS in Computer Engineering in two to three and a half years, depending on the scope and level of their previous education. They should consult with an undergraduate adviser for details.

THE BS/MS ACCELERATED HONORS OPTION

The BS/MS Accelerated Honors Option leads to the simultaneous awarding of a bachelor's and master's degree. Depending on the student's preparation and objective, the two degrees may be completed in as few as four years of study. Each program is individually designed in cooperation with the departmental BS/MS Accelerated Honors Option adviser to allow varied transfer and AP credits, co-op program participation, professional summer jobs and other goals consistent with the Honors program.

Possible BS/MS combinations include a BS in Computer Engineering with an MS in Computer Engineering, Computer Science, Electrical Engineering or Telecommunications Networks.

Incoming freshmen with superior admissions qualifications are invited to participate in the Accelerated Honors Program. Later admission may be considered after students complete no more than one year at Polytechnic. Students must complete 16 to 20 credits each semester, maintain a 3.5 GPA overall and technical average, particularly in key courses, and display a record 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 for the senior Design Project II, and all curriculum footnotes apply. Required credits are the sum of the credits for the two degrees minus the 3 credits of senior Design Project II. Student in this program must complete a Master's Thesis (generally optional for other MS students).

Acceleration may be achieved through summer course work, extra course loads, careful course sequencing or credit by examination. Students may also achieve acceleration through advanced placement credit in such

courses as calculus, computer science or physics.

GUIDANCE FOR UNDERGRADUATE STUDENTS

Instructors provide help for students in their courses during hours posted on their doors or by appointment. Students taking project or thesis courses work closely with faculty project advisers. Computer engineering advisers in the undergraduate or graduate ECE office are available 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 Polytechnic Tutoring Center provides drop-in tutoring in mathematics and physics. Personalized career counseling is available.

SL 1010 Freshman Seminar introduces students to Polytechnic and its curricula. Fellow students are an excellent source of advice on adjusting to the University environment and the demands of an engineering program. In addition to meeting students in class, students are urged to meet students who can provide experienced advice by joining clubs such as the student branch of the Institute for Electrical and Electronics Engineers (IEEE) professional society, Association for Computing Machinery (ACM) or religious or ethnic clubs.

Students are advised to meet with other students to study and to do homework. In this way they benefit both from explanations provided by others and by the deeper understanding they get when they explain a concept or technique to someone else.

INFORMATION

Undergraduate advising information is available on the Department of Electrical and Computer Engineering's website, www.ece.poly.edu. Students should consult that page for further details on honors, probation, approved electives, projects, elective concentrations, course offerings, senior project topics and other matters of interest. Curriculum and prerequisite changes, new courses, special sections and other last minute announcements are also posted on the bulletin boards outside the Office of Electrical and Computer Engineering Advising. All students are

responsible for keeping informed about the latest procedures and regulations.

Descriptions of undergraduate electrical engineering and computer science courses used in the Computer Engineering Program are located in those programs' sections of this catalog.

GRADUATE PROGRAM

The MS in Computer Engineering educates professionals in computer engineering by offering graduate courses that meet the current and projected needs of industry and government in the metropolitan New York area. The program promotes computer engineering through basic and applied research carried out by faculty and students in collaboration with industry and government agencies.

Polytechnic's MS program in Computer Engineering targets two important needs: (1) as a terminal degree for students intending to round out their education and seek employment and (2) as the tools and background necessary to carry out self-directed research for students planning a PhD. 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 toward a PhD in Computer Engineering may do so in the Electrical Engineering Program.

The electrical engineering and computer science faculty's research and teaching interests in computer engineering include computer networks, VLSI design and CAD, verification and testing of VLSI systems, embedded systems design and computer architecture. The MS in Computer Engineering focuses on the principles and concepts underlying the design and integration of hardware and software components and systems.

The needs of modern society for sophisticated and efficient electronically controlled systems and devices is increasing exponentially. Advanced studies in computer engineering provide a needed bridge between the University and industry. The Department of Electrical and Computer Engineering is committed to developing and administering a top-notch academic and research program in computer engineering with strong focus on telecommunications, computer networks and microelectronics.

GOALS AND OBJECTIVES

The MS program in Computer Engineering prepares graduates to practice computer-engineering profession at an advanced level. The program's specific goals and objectives provides students with the following:

- The opportunity to specialize in one of the primary subdisciplines of computer engineering (VLSI, High Speed Networking, etc.), or to achieve breadth across a number of the sub-disciplines
- Analysis and design knowledge necessary to design general purpose as well as specialized, application-specific computer hardware
- The knowledge and skills to design embedded software-hardware systems
- Exposure to state-of-the-art computer engineering techniques and technologies such as new computer architectures and design styles
- A basis for continued lifelong learning in the computer engineering profession

ADMISSION REQUIREMENTS

Admission to the MS program requires a bachelor's degree in computer engineering, electrical engineering or computer science from an accredited institution. Students not meeting these requirements are considered for admission on an individual basis and may be admitted subject to the completion of appropriate courses to remove any deficiencies in preparation. Topics in which deficiencies must be removed include logic circuits design, state analysis and synthesis techniques, computer architecture, data structures and algorithms and C or C++ programming.

DEGREE REQUIREMENTS

To satisfy the requirements for a MS degree, students must complete a total of 36 units as described below. Of these, at least 21 units should be EL units and 9 units should be CS units.

GROUP 1: Core courses

EL 536	Principles of Communication Networks
EL 549	Advanced Hardware Design (VHDL)
CS 613	Computer Architecture I

9 units

COMPUTER ENGINEERING PROGRAM

GROUP 2: Two one-year sequences
6-12 units

GROUP 3: Approved electives are chosen with adviser approval from graduate offerings in EL, CS and, occasionally, pertinent courses from other departments. With adviser approval, students may select other groups or individual courses provided they relate to the various facets of computer engineering.

12-15 units

GROUP 4: Students must take a project that relates to the computer engineering discipline and is approved by an adviser.

3 units

Minimum Total: 36 units

Thesis option: A 9-unit thesis may be selected and used to replace: (1) either a one-year sequence from Group 2 or two electives from Group 3 and (2) the 3-unit project EL 995 from Group 4.

A grade of B is required in all graduate courses taken at Polytechnic, except those used for the undergraduate degree. No more than 9 of 36 units may be taken outside Polytechnic. Also, such units are not used in computing the GPA.

A grade of B is also required in the courses taken to satisfy groups 1 and 2 above. These courses must all be taken at Polytechnic. If some of these courses are excused because they were taken as part of an undergraduate program or were awarded transfer units, substitute courses approved by the adviser are used in calcu-

lating this average. In any case, a total of 36 units are required for the degree.

Students should consult the Department of Electrical and Computer Engineering Graduate Student Manual (www.ece.poly.edu) for more detailed rules and procedures, including student status, transfer units, recommended electives and one-year sequences, current areas of research and disqualification for low grades.

Typical Course of Study for the Bachelor of Science in Computer Engineering

FRESHMAN YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EG 1004	Intro. Engineering & Design	1	3	2	4	
CS 1114	Intro. Prog. & Problem Solving ¹	3	3	0	4	
MA 1024	Calculus I	4	0	0	4	
EN 1014	Writing & Humanities I ³	4	0	0	4	
SL 1010	Freshman Seminar	1	1	0	0	
					16	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
PH 1004	Introductory Physics I	4	1½	1	4	
CS 1124	Object-Oriented Programing ¹	3	3	0	4	
MA 1124	Calculus II	4	0	0	4	
EN 1204	Writing & Humanities II	4	0	0	4	
					16	

SOPHOMORE YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
PH 2004	Introductory Physics II	4	1?	1	4	
EE 2013	Fundamentals of Electric Circuits I ¹	3	0	1	3	
CS 2134	Data Structures & Algorithms ¹	4	0	0	4	
MA 2012	Linear Algebra I (½ semester)	4	0	0	2	
MA 2132	Ordinary Diff. Equ. (½ semester)	4	0	0	2	
					15	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
CM 1004	General Chemistry	3	2	1	4	
EE 2024	Fundamentals of Electric Circuits II ¹	3	1	1	4	
MA 2112	Multi. Calculus A (½ semester)	4	0	0	2	
MA 2312	Discrete Math I (½ semester)	4	0	0	2	
CS 2204	Dig Logic & State Mach Design ¹	3	3	0	4	
					16	

JUNIOR YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 3114	Fundamentals of Electronics I	3½	1½	1	4	
CS 2214	Computer Architech. & Organ. ¹	3	3	0	4	
MA 2212	Data Analysis I (½ semester)	4	0	0	2	
MA 2222	Data Analysis II (½ semester)	4	0	0	2	
HI 2104	Modern World History	4	0	0	4	
					16	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 136	Communication Networks ³	3	0	0	3	
CS 3224	Operating Systems	4	0	0	4	
	HU/SS Elective ⁴	4	0	0	4	
	Sequence Elective I ⁶				4	
EE 3193	Intro. VLSI Circuits ³	3	0	0	3	
					18	

SENIOR YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 4313 or or CS 4513	CompE or CS Design Project I ¹	1	3	1	3	
EE 4144	Intro. Embedded Sys. Design	3½	1½	0	4	
	Concentration I ⁵				3-4	
	HU/SS Elective ⁴	4	0	0	4	
	Sequence Elective II ⁶				4	
					18- 19	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 4323	CompE Design Project II	0	6	1	3	
	EE/CS/EL Elective				3-4	
	Concentration II ⁵				3-4	
	HU/SS Elective ⁴	4	0	0	4	
					13-15	

Total credits required for graduation: 128

1. Grade of C- or better is required.

2. Students who are placed by examination or by an adviser into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1024.

3. Students who are placed by examination or by an adviser into EN 1080 must subsequently register for EN 1034, rather than EN 1014.

4. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II

Elective courses in different disciplines and one from Level III Advanced Elective courses.

5. See list of concentration areas and course groupings in this program section.

6. A list of approved Sequence Electives is available from the department.

COMPUTER SCIENCE PROGRAM

Program Director: Stuart A. Steele

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 geometry, database systems, parallel and distributed computing, and image analysis and understanding. The Computer Science Program is administered by the Department of Computer and Information Science.

UNDERGRADUATE PROGRAM

This program in computer science is accredited by the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET). 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. Extensive hands-on experience with projects and teamwork, breadth and flexibility in elective courses, solid training in mathematics and science, and a general education based upon multidisciplinary courses are an integral part of the curriculum.

GOALS AND OBJECTIVES

The goals and objectives of the Bachelor of Science program in Computer Science are to provide students with the following:

- Strong fundamental science and mathematical base of knowledge
- Skills and fundamentals of computer science
- Proper balance of theory and practice for problem solving

- Well-balanced education with knowledge in humanities, mathematics, science, business and computer science
- Opportunity to explore various aspects of computer science and other fields through flexible electives

OVERVIEW OF THE UNDERGRADUATE CURRICULUM

The main focus of the undergraduate program is on theory, practice, interdisciplinary activities and problem-solving techniques. The curriculum addresses (1) the core/common knowledge that should be required of all computer science graduates and (2) a set of other important topics in computer science that students can choose to study depending on individual interests and career goals. For the required computer science core, courses are chosen in the following six areas: theoretical foundations of computer science, algorithms, data structures, software design, the concepts of programming languages and computer elements and architecture. For the computer science elective courses, the program offers a wide range of advanced topics, including java programming, UNIX programming, parallel and distributed processing, database systems design and interactive computer graphics.

The Computer Science Program allows students to receive a balanced education in the three processes of computing discipline: theory, abstraction and design/skill. Theory provides the underlying mathematical or scientific principles that apply to the discipline of computing. In the abstraction process, students develop models for potential algorithms, data structures, architectures and so forth. In the design process, students engage in the development of a computer system or software using necessary computer skills (e.g., proficiency in a particular programming language or database package).

Undergraduates in computer science at Polytechnic 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 Component (48 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 computer organization and architecture, as well as data structures, software development, database systems, operating systems, C++ and object oriented technologies, 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.

To work with a variety of students with different levels of computer experience, the Department of Computer and Information Science offers two different levels of CS 1114 Introduction to Programming and Problem Solving: 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 who therefore would be bored if these were covered slowly. The course for inexperienced users will be paced for first-time users and will go more slowly through the basic material.

The elective strategy for the proposed BS Computer Science Program consists of eight electives: a two course sequence selected by students from the list of Elective Sequences designated by the University, four CS electives, one technical elective and one free elective.

At least two of the four required CS electives must be chosen from the following list:

- Artificial Intelligence I

- Computer Networking
- Computer Security
- Digital Logic and State Machine Design
- Introduction to Databases
- Introduction to Parallel and Distributed Systems

Computer science is an ever-changing field; the department regularly offers selected topics courses in current areas of computer technology; selected topics are announced every semester.

Mathematics Component (20 credits)

Mathematics is essential to the computer science 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 preparatory mathematics courses in order to prepare them for the calculus sequence. The physics sequence begins in the first term of the sophomore year to take advantage of students' preparation in mathematics.

Basic Science Component (12 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 (4 credits)

Today, computers are used in all disciplines of engineering. Applications range from computer simulation of wind tunnels to computer-aided design (CAD) of automobile parts and loadflow analysis of electric power circuits. It is important that computer scientists can communicate with engineers from different disciplines to understand their needs. EG 1004 Introduction to Engineering and Design introduces computer science students to practical design experience in various disciplines of engineering.

Humanities and Social Sciences Component (30 credits)

Courses in the humanities and social sciences are an important part of the curriculum. Career advancement is based not only 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 PL 4062 Computer Ethics.

University Elective Sequence (8 credits)

A list of approved Elective Sequences for computer science majors is available in the Department of Computer and Information Science.

Technical Elective and Free Elective Components (3 credits each)

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 3 credits of technical electives and 3 credits of free electives.

MINOR IN COMPUTER SCIENCE

The minor in Computer Science consists of 15 credits. Students would need to obtain a grade of C- or better in CS 1114 and maintain an average of 2.0 GPA or better in the entire minor. Transfer students must take at least two of the four courses at Polytechnic University.

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: a BS in Computer Science with an MS in Computer Science; a BS in Computer Engineering with an MS in Computer

Science; and a BS in Electrical Engineering with an MS in Computer Science.

In order to be admitted to the BS/MS Honors Program, students must have exemplary academic achievements in high school, such as high GPAs, strong SAT scores and Advanced Placement credit in calculus and computer science. Students are invited to join the program by the department prior to the start of the first semester of their freshman year. If students are not accepted at that time, their application may be reconsidered after their first semester at Polytechnic by reapplying with the departmental Honors Program Director. Program participants must complete 16 to 20 credits each semester, maintain a technical and overall 3.5 GPA 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 3 free elective credits are excused. Six credits of Master's Thesis are required, and a special nine-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 AP credit in such courses as MA 1024 and 1112 (AP Calculus BC, grade of at least 4 or 5); and CS 1114 (AP Computer Science A or AB, grade of 4 or 5).

TRANSFER STUDENTS

Transfer students are accepted into the Undergraduate Computer Science Program on the same basis described in the admissions section of this catalog. In addition, the department requires that at least 28 credits in computer science, as well as CS 4513 and CS 4523, be completed at Polytechnic. Graduates of technology programs may be able to fulfill the requirements for the BS 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 be granted transfer credit based on evaluation of the content and level of material covered. Periodic re-evaluation of courses at other institutions may lead to a vari-

COMPUTER SCIENCE PROGRAM

ation 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 Department of Computer and Information Science. Transfer students who are exempted from EG 1004 Introduction to Engineering and Design must take a substitute course that includes presentation preparation. Students should meet with their undergraduate adviser for more information.

DEPARTMENTAL STANDARDS, PROBATIONS AND GRADES OF I (INCOMPLETE)

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 requirements listed below. These requirements are in addition to the University requirements for a minimum term and cumulative 2.0 GPA in all courses.

The following requirements apply to all undergraduate computer science students:

1. Students must maintain an average of C (2.0 GPA) or better in CS
2. A grade of C- or better in the following courses: MA 1024 Calculus I; MA 1124 Calculus II; CS 1114 Introduction to Programming and Problem Solving; CS 1124 Object Oriented Programming; and CS 2134 Data Structures and Algorithms
3. Students may repeat a course in which they earned a substandard grade, but no CS course may be taken more than three times (grades of W and AUDIT are not counted for the purpose of this rule)
4. A course receiving an I grade 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 computer science program and courses. If students have any questions, they should feel free to discuss them with an adviser, and preferably in a timely fashion so that good solutions can be found to any problems that may arise.

INFORMATION

Curricula and prerequisite changes, new courses, special sections and other last minute announcements are posted on the bulletin boards outside the offices of the Department of Computer and Information Science. Each student is responsible for keeping informed of such changes.

List of CS Electives:

Undergraduate Courses

CS 205	Assembly Language
CS 239	Advanced UNIX System Programming
CS 308	Introduction to Databases
CS 342	Algorithms for Parallel & Distributed Systems
CS 391	Java & Web Design
CS 392	Computer Security
CS 393	Network Security
CS 394	Special Topics in Computer Science
CS 684	Computer Networking
CS 2204	Digital Logic & State Machine Design
CS 3254	Introduction to Parallel & Distributed Systems
CS 3714	Secure Information Systems Engineering I
CS 3734	Scientific & Engineering Computing I
CS 4724	Secure Information Systems Engineering II
CS 4744	Scientific & Engineering Computing II
EE 136	Communication Networks
MA 4423	Introduction to Numerical Analysis

Graduate Courses Open to Undergraduates

CS 627	Performance Evaluation of Computer Systems
CS 653	Interactive Computer Graphics
CS 661	Artificial Intelligence I
CS 664	Computer Visions & Scene Analysis
CS 667	Neural Networking Computing
CS 684	Computer Networking
CS 901	Unix Systems
CS 902	Applied Electronic Commerce
CS 903	Programming Workshop (Algorithms & Software Libraries)
CS 904	Cryptography with Financial Applications
CS 905	Introduction to Java
CS 907	Human & Computer Interaction
CS 908	Advanced Java Programming
CS 909	Computer Simulation
CS 909	Biometric Identification
CS 910	Object Oriented Design with Java
CS 911	Machine Learning
CS 912	Web Protocols, Principles & Applications
CS 913	Emerging Technology for IP Development
CS 916	Application Security
CS 966	Advanced Project in Computer Science*
EL 514	Multimedia Laboratory
EL 547	Introduction to VLSI

* Offered every semester under different topics: information security management; penetration testing and system analysis; digital forensics; and cryptography.

GRADUATE PROGRAMS

GOALS AND OBJECTIVES

The goals and objectives of the Master of Science program in Computer Science are to provide students with the following:

- Core computer science knowledge base for advanced work
- Professional level courses in computer science
- Opportunity to specialize in selected technology areas of utmost interest
- Solid, well-balanced program to advance to the PhD level

The goals and objectives of the Doctor of Philosophy program in Computer Science are for students to develop the following:

- Strong fundamental knowledge in one of the areas of computer science
- Knowledge for independent research to be accomplished in computer science
- Fundamental research that advances a sub area of computer science

REQUIREMENTS FOR MASTER OF SCIENCE

Entrance Requirements

For entrance into the Master of Science degree programs, students are required to have an undergraduate degree in computer science, mathematics, science or engineering, with a superior undergraduate record from an accredited institution. 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:

1. At least one year of university-level science
2. A working knowledge of a high-level general-purpose programming language (preferably 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 in computer science or with a bachelor's 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 with 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 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 9 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. An average of B is required for all graduate courses taken. 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 Foundations 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 603/604 Design and Analysis of Algorithms I/II
 CS 606 Software Engineering I
 and either
 CS 607 Software Engineering II
 or
 CS 608 Principles of Database Systems
 CS 613/614 Computer Architecture I/II
 CS 623/624 Operating Systems I/II
 CS 641/642 Compiler Design and Construction I/II
 CS 661 Artificial Intelligence I
 and either
 CS 662 Artificial Intelligence II
 or
 CS 664 Vision and Scene Analysis
 or
 CS 665 Expert Systems and Knowledge
 Engineering
 or
 CS 667 Neural Network Computing
 EL 536 Principles of Communication Networks
 and
 EL 537 Protocols for LAN
 CS 681 Information, Privacy and Security
 CS 682 Network Management and Security

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.

REQUIREMENT FOR THE DOCTOR OF PHILOSOPHY

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:

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 PhD program consists of three parts:

1. Courses and qualifying exam
2. Choosing an adviser and forming a committee
3. Thesis

In order to maintain PhD candidacy reasonable progress must be made, including taking and passing the qualifying exam in a timely manner.

Courses and Qualifying Exam

A minimum of 90 units of graduate work beyond the BS, including at least 24 units of dissertation and at least 60 units of course work, is required for the PhD.

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 and Information Science.

The qualifying exam is given once a year and consists of three parts:

- (1) Algorithms and theory of computation
- (2) Architecture and operating systems
- (3) Programming languages, compilers and 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 will normally take the exam within two years. Students entering Poly with a master's in computer science are advised to take the qualifying exams within a year of entering the PhD program.

Choosing an adviser and the formation of a committee

After passing the qualifying exam, students should begin preparing to conduct thesis research in two steps: (1) they should choose an adviser and agree on a research area, and (2) 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, PhD students must write a survey paper and give an oral presentation to the committee. The committee will judge the papers 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 passing the qualifying exams. In order for students 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 Department of Humanities and Social Sciences.

Thesis

The third and most substantial aspect of the PhD program is the thesis. The thesis must embody a significant original research contribution and must be written in an 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 determines 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 then be scheduled. Additional requirements for the PhD thesis are available from the office of the Dean of Graduate Studies.

CERTIFICATES IN INFORMATION ASSURANCE

As a National Security Agency-designated Center of Academic Excellence in Information Assurance, Polytechnic is offering NSA-approved certificates in information assurance. The certificates are awarded to students who are pursuing a bachelor's or master's degree in computer science, computer engineering, telecommunication or electrical engineering at the University and have completed the following course requirements:

NSTISSI 4011: Information Security Professional

Course Requirements for the Information Security Professional Certificate (27 Credits)

- CS 540 or
- CS 2134 Data Structures and Algorithms*
- CS 637 or
- CS 3314 Programming Languages*
- CS 623 or
- CS 3224 Operating Systems*
- EL 536 or
- EE 136 Principles of Communication Networks*
- CS 684 Computer Networks**
- CS 681 Information, Privacy and Security
- or
- CS 392 Computer Security
- CS 682 Network Management and Security
- or
- CS 393 Network Security
- CS 996 Information Security Management

NSTISSI 4013: Information Systems Administration

Course Requirements for the Information Systems Administration Certificate

- 4011: Information Systems Administration
- CS 996 Penetration Testing and System Analysis
- CS 624 Operating Systems II***

NOTE:

* These courses can be waived if the student has attended a comparable course and has demonstrated proficiency in the required topics/subjects.

** Can be replaced with EL 537

*** Can be replaced with CS 3254

For more information, contact Professor Nasir Memon at memon@poly.edu.

GRADUATE CERTIFICATE IN CYBER SECURITY

The demand for skilled information security professionals is growing significantly. This graduate certificate allows technical professionals to obtain key bodies of knowledge and specializations in cyber security. Students acquire an understanding of various technologies in emerging areas of security, including computer and network security, digital forensics, cryptography and biometrics. Students are able to immediately apply their knowledge to manage the risk of cyber attacks. Courses are developed and taught by Polytechnic faculty in the Information Systems and Internet Security (ISIS) Laboratory. Those who choose to work toward a master's degree are able, upon admission, to apply all courses taken toward a certificate toward fulfillment of a degree program.

Admission to the certificate program requires a bachelor's degree in an appropriate preparatory discipline from an institution acceptable to Polytechnic.

Course Requirements for the Cyber Security Certificate (15 units)

- Core Courses 9 units**
- CS 6804 Information Systems Management
 - CS6814 Information, Privacy & Security
 - CS 6824 Network Management & Security

Electives 6 units

- CS 9094 Biometrics
- CS 9044 Cryptography
- CS 9164 Application Security
- CS 9974 Digital Forensics

For more information, contact Professor Nasir Memon at memon@poly.edu

GRADUATE CERTIFICATE IN SOFTWARE ENGINEERING

In response to the tremendous growth of the software development industry, Polytechnic introduced a new certificate program in software engineering. This course module gives students the knowledge and skills needed to compete successfully in this arena. Topics covered include object oriented software design, software validation and project management.

The software engineering certificate is a series of five graduate-level courses. Three required core courses are designed to equip the computer science professional for an advanced software development career. In addition, students choose two other courses from a variety of electives offered on a rotating basis. The elective courses cover areas

of current interest to the software engineering community and allow students to customize their education.

Course Requirements for the Software Engineering Certificate (15 units)

Core Courses 9 units

CS 606	Software Engineering I
CS 607	Software Engineering II, Advanced Project
CS 608	Principles of Database Systems

Electives 6 units

Electives can be chosen from the following list of courses: CS 618 Fault Tolerant Computers, CS 681 Information, Privacy and Security or approved selected topics courses related to software engineering.

The list below shows some recent offerings of selected topics that would qualify for this certificate:

- Software Validation, Verification and Testing
- Object-Oriented Design in C++ or Java
- Open Systems Software and Protocols
- Client Server Infrastructure in an OO Environment
- Human Factors in Computer Interface Design

Entrance requirements for the certificate program are the same as for the MS program. For students having superior academic credentials but lacking sufficient background in computer science, there are three prerequisite courses (CS 530 Introduction to Programming and Problem Solving, CS 540 Data Structures and Algorithms and CS 600 Foundations of Computer Science) that must be taken to prepare for courses in the software engineering certificate. These prerequisite courses are offered every year on all campuses.

UNDERGRADUATE COURSES

Students are advised to consult the Schedule of Classes for changes in prerequisites in effect after publication of this catalog. Students may not register for any junior- or senior-level courses until all freshmen requirements are completed. The annotation 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 graduate courses) are awarded upon successful completion of the course.

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

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 2134 (C- or better).*

CS 239 UNIX System Programming 3:0:0:3

Programming and system administration of UNIX systems. Covers shell programming, special purpose languages, UNIX utilities, UNIX programming tools, systems programming and system administration. *Prerequisites: CS 3224 and junior status.*

CS 308 Introduction to Databases 3:0:0:3

This course introduces students to database systems and motivates the database approach as a mechanism for modeling the real world. The course will cover data models (relational, object-oriented), physical database design, query languages, query processing and optimization, as well as transaction management techniques. Implementation issues, object-oriented and distributed databases will also be introduced. *Prerequisites: CS 2134 and CS 3224.*

CS 342 Algorithms for Parallel and Distributed Systems 3:0:0:3

Covers the design, implementation and evaluation of algorithms for parallel and distributed systems. Scheduling and load-balancing, parallel and distributed information retrieval and database operations, parallel scientific algorithms. Concurrency control. Security in distributed systems. *Prerequisite: CS 3254.*

CS 391 Java and Web Design 3:0:0:3

Programmers familiar with C or C++ will learn how to develop Java applications and applets. This course will teach students the syntax of the Java language, object-oriented programming in Java, creating graphical user interfaces (GIU)

using the Java 2 Platform technology event model, Java exceptions, file input/output (I/O) using Java Foundation Class threads and networking. *Prerequisite: CS 2134.*

CS 392 Computer Security 3:0:0:3

Covers the following topics: Cryptographic systems. Capability and access-control mechanisms, authentication models, protection models. Database and operating system security issues, mobile code, security kernels. Malicious code, trojan horses and computer viruses. Security policy formation and enforcement, legal aspects and ethical aspects. *Prerequisites: CS 2214 and MA 2312. Co-requisite: CS 3224*

CS 393 Network Security 3:0:0:3

Review of topics in networking. Basic notations of confidentiality, integrity, availability; cryptographic systems, coding and decoding messages. cryptographic protocols for privacy, integrity, key exchange and access control. TCP/IP security; Firewalls, IPSec; secure e-commerce. Intrusion detection, prevention, response. Advanced topics. *Prerequisites: CS 3224 and CS 684, or EE 136, EL 536 or EL 537.*

CS 394 Special Topics in Computer Science

A variable credit special topics course designed for juniors and seniors. *Prerequisite: department's permission.*

CS 1114 Introduction to Programming and Problem Solving 3:3:0:4

An introduction to computer programming and problem solving. General topics covered include the fundamentals of programming, good software development practices and solving problems using computer programming. Specific topics include compiling, running and debugging a program, program testing, documentation, variables and data types, assignments, arithmetic expressions, input and output, top-down design and procedures, the random number generator, conditionals and loops functions, arrays, and an introduction to classes and object oriented programming. Grade of C- or better required of undergraduate computer science and computer engineering majors.

CS 1124 Object-Oriented Programming 3:3:0:4

An intermediate-level programming course teaching object-oriented programming in C++. Pointers, dynamic memory allocation, and recursion. Classes and objects including constructors, destructors, methods (member functions) and data members. Access and the interface to relationships of classes including composition, association, and inheritance. Polymorphism through function overloading operators. Inheritance and templates. The standard template library will be used to introduce elementary data structures and their use. Grade of C- or better required of computer science and computer engineering majors. *Prerequisite: CS 1114 (C- or better).*

CS 2134 Data Structures and Algorithms 4:0:0:4

Abstract data types and the implementation and use of standard data structures. Fundamental algorithms and the basics of algorithm analysis. Grade of C- or better required of undergraduate computer science and computer engineering majors. *Prerequisites: CS 1124 (C- or better) and MA 1024. Co-requisite: MA 2312/2322.*

CS 2204 Digital Logic and State Machine Design 3:3:0:4

Combinational and sequential digital circuits. An introduction to digital systems. Number systems and binary arithmetic. Switching algebra and logic design. Error detection and correction. Combinational integrated circuits, including adders. Timing hazards. Sequential circuits, flip-flops, state diagrams and synchronous machine synthesis. Programmable Logic Devices, PLA, PAL and FPGA. Finite-state machine design. Memory elements. Grade of C- or better required by undergraduate computer engineering majors. *Prerequisite: CS 1114 (C- or better).*

CS 2214 Computer Architecture and Organization 3:3:0:4

A top-down approach to computer design. Computer architecture: introduction to assembly language programming and machine language set design. Computer organization: logical modules; CPU, memory and I/O units. Instruction cycles, the datapath and control unit. Hardwiring and microprogramming. The

memory subsystem and timing. I/O interface, interrupts, programmed I/O and DMA. Introduction to pipelining and memory hierarchies. Fundamentals of computer networks. *Prerequisites: CS 2204 and CS 2134 (C- or better for undergraduate computer engineering majors); CS 2134 (C- or better) and MA 2312/2322 for CS students.*

CS 3224 Operating Systems 4:0:0:4

This course will study the fundamental concepts and principles of operating systems. Batch, spooling, and multiprogramming systems are introduced. The parts of an operating system are described in terms of their functions, structure and implementation. Basic policies for allocating resources are also discussed. *Prerequisite: CS 2214.*

CS 3254 Introduction to Parallel and Distributed Systems 3:3:0:4

The goal of this course is to give you a solid grounding in the basic issues and techniques of parallel and distributed computing. The material we cover will cover the spectrum from theoretical models of parallel and distributed systems to actual programming assignments. *Prerequisite: CS 2134.*

CS 3314 Design and Implementation of Programming Languages 4:0:0:4

This course covers issues underlying the design of high-level programming languages, along with elements of the compiler technology used to translate those languages into executable code. Topics covered include formal description of language syntax, parsing, memory management, attributes of variables and their binding times, control and data abstraction mechanisms, and object-oriented language features. The focus is on imperative and object-oriented languages, with brief introduction to functional and logic-programming paradigms. Substantial programming projects are required. *Prerequisites: CS 2134 (C- or better) and MA 2312.*

CS 3414 Design and Analysis of Algorithms 4:0:0:4

This course covers the fundamental principles of the design and analysis of algorithms. Topics include asymptotic notation, recurrences, randomized algorithms,

sorting and selection, balanced binary search trees, augmented data structures, advanced data structures, algorithms on strings, graph algorithms, geometric algorithms, greedy algorithms, dynamic programming, and NP completeness. *Prerequisites: CS 2134 (C- or better) and MA 2312/2322.*

CS 3714 Secure Information Systems Engineering I 4:0:0:4

An approach to secure information systems engineering is developed consistent with today's vulnerabilities, threats and risks. Grounding is established in the basic security technologies and strategies in use today. A concept of security engineering is constructed for whole elements of the critical infrastructure (e.g., utilities, government services, financial services, etc.) including legacy environments, the Internet, wireless and the coming evolution of "ubiquitous computing." *Prerequisite: junior standing.*

CS 3734 Scientific and Engineering Computing I 4:0:0:4

This course takes advantage of the programming skills that students learn in introductory level computer science courses to exploit the broad power of modern computing related to their science and engineering disciplines. Computational techniques are taught in parallel with programming and problem-solving methodologies. Students learn how to recognize a good or bad formulation of a problem, select the proper algorithm to solve a given computational problem and interpret the results; thus, learning to become intelligent users, rather than creators, of computational software. *Prerequisites: CS 1114, MA 1124, MA 2012/2132.*

CS 4513 Software Engineering I 2'b:1'b:0:3

The first in a two-course design project sequence (DP I and DP II) with a focus in software engineering. This course introduces the software engineering techniques to specify, design, test and document medium and large software systems. Design techniques include information engineering, object-oriented, and complexity measures. Testing methods such as path testing, exhaustive test models, and construction of test data. An introduction to software tools and project

management techniques is presented. Student projects involve team software development and tracking. *Prerequisites:* CS 2134 (C- or better), CS 3224 and senior status.

CS 4523 Design Project II 1:6:0:3

The second course in a two-course design project sequence (DP I and DP II). This is a project course in which a student or several students work with a faculty member and/or graduate students on a current topic in computer science. Each term, a project course with a particular theme is offered by the Department of Computer and Information Science. A faculty member will assign individual or group projects to students in the class. The project course will be highly structured and will be under close supervision of the faculty. It is expected that students will make use of the design and project management skills they have learned in CS 4513 Software Engineering. Alternatively, students can work with a faculty member to develop an individual project of mutual interest. A written report and oral presentation are required. *Prerequisite:* CS 4513.

CS 4724 Secure Information Systems Engineering II 4:0:04

The second semester consists of projects, labs and discussions in the area of Applied Secure Information Systems Engineering. Specifically, students build a comprehensive platform for secure computing based on best of breed Open Source components starting with OpenBSD or the like. This platform is then contrasted to Java Security and to the secure computing efforts of Microsoft and its associates. A "Student Hackathon" is conducted to test findings and assumptions. Finally, recommendations are made to support the future security procurement needs for whole elements of the critical Infrastructure.

CS 4744 Scientific and Engineering Computing II 4:0:04

Making use of the knowledge acquired in part I of the course, the second semester focuses on well recognized major computational developments that have the greatest influence on the development and practice of science and engineering in the last century. Course draws upon a variety of computational problems from the

breadth of science and engineering to interest students and establish the relevance of the computational problem-solving approach. Students will be involved in projects. *Prerequisite:* CS 3734.

GRADUATE PREPARATORY COURSES

The graduate courses listed in this section were formulated to accommodate the needs of students who wish to pursue graduate studies in computer science, but who lack sufficient undergraduate preparation. No credit will be allowed for any of these courses toward graduate degrees in computer science, information systems engineering or other graduate degree programs administered by the Department of Computer and Information Science. Submission of substantial computer programming assignments is required in all these courses.

CS 530 Introduction to Programming and Problem Solving 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 and 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 micro-programmed control systems are investigated. Assembly language and instruction sets are presented. Memory organization alternatives are explored. *Prerequisite:* graduate status. *Co-requisite:* 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 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. 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 units 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 and proof of correctness of programs. Sets, relations and functions. Combinatorics and 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. *Co-requisite: CS 530.*

CS 603 Design and Analysis of Algorithms I 2½:0:0:3

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 and CS 600.*

CS 604 Design and Analysis of Algorithms II 2½:0:0:3

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 2½:0:0:3

Software development and modeling tools. Software architecture, requirements, design, validation, reliability estimation and management. Top-down, object-oriented, modular and domain-specific design. Design tools and representation techniques. Definition of various code metrics and their use in program development and screening. Specification-based and program-based testing techniques. Path testing, system testing. Error, reliability and mean-time-between-failure models. Team programming and programming in the large. *Prerequisite: CS 540.*

CS 607 Software Engineering II 2½:0:0:3

A continuation of the material begun in CS 606 with emphasis on student projects. Software management principles. Cost estimation models. Approaches to fault-tolerant software. Students will be organized into project groups and will plan and design a software system using manual and computerized development tools. Class presentations, exams and term project. *Prerequisite: CS 606.*

CS 608 Principles of Database Systems 2½:0:0:3

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 instructor's permission, and CS 600.*

CS 613 Computer Architecture I 2½:0:0:3

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 2½:0:0:3

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 2½:0:0:3

Microprocessor-based high-performance systems. Advanced microprocessors. Memory management and caching techniques. Backplane techniques. Advanced I/O concepts. Multiprocessor configurations. Software impact of new architectures and organizations. RISC/CISC tradeoff. *Prerequisite: CS 613.*

CS 618 Fault-Tolerant Computers 2½:0:0:3

Introduces a variety of hardware and software techniques for designing and modeling fault-tolerant computers. Topics include coding techniques (Hamming, SECDED, SECDED, 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 nonstop systems (TANDEM and STRATUS). RAID memory systems. Fault-tolerant modeling tools such as HARP, SHURE and SHARPE. *Prerequisite: CS 2204 or CS 580.*

CS 623 Operating Systems I 2½:0:0:3

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

2½:0:0:3

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

2½:0:0:3

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. *Prerequisites: EL 531 or MA 2212/2222 and instructor's permission.*

CS 637 Programming Languages

2½:0:0:3

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

2½:0:0:3

Compiler organization. Lexical analysis, syntax analysis, abstract syntax trees, symbol table organization, code generation. Introduction to code optimization techniques. *Prerequisites: CS 540, CS 580 and CS 600.*

CS 642 Compiler Design and Construction II

2½:0:0:3

Further considerations of syntactic analysis, semantic analysis and code optimization techniques. *Prerequisite: CS 641.*

CS 653 Interactive Computer Graphics

2½:0:0:3

This course introduces students to the fundamentals of computer graphics. Topics covered include graphics software and hardware, 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 2012 or equivalent.*

CS 661 Artificial Intelligence I

2½:0:0:3

This course introduces students to the many concepts and techniques in artificial intelligence. Topics covered include problem spaces and search, heuristic search techniques, predicate logic, game playing techniques, planning, learning, natural language processing and machine perception. *Prerequisite: CS 540.*

CS 662 Artificial Intelligence II

2½:0:0:3

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

2½:0:0:3

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 processing, 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 2012 or equivalents or instructor's permission.*

CS 665 Expert Systems and Knowledge Engineering

2½:0:0:3

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

2½:0:0:3

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, both 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

2½:0:0:3

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

2½:0:0:3

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 instructor's permission.*

CS 6804 Information Systems Management 3:0:0:3.6
(ePoly online course)

The primary goal of this course is to present a system and management view of information security: What it is, what drives the requirements for information security, how to integrate it into the systems design process, and life-cycle security management of information systems. A second goal is to cover basic federal government information security policies and methodologies. This course, combined with courses in computer security and network security, provide the qualifications for the U.S. government NSTISSI-4011-INFOSEC Professionals, National Training Standard certification. *Prerequisite: CS 392 or equivalent.*

CS 681 Information, Privacy and Security 2½:0:0:3

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 6814 Information, Privacy and Security 3:0:0:3.6
(ePoly online course)

This course is equivalent to CS 681. It includes the same topics and requirements, with additional class and laboratory exercises to supplement each topic.

CS 682 Network Management and Security 2½:0:0:3

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 536.*

CS 6824 Network Management and Security 3:0:0:3.6
(ePoly online course)

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 536.*

CS 684 Computer Networking 2½:0:0:3

Introduction course to the underlying principles of computer networking. The principles are presented in a general framework and then illustrated with Internet protocols and technology. The course is organized around the five layers of a computer network, from top to bottom: application layer, transport layer, network layer, link layer and physical layer. *Prerequisite: CS 2134.*

CS 685 Network Protocols II 2½:0:0:3

This course concentrates on the TCP/IP protocol, including addressing, address translation, routing protocols (OSPF and RIP), address exhaustion and wireless LANs. Each of the key TCP/IP protocols (HTTP, DNS, FTP, TFTP, NTP, etc) is investigated and detailed using actual packet traces and real world examples.

CS 687 Project in Telecommunication Networks 2½:0:0:3

A design course where students design, develop and test communications software. It builds on the knowledge and software skills developed in the prerequisite, Network Protocols I, where students are taught both the theory and implementation of common telecommunications protocols and perform basic experiments as part of the course work. It is expected that students will work in small groups on a project under the direction of a professor. A telecommunication networks laboratory will provide the students with basic equipment such as workstations, X-terminals, Ethernet Local Area Networks (LANs), LAN analyzers, routers and bridges. Other equipment may be added to this list based on availability and need. *Prerequisites: CS 684 and instructor's permission.*

CS 901-920 Selected Topics in Computer Science each 2½:0:0:3

Topics of current interest in computer science. Recent offerings include software specification and validation, parallel algorithms and architectures, client server systems and advanced object oriented design (Java). Advanced topics in databases, performance analysis, computer simulation, Java programming, Unix programming, human and computer interaction, cryptography with financial applications and biometric identification. *Prerequisite: specified when offered.*

CS 9044 Cryptography 3:0:0:3.6
(ePoly online course)

The course covers a thorough introduction to the theory and applications of cryptography. Introduces underlying number theory and develops public and private-key algorithms; RSA, El-Gamal, DES, AES are analyzed. Various modes of operations of the algorithms, advantages and disadvantages of different modes are also discussed. Protocols for important applications such as authentication and key-distribution are developed. The course highlights the weaknesses and strengths of each system, possible attacks and implementation considerations. *Prerequisite: graduate status.*

CS 9094 Biometrics 3:0:0:3.6
(ePoly online course)

This course introduces various types of biometric identification schemes. An introduction to physical security and effective implementation of physical security is discussed with the help of case studies. Basic signal processing is introduced using JPEG algorithm; Theory and practices of voice identification, fingerprint and retinal scans are introduced. The course introduces, with the use of examples from MATLAB, face recognition and retina identification. Each year the students do a field trip to the Biometric Testing Lab of the International Biometrics Group, a consulting company located in the Financial District. *Prerequisite: graduate status.*

CS 9164 Application Security 3:0:0:3.6
(ePoly online course)

This course gives students the theoretical foundation and practical knowledge of applying computer security principles on the application level. First, they study the principles important for application security, concentrating on the issues of access control and data hiding and encapsulation. They then study the security model in Java 2 in detail, performing programming assignments that use this model. The topics covered include configuring the security policy on trusted hosts that may run untrusted code; using digital signatures to sign code components; deploying code in the form of signed and sealed classes; using assertion mechanisms to check for object integrity at run-time; security aspects of using the Java serialization mechanism; and using the Java security model in the context of RMI. *Prerequisite: graduate status.*

CS 941/942 Readings in Computer Science I/II *each 2½:0:0:3*

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. Examination or term report required. *Prerequisite: graduate status.*

PROJECT AND THESIS

Students may register and get credit for these courses more than once.

CS 996 Advanced Project in Computer Science *2½:0:0:3*

This course permits the student to perform research in computer science with a narrower 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: graduate 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 6 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. *Prerequisites: graduate status and satisfactory grades in prescribed courses.*

CS 9974 Digital Forensics 3:0:0:3.6
(ePoly online course)

This course covers the all technical, legal and law enforcement aspects of digital forensics. The course covers the following topics: real-world incidents (why do we need forensics); incident response process; preparing for incidence response (building a forensic-ready infrastructure); after detecting an incident; live-data collection from Windows; live-data collection from Unix; forensic duplication (copying hard drives); network-based evidence; evidence handling; computer storage fundamentals; data analysis techniques; investigating Windows systems; investigating Unix systems; analyze network traffic; investigate hacker tools; investigate routers; and writing forensic reports. *Prerequisite: graduate status.*

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). *Prerequisites: passing of qualifying examination and approval of the Department of Computer and Information Science.*

Typical Course of Study for the Bachelor of Science in Computer Science

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
CS 1114	Intro. Prog. & Problem Solving ¹	3	3	0	4
CM 1004	General Chemistry	3	2	1	4
EN 1014	Writing & Humanities I ²	4	0	0	4
MA 1024	Calculus I	4	0	0	4
SL 1010	Freshman Seminar	1	1	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
CS 1124	Object-Oriented Programming	3	3	0	4
EG 1004	Intro. Engineering & Design	1	3	2	4
MA 1124	Calculus II	4	0	0	4
EN 1204	Writing & Humanities II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

CS 2134	Data Structures & Algorithms	4	0	0	4
MA 2312	Discrete Math. I (½ semester)	4	0	0	2
MA 2322	Discrete Math. II (½ semester)	4	0	0	2
PH 1004	Introductory Physics I	4	1½	1	4
HI 2104	Modern World History	4	0	0	4
					16

Spring Semester

CS 2214	Computer Arch. & Organization	3	3	0	4
MA 2212	Data Analysis I (½ semester)	4	0	0	2
MA 2222	Data Analysis II (½ semester)	4	0	0	2
PH 2004	Introductory Physics II	4	1½	1	4
	HU/SS Elective ⁴	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

CS 3314	Design & Impl. Prog. Languages	4	0	0	4
MA 2012	Linear Algebra I (½ semester)	4	0	0	2
MA 2132	Ordinary Diff. Equ. (½ semester)	4	0	0	2
	CS Elective ⁵				4
	HU/SS Elective ⁴	4	0	0	4
					16

Spring Semester

CS 3224	Operating Systems	4	0	0	4
CS 3414	Design & Analysis Algorithms	4	0	0	4
	CS Elective ⁵				4
	Sequence Elective I ⁶				4
					16

SENIOR YEAR

Fall Semester

CS 4513	Software Engineering I	2½	1½	0	3
PL 4062	Computer Ethics	2	0	0	2
	CS Elective ⁵				3
	HU/SS Elective ⁴	4	0	0	4
	University Elective Sequence II ⁶				4
					16

Spring Semester

CS 4523	Design Project II	1	6	0	3
	CS Elective ⁵				3
	Technical Elective	4	0	0	3
	HU/SS Elective ⁴	4	0	0	4
	Free Elective ⁸				3
					16

Total credits required for graduation:

128

- Grade of C- or better is required in CS 1114, CS 1124 and CS 2134
- Students who are placed by examination or by an adviser into EN 1080 must subsequently register for EN 1034, rather than EN 1014.
- Students who are placed by examination or by an adviser into MA 914 must defer registration for MA 1024.
- Approved HU/SS Electives have the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II Elective courses in different disciplines and one from Level III Advanced Elective courses.
- At least two of the four required CS Electives must be chosen from the following: CS 392, CS 684, CS 308, CS 2204, CS 3254, CS 661. With departmental

approval, certain graduate CS courses may also be used as CS Electives depending on course content and prerequisites.

- A list of approved Sequence Electives is available from the Department of Computer and Information Science.
- Approved Technical Electives courses for computer science majors can be in mathematics, management, industrial engineering, electrical and computer engineering and technical and professional communication provided they contain enough technical (or management) content that does not duplicate materials studied in other courses.
- The Free Elective could be a course offered by any department, provided it does not duplicate material studied in other course.

CONSTRUCTION MANAGEMENT PROGRAM

Program Advisers: Fletcher H. (Bud) Griffis and Lawrence Chiarelli

UNDERGRADUATE PROGRAM

The Bachelor of Science in Construction Management is an interdisciplinary program administered by the Center for Construction Management Technology in the Department of Civil Engineering. The program prepares students for a challenging career in the construction industry – as future leaders in a dynamic and ever-changing environment. It concentrates on the essential skills necessary to develop competency in the profession and be competitive in the marketplace. Graduates will be positioned for opportunities with owners, developers, construction managers, contractors, architects and engineers, lenders and others involved in the construction industry.

The Bachelor of Science in Construction Management program covers a broad range of basic through advanced subjects in engineering and construction management, such as planning, cost estimating, scheduling, project management and construction administration. The program also exposes students to the latest applications in construction research and technology. The program teaches students the fundamentals of engineering and construction science, as well as business aspects of construction and the application of traditional and emerging construction methods and technologies. Students also learn basic economics and management, with particular emphasis on their application to the construction industry.

Modern and practical systems integration courses and projects in the program's junior and senior years provide project management knowledge through the utilization of course materials from, and site visits to, actual construction projects led by experienced mentors.

Beyond the classroom, real-world work experience is available through internships and summer and part-time employment and through professional organizations and associated student chapters, including the Construction

Management Association of America (CMAA), the American Society of Civil Engineers (ASCE) and the New York Building Congress (NYBC). Polytechnic's Office of Career Services and Cooperative Education also supports these efforts.

GOALS AND OBJECTIVES

The objective of the Bachelor of Science in Construction Management is to provide the following for its students:

- A solid foundation of knowledge in mathematics and the basic sciences toward application to construction management.
- The knowledge and skills necessary to excel at an entry-level position as a construction professional and/or continue graduate study in construction management or a related field.
- The appropriate communications skills, both written and verbal, to allow graduates to grow into leadership positions in the profession.
- A thorough understanding of state-of-the-art techniques and tools in construction management involving three-dimensional computer modeling, integration of information technology, and the application of innovative planning, design and construction administration methodologies.
- A broad education in preparation for life-long learning and individual growth. Students are required to take courses in history, writing and the humanities, and electives allow students to further customize their education to enhance their individual interests.

PEDAGOGY

Construction management courses are taught using a variety of pedagogical models. These include theory-led teaching, case-method education and project-based/team-based teaching.

Teaching based on exposition of theory is applied to engineering and construction science. Fundamentals in math and physics, statics and dynamics, mechanics of materials, estimating, scheduling, planning, and construction operations are necessary prerequisites to the develop-

ment and application of construction management skills.

Case-method teaching utilizes real-world business experiences in order to demonstrate the application of general principles and to apply them to specific problems posed in the course of instruction. This pedagogy is used in the teaching of construction contracts and administration, safety and business law.

Project-based and team-based education is experiential; students learn by doing, much as they would in a natural sciences laboratory class. Project-based education also provides students an opportunity to learn how to assemble and coordinate necessary information, assert authority and delegate responsibility. This is particularly important in construction management, in which the essential tasks are the management of people and information.

It is very common in construction management courses for all pedagogical approaches to be employed. The construction management faculty brings together theory-based instruction and an intimate understanding of state-of-the-art construction management practices.

The City of New York provides a universe of projects of all types that are readily available to students to serve as a virtual laboratory. Drawings and specifications are made available to students for classroom study and before visiting project sites. Faculty who are actively involved in those projects discuss the many unique and special problems encountered on these projects, as well as potential solutions. Field visits to project sites are an essential part of the educational process.

PROGRAM CONTENT

The construction management curriculum incorporates the following subject areas:

	Credits
General Education	15
Mathematics and the Sciences	15
Business and Management	18
Construction Science	20
Construction	30
Other	30
Total	128

CONSTRUCTION MANAGEMENT PROGRAM

CURRICULUM

The Bachelor of Science in Construction Management program is establishing a Technical Advisory Group, made up of leaders of the construction profession to assist in assessing and continually updating the program curriculum. The general requirements of the curriculum accommodate the continually expanding requirements of the profession, advancements in knowledge and the contributions of related disciplines. Its offerings exceed the American Council for Construction Engineering (ACCE) Standards and Criteria for Accreditation. A minimum of 120 semester credit-hours is required for accreditation. Polytechnic University's requirement is 128 credit hours.

Table 1 summarizes the Construction Management Curriculum by subject category. A typical four-year schedule for the program is included at the end of this section of the catalog.

Table 1: Curriculum for B.S. (Construction Management)

Course No.	Course Title	Credits	Sem ¹
Required courses in mathematics:			
MA 1054	Integrated Calculus A ²	4.0	F1
MA 1154	Integrated Calculus B ³	4.0	F2
	or		
MA 2054	Applied Data Analysis ³	4.0	F2
	or		
MA 2122	Data Analysis I ⁴	2.0	So2(a)
	(? semester)		
MA 2122	Data Analysis II ⁴	2.0	So2(b)
	(? semester)		
MA	Mathematics Elective ³	4.0	So2
Total Required Credits in Mathematics		12.0	
Required courses in the physical sciences:			
CM 1004	General Chemistry	4.0	F1
PH 1004	Introductory Physics I	4.0	F2
Total Required Credits in Physical Sciences		8.0	
Required courses in humanities and social sciences:			
EN 1014	Writing and the Humanities I ⁴	4.0	F1
EN 1204	Writing and the Humanities II	4.0	F2
HI 2104	Modern World History	4.0	So1
PL	Philosophy Elective ⁵	4.0	So2
	Level II HU/SS Elective ⁶	4.0	J2
	Level III HU/SS Elective ⁶	4.0	S2
Total Required Courses in Humanities and Social Sciences		24.0	
Required courses in management and economics:			
MG 2204	Financial Accounting	4.0	So1
EC 2504	Basic Economics	4.0	So2
MG/EC	MG/EC Elective I ⁷	4.0	J1
MG/EC	MG/EC Elective 2 ⁷	4.0	J2
MG/EC	MG/EC Elective 3 ⁷	4.0	S1
Total Required Courses in Management and Economics		20.0	

Required courses in civil engineering:

CE 2114	Statics and Dynamics	4.0	So1
CE 2124	Mechanics of Materials	4.0	So2
CE	CE Elective ⁸	3.0	S2

Total Required Courses in Civil Engineering 11.0

Required courses in Construction Management:

CE 1504	Leadership and Foundations of Construction	4.0	F2
CE 2504	Construction Modeling and Data Struc. I	4.0	So1
CE 3503	Cost Estimating	3.0	J1
CE 3513	Construction Scheduling	3.0	J1
CE 3544	Site Planning, Design, and Surveying	4.0	J1
CE 3523	Contracts and Specifications	3.0	J2
CE 3553	Non-Structural Building Systems	3.0	J2
CE 4523	Structural Building Systems	3.0	S1
CE 4513	Construction Project Administration	3.0	S1
CE 4533	Construction Law	3.0	S2
CE 4543	Construction Management Project	3.0	S2
CE 4503	Construction Engineering	3.0	S2

Total Required Courses in Construction Management 39.0

Other required courses:

EG 1004	Introduction to Engineering and Design	4.0	F1
CS 3xx2	Computer Concepts and Applications	2.0	J1
	Sequence Elective I ⁹	4.0	J2
	Sequence Elective II ⁹	4.0	S1

Total Other Courses 14.0

Total Credits for Degree: 128.0

Footnotes for Table 1:

1. Sem = semester usually taken; F=Freshman, So=Sophomore, J=Junior, S=Senior, I=Fall, 2=Spring; for ? semester courses, (1)=first half, (2)=second half.
2. The department wishes all students to take MA 1054, which contains an additional two hours per week of precalculus review. It believes that this review is valuable, even for good math students. Students may take a placement examination to place out of this course in favor of MA 1024, Calculus I, or may be advance-placed based upon AP or college math credit earned in high school.
3. Students who elect to take MA 2054 in the freshman spring semester may take a Math elective in the sophomore spring semester. Students who elect to take MA 1154 in the freshman spring semester may take either MA 2054 or MA 2212/2222 in the sophomore year spring semester.
4. All students take a writing placement examination. Students with an ESL background may be placed in EN 1034, which includes additional hours of language education. Students may also be placed in a remedial section based upon the exam results, which does not carry degree credit.
5. PL electives include: PL 2054, PL 2064, PL 2084, PL 3054, or other approved course containing at least 1 credit of ethics.
6. Approved HU/SS electives are courses with the following prefixes: AH (Art History), AN (Anthropology), EC (Economics), EN (English literature), HI (History), MU (Music), PL (Philosophy), or PS (Psychology). A level II course has a 2xxx number, while a level III course has a 3xxx number. Level III electives generally have a prerequisite of a

related level II elective. Students who take up to two courses with an EC prefix in fulfillment of the MG/EC requirement may substitute a course with a CE (civil engineering) prefix and not more than one course with a TC (technical communications) prefix.

7. Approved MG electives include MG 2004, MG 2014, MG 2104, MG 2304, MG 3204, and MG 3404. Approved EC electives are EC 2514, EC 2524, EC 2534, EC 3254 and EC 3264.

8. CE elective is any course with a CE prefix for which the student has appropriate prerequisites.

9. All students must select a Sequence (2 courses; 8 credits) from a list of approved sequences. Approved sequences are listed elsewhere in this catalog, and a current list is available from the department.

PART-TIME STUDENTS

Students can register as part-time students (less than 12 credits per semester). Such students must be advised, however, that the department no longer offers many undergraduate courses in the evening, and part-time students are required to take most of their courses during the day. Part-time students should maintain close contact with their academic advisers to plan an effective and efficient course sequence.

GRADUATE PROGRAMS

Polytechnic University offers a Master of Science in Construction Management and two graduate certificate programs: one in executive construction management (Exec 21) and the other in construction management.

THE EXEC-21 PROGRAM: GRADUATE CERTIFICATE PROGRAM IN EXECUTIVE CONSTRUCTION MANAGEMENT

The Exec 21 Certificate Program in Executive Construction Management (Exec 21) is offered by the Department of Civil Engineering and administered by CCMT. It is directed toward individuals with significant professional experience in construction. It does not contain any general management content, and it is focused entirely on the construction industry.

Students without significant work experience in the industry should enroll in the Certificate Program in Construction Management, which is jointly offered by the Department of Civil Engineering and the Department of Management. That program includes general management courses in addition to construction management courses, and it does not require any prior work experience for full participation.

Exec 21 is a leadership program for construction professionals who do not wish to commit themselves to the full Master of Science program, but seek some formal certification in construction management. This may include students with a bachelor's degree who wish to specialize in construction management or those who may have previously completed an advanced degree and wish to develop additional skills.

Recognized throughout the construction industry as a vital and innovative educational experience (recipient of the CMAA Academic Achievement Award), Exec 21 courses are taught by eminently qualified construction industry professionals and faculty members.

Admission

Students seeking admission to the Exec 21 Certificate Program should have earned a bachelor's degree in an appropriate discipline, and should have a minimum of three to five years of related professional experience. Undergraduate backgrounds in engineering, mathematics, science, management and/or the liberal arts are appropriate with the requisite work experience for admission.

Curriculum

Students must complete 15 units of coursework to earn a certificate. A minimum of 9 units are selected from eight Exec 21 core courses, and up to 6 units are selected from a list of approved electives or other courses approved by the director or associate director of CCMT. The courses, all of which are 3 units, are as follows.

CE 870	Managing & Leading in the 21st Century
CE 871	Construction & the Law
CE 872	How to Succeed in Construction
CE 873	Infrastructure Financing
CE 875	Employer-Focused Residency
CE 876	Capital Program Management/Program Development
CE 877	Dispute Avoidance & Resolution
CE 878	Construction Management & Planning

Approved Elective Courses for Exec 21 are as follows:

CE 798	Special Topics in Construction
CE 827	Contracts & Specifications
CE 830	Information Systems in Project Management

Additional Courses which may be approved by the director or associate director of CCMT:

CE 825	Project Management for Construction
CE 826	Construction Cost Estimating
CE 828	Risk Analysis
CE 829	Operations Analysis
CE 831	Engineering for Construction I: Methods & Technologies
CE 832	Engineering for Construction II: Design

Grade Requirements

Students must maintain a B average (3.0 cumulative average) in all graduate courses taken at Polytechnic University.

Campus

Some of the Exec 21 courses are offered at an extension site at 2 Broadway in downtown Manhattan.

GRADUATE CERTIFICATE IN CONSTRUCTION MANAGEMENT

The Department of Civil Engineering, in conjunction with the Department of Management, offers a graduate certificate to students completing 15 units of coursework in construction management. The certificate program provides engineers and other professionals in the construction industry with the knowledge necessary to understand relevant managerial and physical technological developments, and to effectively apply such knowledge in the construction management profession.

Admission

Applicants for the Certificate in Construction Management must hold appropriate bachelor's degrees. Appropriate backgrounds include engineering, math, science, management and the liberal arts. The undergraduate degree must be from an acceptable institution.

Curriculum

Students can select any five courses (15 units) from the following cluster of courses. All courses are 3 units.

CE/MG 825	Project Management for Construction
CE/MG 826	Construction Cost Estimating
CE/MG 827	Contracts & Specifications

CE 828	Risk Analysis
CE 829	Construction Operations Analysis
CE 830	Information Systems in Project Management
CE 831	Engineering for Construction I: Methods & Technologies
MG 624	Organizational Development
	or
MG 631	Organization Theory & Design
MG 630	Operations Management
	or
MG 635	Managing for Quality
MG 820	Project Assessment & Management

Grade Requirements

Students must achieve a B average (3.0 cumulative average) in all graduate courses taken at Polytechnic.

MASTER OF SCIENCE IN CONSTRUCTION MANAGEMENT

The Master of Science in Construction Management program requires 36 units of course work. Courses include those in the Exec 21 Construction Management certificate programs, the Master of Science in Civil Engineering program courses in construction management and elective courses from other Polytechnic University graduate programs. Students also have the opportunity to take elective courses presently being offered by England's University of Salford through its internet distance learning center. An independent project is required of all students.

Courses taken as part of the Exec 21 Certificate Program in Executive Construction Management and the Graduate Certificate Programs in Construction Management may apply these credits towards the Master of Science in Construction Management program with the approval of the program adviser.

Objectives

The Master of Science in Construction Management program is intended to prepare students for leadership positions in the construction industry. Specifically, the program seeks to provide a thorough understanding of:

- Basic management principles as applied to the construction industry
- Principles of leadership in the construction industry
- Integration of modern technology in construction
- Innovative management tools for the analysis and control of construction projects
- Principles and methods of planning and financing construction projects
- Fundamental tools for communication with diverse employee, client and public groups

Admission

Students seeking admission to the Master of Science in Construction Management program must hold a bachelor's degree in an appropriate field from a reputable undergraduate institution. They should have a minimum undergraduate grade-point average of 2.75, although this

CONSTRUCTION MANAGEMENT PROGRAM

requirement can be waived for candidates with sufficient professional experience in the field of construction management. Appropriate undergraduate backgrounds include engineering, mathematics, science, business, management and the liberal arts. All candidates are expected to have sufficient background in college-level mathematics to allow for successful completion of the program. This requirement will be evaluated by the program adviser.

Transfer Credits

The residency requirement for the MS degrees is 27 units. This is the minimum number of graduate units that students must take at Polytechnic to be awarded a Master of Science degree at the University.

Students may transfer up to 9 units of acceptable coursework towards the Master of Science in Construction Management. To be transferred, the course(s) must be relevant to the student's degree program, be taken at an acceptable institution and earn a grade of "B" or better. No transfer credit is awarded for courses in which a grade less than "B" was earned. Pass/fail courses will not be considered for transfer unless accompanied by a detailed written evaluation by the course instructor.

All transfer credit requests must be accompanied by an official transcript from the transferring institution. Application for transfer credits are not considered until the candidate has earned a minimum of 12 graduate units at Polytechnic University.

Validation credits by examination cannot be used towards any graduate program in the Department of Civil Engineering.

Curriculum

A minimum of 15 units (5 courses) must be selected from the following courses:

CE 798	Selected Topics in Construction
CE 825	Project Management for Construction
CE 826	Construction Cost Estimating
CE 827	Contracts & Specifications
CE 828	Risk Analysis
CE 829	Construction Operation Analysis
CE 830	Information Systems in Project Management
CE 831	Engineering for Construction I: Methods & Technologies
MG 601	Organizational Behavior

The following Exec 21 courses may be substituted by a student who is enrolled in or has completed the Exec 21 Graduate Certificate Program, or by any other stu-

dent with the consent of the Construction Management Program adviser:

CE 870	Managing & Leading in the 21st Century
CE 871	Construction & the Law
CE 872	How to Succeed in Construction
CE 873	Infrastructure Financing
CE 875	Employer Focused Residency
CE 876	Capital Program Management/ Program Development
CE 877	Dispute Avoidance & Resolution
CE 878	Construction Management & Planning

Alternatively, up to three (3) of the following courses may be substituted by a student who is enrolled in or has completed the Construction Management Graduate Certificate Program, or by any other student with the consent of the Construction Management Program adviser:

MG 624	Organization Development; or
MG 631	Organization Theory & Design
MG 630	Operations Management; or
MG 635	Managing for Quality
MG 820	Project Assessment & Management

All students are required to complete a minor concentration of study, which shall consist of a minimum of 9 units (3 courses), but not more than 12 units (4 courses), selected from courses in any one of the following concentrated areas of study offered by the University, or any other area of study approved by the program adviser:

- Biomedical Engineering
- Chemical and Biological Engineering
- Civil Engineering
- Computer Engineering
- Environmental and Water Resources Engineering
- Geotechnical and Geoenvironmental Engineering
- Structural Engineering
- Electrical Engineering
- Electrophysics
- Environmental Engineering and Science
- Financial Engineering
- Industrial Engineering
- Information Systems Engineering
- Management
- Management of Technology
- Manufacturing Engineering
- Material Science
- Mathematics
- Mechanical Engineering
- Systems Engineering
- Systems Integration
- Technical and Professional Communications
- Technology Management

- Telecommunications and Information Management
- Telecommunications Networks
- Transportation
- Urban Systems Engineering and Management

The selection of the minor concentration of study shall be made with the advisement and consent of the program adviser.

All students must complete a 3-unit independent project (which may be completed in conjunction with CE 875). The project is considered a capstone experience for the degree.

CE 993	Project for the Master of Science in Construction Management
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The remaining courses needed to fulfill the 36-unit requirement shall be selected from the Civil Engineering or Construction Management Programs (bearing a CE_{xxx} designation), unless otherwise authorized by the Construction Management Program adviser. However, if the minor area of study is from the Civil Engineering Program, the remaining courses may be selected from any other electives offered by the University with the consent of the Construction Management Program adviser.

Note that some electives involve prerequisites that not all program enrollees may have completed. Students cannot register for a course for which they have not satisfied the stated prerequisites unless they have written permission from both the course instructor and the Construction Management Program adviser.

Grade Requirements

To earn the Master of Science in Construction Management, students must maintain a B average (3.0 cumulative average) in all graduate courses taken at Polytechnic University and must achieve a B or better grade in the required project course – CE 875 or CE 993.

Campus

Some courses in the Master of Science in Construction Management program that are also part of the Exec 21 Certificate Program may be offered at an extension site at 2 Broadway in downtown Manhattan or other locations selected by Polytechnic University. To earn the Master of Science in Construction Management, students must take a minimum of 9 units at the Brooklyn campus.

UNDERGRADUATE COURSES

CE 1504 Leadership and Foundations of Construction 4:0:0:4

Course provides a basic understanding of construction science, including basic introduction to fundamental blue-print reading, specifications reading, contract forms, estimating and scheduling, construction mechanics, structural analysis, soil mechanics, rigging and temporary construction.

CE 2504 Construction Modeling and Data Structures I 3:3:0:4

This course is an introduction to architectural drafting and computer graphics. It takes advantage of advances in state-of-the-art computer applications in the management of construction. The course familiarizes the student with two-dimensional construction drawings that represent the current standard in the industry, and it propels the student towards the future by teaching the basics of three-dimensional computer modeling. This course also introduces the student to the use of the 3-D model with associated databases utilized in the management of construction.

CE 3503 Cost Estimating 3:0:0:3

Classification of work and quantity surveying techniques and basic estimating principles applied to simple construction projects. Also addressed are contracts, specifications and other construction documents; and the identification and allocation of direct and indirect project costs, overhead and profit. Introduction to computer-based estimating techniques and software. *Prerequisite: CE 1504.*

CE 3513 Construction Scheduling 2:3:0:3

Students learn to apply the Critical Path Method (CPM) to construction projects, using precedence diagram networks. Course covers sequencing, cost allocation, updating, cash flow, resource constraints and scheduling, manpower leveling and distribution, time scale networks, lead and lag time constraints, time-cost tradeoffs, overlap and other specific leading edge scheduling techniques. Students direct an entire project from planning through scheduling and control, both

manually and through applicable software. *Prerequisite: CE 1504.*

CE 3523 Contracts and Specifications 3:0:0:3

This course will cover the documents used in the design and construction of a building, including design and construction agreements, drawings and specifications, general and special conditions and others used for procurement and construction administration. The course will also examine the relationships among the owner, designers, contractors and suppliers. In addition, students will have the opportunity to consider and discuss issues of quality, safety, and business and professional ethics. *Prerequisite: CE 1504.*

CE 3544 Site Planning, Design and Surveying 3:3:0:4

This is a comprehensive course that studies surveying and its practical applications regarding site design and planning. The first portion of the course concentrates on the fundamentals of land surveying, including mathematics, horizontal and vertical control and special survey methods. The second portion of the course familiarizes the students with site planning and design, including concepts of grading, drainage and utility considerations.

CE 3553 Non-Structural Building Systems 3:0:0:3

Course introduces the students to the mechanical, electrical and vertical transportation systems for buildings. It will examine the fundamental aspects of the design, procurement and construction of heating, ventilating and air conditioning (HVAC), supply and sanitary plumbing, fire detection and suppression, high-and low-voltage electrical, security, elevator and escalator, and building management systems. *Prerequisite: CE 1504 and junior standing.*

CE 4503 Construction Engineering 3:0:0:3

Course covers both traditional engineering fundamentals and developing trends relating to the planning and utilization of excavating and earth-moving equipment, trucks, pumps, drilling and blasting equipment, and cranes. Also considered

will shoring and bracing and other temporary site construction operations. *Prerequisite: senior standing.*

CE 4513 Construction Project Administration 3:0:0:3

The course examines the roles of the project participants in the execution of a construction project focusing on the delegation of administrative duties and responsibilities, the management and coordination of the physical work, and administrative control of project information and records. Utilization of computer-based project administration techniques and software. *Prerequisite: CE 3523 (or permission of Program Adviser) and junior standing.*

CE 4523 Structural Building Systems 3:0:0:3

This course introduces the general principles of loads on buildings and the design and analysis of conventional structural building systems in steel, concrete, wood and masonry. It will also address the construction of such systems. *Prerequisite: CE 1504 and junior standing.*

LW 4533 Construction Law 3:0:0:3

The course is intended to introduce students to the areas of the law that they are most likely to encounter in construction. Following an introduction to the legal system and form of legal analysis, areas to be addressed will include contracts, procurement, scope definition, delays and acceleration, site conditions, warranties, termination, tort claims, dispute resolution and ethics. *Prerequisite: junior standing.*

GRADUATE COURSES

CE 798 Selected Topics in Construction 2½:0:0:3

Topics of special interest in current areas of construction management announced in advance of each semester's offering.

CE 825 Project Management for Construction 2½:0:0:3

Course deals with topics specific to the development and coordination of large projects, including organizational structures, management functions, pricing and estimating project costs, bidding and con-

CONSTRUCTION MANAGEMENT PROGRAM

tracting, risk allocation, scheduling, time and cost control, labor relations, quality management and project life-cycle activities. Also listed under MG 825.

CE 826 Construction Cost Estimating 2½:0:0:3

Estimates and costs from the viewpoint of contractor or construction engineers; details of estimating with emphasis on labor, materials, equipment, and overhead costs. Also listed under MG 826

CE 827 Contracts and Specifications 2½:0:0:3

Principles of contract law as applied to the construction industry and legal problems in preparing and administering construction contracts. Also listed under MG 827.

CE 828 Risk Analysis 2½:0:0:3

A thorough investigation of the ever-rising importance of risk analysis in project management. Analysis of qualitative and quantitative risk. Techniques in probability analysis, sensitivity analysis, simulation of risk and utility theory. Computational methods for calculating risk. An exposure to real-world corporate and public problems through case investigations.

CE 829 Construction Operation Analysis 2½:0:0:3

Evaluation and model development of productivity, safety, quality and materials handling in construction operations. Principal methods for analysis and pre-planning work activities, including the use of work sampling, questionnaires and surveys. The implementation of video/time-lapse 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 simulation. Field implementation and projects.
Prerequisite: Degree in civil engineering or adviser's approval.

CE 830 Information Systems in Project Management 2½:0:0:3

Development of a strong understanding of contemporary tools for managing the vast array of information in the project

life-cycle. Information handling is reviewed from the perspectives of both knowledge acquisition and knowledge presentation. The course focuses on the concepts of fully integrated and automated project processes and the interrelationships of 3-D computer models, simulation, cost estimating, scheduling, procurement and information technology (emphasis on the implementation of 3-D computer models and relational databases as information systems for project information handling and project automation).
Prerequisite: Degree in civil engineering or adviser's approval.

CE 831 Engineering for Construction I: Methods and Technologies 2½:0:0:3

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.

CE 832 Engineering for Construction II: Design 2½:0:0:3

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 instructor's permission.

The following courses are part of the Exec 21 Executive Construction Management Certificate Program. They are open only to students with at least four years of practical experience in construction management, unless otherwise approved by the director or associate director of CCMT.

CE 870 Managing and Leading in the 21st Century 2½:0:0:3

Today's mega projects require the formation of large multidisciplinary teams including engineers, constructors and financial, legal and business experts.

Success in this challenging environment requires up-to-date and proven leadership and management skills. This course covers the basic components of management planning, organizing, directing, controlling and decision-making. It defines the engineering and construction team and discusses leadership styles. This course also addresses the management of change, external factors that shape decisions, the development of a personal leadership profile and, ultimately, 21st-century leadership requirements.

CE 871 Construction and the Law 2½:0:0:3

Construction industry executives need not be legal experts, but they must be aware of the legal issues affecting their industry and their bottom line. This course uses the case study method to lead students through the concepts of design and construction law. The course focuses on the interface of legal, business and technical issues and their resolution. It includes the design and organization of construction documents; the legal aspects of bidding, subcontracting, bonds, insurance, mechanic's liens, etc; and the implication of delays, changes and charged conditions. Alternative dispute resolution (ADR) methods are introduced.

CE 872 How to Succeed in Construction 2½:0:0:3

Course leads students through the how-to's of running a successful, large, complex construction company. It analyzes how the industry actually works, including contractual relationships with clients in all types of projects from design/build to privatization. It covers the business fundamentals of running a construction company, including issues such as surety and insurance: various types of construction organizations, domestic and international; and company culture—inner workings of a business that can mean the differences between success and failure.

CE 873 Infrastructure Financing: Structuring of a Deal 2½:0:0:3

Course examines what it takes to structure a deal from a credit perspective, legally and financially—for both domestic and international projects. In the domestic sector, the course focuses on transportation projects, examining the peculiarities and the uniqueness of the

capital market. Examples are studied and recent changes are discussed in areas such as financing transportation projects and the dramatically changing nature of financing these projects. In the international sector, the course covers new and innovative financing techniques.

CE 875 Employer Focused Residency
3 units

The scope of this course is for students to define a proposal for a project that is related to their employment. Students work one-on-one with an adviser throughout the semester. There is no formal classroom work; however, students must update their adviser on weekly bases. The project will run no longer than one semester. Students present their projects' findings formally in front of invited guests in Polytechnic's Dibner Auditorium at the end of the semester.

CE 876 Capital Program Management/ Program Development
2½:0:0:3

Drawing upon their considerable experience in major projects with the Port Authority of New York and New Jersey and the New York Metropolitan Transit Authority, two veteran industry executives examine capital program management and development from the public sector point of view. The course analyzes how the public sector looks at a project and develops it, and the internal workings of an organization in determining how a project is selected, funded and managed. The course explains privatization and why it is chosen. It uses case studies of three existing projects—a resource recovery plant, a co-generation project and the JFK light rail DBOM project—to examine various contracting strategies. Concepts of risk allocation, funding and project finance (consolidated bonds, special use bonds), DBOM contracts and various privatization models are explored.

CE877 Dispute Avoidance and Resolution
2½:0:0:3

The course analyzes the basic causes for construction disputes and introduces methods for dispute avoidance through proper risk allocation, management and control, as well as other techniques such as partnering. It uses the case study method to address litigation and provides an understanding of the process of arbitra-

tion and other alternative dispute resolution (ADR) methods such as negotiation, mediation, mini trials and dispute review boards.

CE 878 Construction Management and Planning
2½:0:0:3

Strategic planning is indispensable to achieving superior management. This course in business planning provides practical advice for organizing the planning system, acquiring and using information, and translating strategic plans into decisive action. This is an invaluable resource for top- and middle-level executives.

Suggested Courses in Distance Learning from the University of Salford are:

CE 881 IT Applications and Implementation
2½:0:0:3

The penetration of information technology (IT) application into the construction industry has been gathering pace in recent years due to the great improvement of computer hardware and software. Today, a large number of software packages are available to all disciplines of the construction team and for all stages of the construction process. They provide support for a broad range of activities such as computer aided design and drafting, building visualization, design appraisal, project management, information storage and retrieval, accounting and estimating, structural analysis, on-site management, etc. This course gives an overview of the state-of-the-art construction IT Systems. It addresses not only "what" are available but also "why" they are beneficial and "how" they can be applied to the improvement of the construction practice.

CE 882 Construction Integrated Environments
2½:0:0:3

Course requires students to detail the way in which the principles of the whole project life cycle including design, production and operation in the construction can be integrated. It embraces the study of the general principles of systems integration and their application in a construction manufacture context. It also entails study of the fundamental principles of simultaneous or concurrent engineering and addresses the issue of integration through a technology driven approach.

CE 883 Systems Development Life Cycle
2½:0:0:3

Course guides the students through systems development from the feasibility studies through to systems implementation. It provides an overall appreciation of issues involved in systems development including requirements capture, project management, modeling data and processes, documentation methods and testing and installation. An emphasis of the course prepares students to play an integral role in the analysis and design of information systems. It aims to bridge the gap between construction managers and systems analysts and computer programmers by familiarizing students with analysis methods and techniques.

CE 884 Strategic Management & Business Process Analysis
2½:0:0:3

Principles and models of strategic management and business process re-design and theories of competitive advantage are studied in, and applied to, the context of construction, by addressing the different applications levels of government bodies, professional institutions, construction enterprises and major construction projects. Students apply strategy and re-engineering concepts to their work environment in developing technology strategies context of competitive advantage, core competence and capability, corporate bench marking, technology strategies, business process analysis and redesign and methodologies for strategic management.

CE 993 MS Project in Construction Management
3 units

A capstone, individually-advised project resulting in a substantial report in an appropriate area of construction management.

For course descriptions of elective courses, see relevant sections in this catalog:
Civil Engineering Program
Environmental Program
Management Program
Transportation Program
Urban Systems Program

Typical Course of Study for the Bachelor of Science in Construction Management

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
CM 1004	General Chemistry	3	2	1	4
EN 1014	Writing & the Humanities I ¹	4	0	0	4
MA 1054	Integrated Calculus A ²	4	0	2	4
EG 1004	Intro to Eng & Design	1	3	2	4
SL 1010	Freshman Seminar	1	1	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
PH 1004	Introductory Physics I	4	1½	1	4
CE 1504	Leadership & Found. of Const.	4	0	0	4
EN 1204	Writing & the Humanities II	4	0	0	4
MA 2054	Applied Data Analysis ³ -or-	4	0	0	4
MA 1154	Integrated Calculus II ³	4	0	2	4
					16

SOPHOMORE YEAR

Fall Semester

CE 2114	Statics & Dynamics	4	0	0	4
HI 2104	Modern World History	4	0	0	4
CE 2504	Const Model & Data Str I	3	3	0	4
MG 2204	Financial Accounting	4	0	0	4
					16

Spring Semester

CE 2124	Mechanics of Materials	3½	1½	0	4
EC 2504	Basic Economics	4	0	0	4
PL	Philosophy Elective ⁴	4	0	0	4
MA	Math Elective ⁵ -or-	4	0	0	4
MA 2122	Data Analysis I ³ (½ semester)	2	0	0	2
MA 2222	Data Analysis II ³ (½ semester)	2	0	0	2
					16

JUNIOR YEAR

Fall Semester

CE 3503	Cost Estimating	3	0	0	3
CE 3513	Construction Scheduling	2	3	0	3
CE 3544	Site Plng, Des, & Survey.	3	3	0	4
CS 3xx2	Computer Conc & Apps	2	0	0	2
MG/EC	Mgt/Economics Elective ⁵	4	0	0	4
					16

Spring Semester

CE 3523	Contracts & Specifications	3	0	0	3
CE 3553	Non-Structural Building Systems	3	0	0	3
MG/EC	Mgt/Economics Elective ⁵	4	0	0	4
HU/SS	Level II Elective ⁶	4	0	0	4
	Sequence Elective I ⁷	4	0	0	4
					18

SENIOR YEAR

Fall Semester

CE 4523	Structural Building Sys.	3	0	0	3
CE 4513	Construction Project Adm	3	0	0	3
MG/EC	Mgt/Economics Elective ⁵	4	0	0	4
	Sequence Elective II ⁷	4	0	0	4
					14

Spring Semester

CE 4533	Construction Law	3	0	0	3
CE 4543	Construction Mgt Project	3	0	0	3
CE 4503	Construction Engineering	3	0	0	3
CE4	CE Elective	3	0	0	3
HU/SS6	HU/SS Level III Elective	4	0	0	4
					16

Total credits required for graduation:

128

1. All students take a writing placement examination. Students with an ESL background may be placed in EN 1034, which includes an additional two hours a week of language instruction. Any student may be placed in a remedial section based upon exam results, which does not carry degree credit.

2. The department recommends that all students take MA 1054 Integrated Calculus A, which includes an additional two hours a week of pre-calculus review. It believes that this is useful for all students, including those with an excellent math background. Students may take a placement test to be placed in MA 1024 Calculus I, or may be advanced placed based upon AP or college credit earned while in high school.

3. Students who elect to take MA 2054 in the freshman spring semester may take a Math elective in the sophomore spring semester. Students who elect to take MA 1154 in the freshman spring semester may take either MA 2054 or MA 2212/2222 in the sophomore spring semester.

4. Approved PL electives include PL 2054, PL 2064, PL 2084, PL 3054 or other approved courses containing at least 1 credit of ethics.

5. Approved MG electives are MG 2004, MG 2014, MG 2104, MG 2304, MG 3204 and MG 3404. Approved EC electives are EC 2514, EC 2524, EC 2534, EC 3254 and EC 3264.

6. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Level II electives have 2xxx numbers; level III electives have 3xxx numbers, and normally have a level II elective as a prerequisite. Students who take up to two courses with an EC prefix in fulfillment of the MG/EC electives may substitute any course with a CE prefix and not more than one course with a TC prefix.

7. A list of approved sequences appears elsewhere in this catalog; a current list is always available from the department.

DIGITAL MEDIA PROGRAM

The Department of Humanities and Social Sciences offers a Master of Science in Integrated Digital Media*. The program is designed to make the best use of Polytechnic's extensive resources in the interests of expanding the traditionally separate areas of media creation, criticism and technology development. New media creation depends upon the incorporation of media theory and practice for its viability. This program explores the creative, technological and analytical dimensions of digital media into an integrated whole. The program requires students to demonstrate not only a mastery of technique, but also of concepts and context. The integration of theory and practice at a level set by the department requires students' complete attention. The concentration of graduate studies into a specific, manageable block of time allows participating students to complete a graduate degree in 12 months.

Polytechnic's location offers access to leaders in the field of digital media—academics, designers, developers, producers and their various workplaces and equipment, all within a 10-mile radius of the Polytechnic campus. The program can draw on this pool of talent for specific contributions to the curriculum.

The Integrated Digital Media Lab is a media recording and production studio with a flexible layout and provisions for necessary peripherals—from cameras and lights, microphones, workstations and disk arrays to post-production software, sound mixing facilities and a set of data projectors driven by a flexible network of appropriately powerful computers.

The goal of the program is to integrate students into the highest levels of New York's digital media industry. Periodic conferences will showcase students' accomplishments in the context of presentations by the best in the field, at one of digital media's epicenters: New York City.

* pending New York State approval

GOALS AND OBJECTIVES

Specific objectives of the MS in Integrated Digital Media are to:

- Explore the traditionally separate areas of media creations, criticism and technology development
- Combine the understanding of media theory with elements of practice
- Eliminate the false choice between technology and creativity for students
- Integrate the technological, creative and analytical dimensions of digital media

REQUIREMENTS FOR MASTER OF SCIENCE

A total of 36 units is required for the master's degree. Normally, students start by taking introductory courses (600 and 601) and then proceed to more advanced courses and seminars. Students are encouraged to take 9 units of work in related fields outside the program. To qualify for a degree, students may elect to write either a comprehensive examination or a thesis embodying appropriate and substantive research. If students choose the former, examinations may be taken in the term in which courses are completed. Students choosing the thesis may apply up to 12 units of thesis course work toward requirements for the degree. Acceptance of a thesis involves an oral presentation and defense.

UNDERGRADUATE COURSES

Digital media studio courses complement current offerings in Liberal Studies and Technical Communication programs and offer a range of electives for students in other programs.

DM 2114 Video Production I 4:0:0:4

Students develop a basic understanding of video technologies and production practices. The class is highly structured, with a minor assignment due every two weeks. There is some latitude for experimentation, but the course's primary pur-

pose is to provide a solid technical foundation. Software: DV editing program (Final Cut Pro, Adobe Premiere, or equivalent); DVD authoring program (DVD Studio Pro or equivalent). Hardware: MiniDV camcorder (one for every four students); students to use their own laptop in class and for assignments; external firewire or USB 2.0 HD highly recommended. Consumables: students must supply their own MiniDV and DVD-R media.

DM 2124 Audio Production I 4:0:0:4

An introductory studio course designed to familiarize students with the theory and practice of audio production and post-production. The course's structure calls for three two-week assignments, and one final three-week assignment. To successfully complete the assignments, participants should plan to work outside class hours. Required equipment: a laptop running Windows XP, Mac OS X or Linux.

DM 2134 3D Graphics 4:0:0:4

Students learn and apply fundamental principles of 3-D model construction and editing. A substantial proportion of the class is devoted to lab time, as the software is served via the lab's LAN. Students have access for additional time on their projects, which is essential for those wanting to do excellent work. Required equipment: a laptop running Windows XP, Mac OS X or Linux. Software: Alias Maya.

DM 3114 Video Production 2 4:0:0:4

In the course, students use the skills they have developed in DM 2114 to explore and make the most of digital video technology. Class time is divided between hands-on technical demonstrations, group work and case studies of particularly relevant historical work in film and video. The emphasis on experiment and group work is designed to reflect the realities of video production in the media industries. A range of approaches

DIGITAL MEDIA PROGRAM

to video is demonstrated and encouraged. *Prerequisite: DM 2114.*

DM 3124 Audio Production 2 4:0:0:4

Students use the fundamental principles and skills they developed in DM 2124 to complete projects in three of four categories: interview, drama, sound design, music. This course is primarily intended as an intermediate production studio, using professional examples to guide experimentation and production. The emphasis is on developing students' understanding of how technical decisions and execution affect listener experience in a broad range of formats. *Prerequisite: DM 2124.*

DM 3134 4D Animation 4:0:0:4

Students apply their 3-D modeling skills and understanding of the Studio Tools environment to the fourth dimension: time. Using Maya, one of the leading industry-standard animation packages, students produce a short animation over the course of one term; the project is structured as a sequence of three phases, to balance the need for structure with the fundamental reality of high-quality animation work—it takes time. Students must be prepared to devote considerable time outside of class hours if they want good results. Through case studies and group discussion, students are encouraged to develop their creative and critical skills, as well as their proficiency. *Prerequisite: DM 2134.*

DM 3404 Special Topics in Digital Media 4:0:0:4

Focus on a special topic in digital media completed under the guidance of a faculty member. Course may be repeated for credit on a different topic. *Prerequisite: instructor's permission.*

DM 3504 Independent Study in Digital Media 4:0:0:4

Independent or small group work, under supervision of instructor, by special arrangement. *Prerequisites: for Liberal Studies and Digital Media majors only and instructor's permission.*

DM 4504 Senior Project 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project adviser. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: for Liberal Studies and Digital Media seniors only and by permission of the department.*

GRADUATE COURSES

DM 603 Media Structures I 3:0:0:3

The course lays the conceptual groundwork for the Master of Science degree by studying cases and principles of structural analysis of organizations, their culture and products and their value and limits as tools and contexts for specific objectives and ways of working.

DM 613 Digital Production I 3:0:0:3

The course is an intensive orientation in the technical tools and skills required to produce digital media for broadcast, web and multimedia presentations, with a conceptual emphasis on logistical requirements and best practices for the planning of different production types. As students work hands-on with state-of-the-art production tools, they learn how to assess different technology configurations, working styles, workflow arrangements and the sheer number of person-hours it takes to actually produce top-quality media.

DM 623 Philosophy and Law I 3:0:0:3

The course familiarizes students with two areas of crucial importance to working media producers: (1) practical, an orientation to the legal and regulatory standards governing media production and distribution in the marketplace today; and (2) theoretical, an examination of the principles and concepts on which those standards are based, grounded in a historical understanding of the conditions and rationales that brought those standards into being.

DM 633 Media History I 3:0:0:3

The first of a sequence of two lecture-seminar courses designed to provide students with a mature understanding of the historical, technical, and cultural forces that have shaped today's media landscape. This course complements DM 603 by analyzing the precedents and circumstances driving the development of mass media in the first instance, and the more evolved forms that have grown out of them up to the present. *Co-requisite: DM 603.*

DM 703 Structures II 2?:0:0:3

"Form follows function" (and vice-versa). This is the second of a three-course sequence, designed to develop understanding of the state of the media arts in different sectors of the world economy, both in the advanced and developing nations. The intimate connections between management, economics and content are considered in depth.

DM 713 Production II 3:0:0:3

The course follows up on the pre-production course DM 703. The emphasis is on making the fullest use of a variety of image, audio and video production tools to achieve the very best quality by the most-efficient means. Students are expected to devote time to experimentation, as well as produce examples of top-quality media for a variety of formats. Individual students are expected to demonstrate proficiency across a broad range of tools, but are also encouraged to focus on those tools for which they have the greatest aptitude or which will be the most useful for their thesis project. *Prerequisite: DM 703.*

DM 723 Philosophy and Law II 3:0:0:3

An advanced seminar exploring in depth the theoretical and practical aspects of the principles and regulations that should be taken into account by working professionals in the field of media communications. This course focuses on the practical implications of the general concepts covered in DM 623. *Prerequisite: DM 623.*

DM 733 Media History II 3:0:0:3

This lecture/seminar course follows up on DM 633 through study of subsequent developments in the technological and social aspects of media production and distribution. It provides students with a deeper understanding of the forces that have influenced present practices and circumstances, with a view to anticipating and directing future developments. *Prerequisite: DM 633.*

DM 803 Structures III 3:0:0:3

“The forest for the trees” (and vice-versa). This is the final seminar of a three-course sequence, designed to orient participants to the next generation of forms, tools and practices: the generation they will be remembered for. Students investigate current research and development projects, and use the information and ideas developed in DM 603 and 703 as the foundation of speculative and/or original creative projects related to each participant’s research focus. *Prerequisites: DM 603 and DM 703.*

DM 813 Digital Production III

3:0:0:3

Advanced computer documentation course in which students learn how to produce effective online documentation, effectively index documentation projects and revise and update documentation manuals and programs. Intensive practice in project management. *Prerequisite: JW 608 or instructor’s permission.*

DM 906 Digital Media Thesis Project

0:0:0:6

This 6-unit course is the capstone of the MS in Integrated Digital Media. Under the guidance of a thesis adviser, and with the support of other faculty as required by the particular project, each student will complete a major media production project. The form and format of the thesis will be set out by agreement between the students and their adviser, with the approval of the department, with a view to advancing the student’s career and contributing constructively to the profession as a whole. Students are encouraged to seek professional outlets for their thesis, where appropriate; the department and the University will do everything possible to help ensure that its graduates’ excellent work find its audience and its market.

ELECTRICAL ENGINEERING PROGRAM

Program Director: Peter J. Voltz

The Department of Electrical and Computer Engineering offers an Electrical Engineering Program for the degrees Bachelor of Science, Master of Science and Doctor of Philosophy.

ELECTRICAL ENGINEERING PROFESSION

Electrical engineering is a rapidly growing profession that has evolved from its early beginnings in electric power generation and distribution through the development of radio, television, control, materials, computers, telecommunications and health care. 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 100 years ago. Their inventions have made the world a smaller, safer place, and allow for immediate reporting and images from distant places, making world events part of daily life.

While undergraduate and graduate students in electrical engineering concentrate on areas of electrical science, graduates eventually apply their training to such diversified fields as electronic design, bioengineering, city planning, astronautics, radio astronomy, system engineering, image processing, telemetry, the Internet, computer design, 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 microelectronic devices and systems; computer engineering and computer science; telecommunications; speech and image processing; electro-optics and electroacoustics; microwave engineering; wireless personal communications; power systems and energy conversion; plasma science and engineering; and systems and control engineering.

Additional information about electrical engineering careers can be found online at www.ieee.org/organizations/eab/student-careers.htm.

UNDERGRADUATE PROGRAM

The BS program in Electrical Engineering gives student a broad-based background in electrical engineering, preparing them for immediate employment in industry or government or for graduate study.

GOALS AND OBJECTIVES

The Bachelor of Science program in Electrical Engineering achieves the following objectives for students:

- Instills in them a broad-based understanding of the fundamental technical subject areas associated with electrical engineering
- Requires them to achieve technical depth in at least one area of specialization and allows them to take electives in other areas
- Develops their problem-solving skills with modeling, analysis, design and computer simulation as tools
- Provides them with a broad educational component that complements the technical content of the electrical engineering discipline, including multidisciplinary experience, humanistic and societal issues, with particular emphasis on the development of effective oral and written communication skills.

The BS program includes analysis and design courses in the major areas of electrical engineering that build on fundamental courses in mathematics and science. Many of the electrical engineering courses include hands-on laboratory components. A variety of electives are available to undergraduates to provide depth and specialization, many in commercially viable areas such as local area networks, wireless communication and deregulated power systems.

Since most current engineering design is computer facilitated, the department includes computer-aided design (CAD) programs in many undergraduate courses to emphasize possibilities for large-scale design, corrections for unmodeled complexities, trade-offs among performance criteria and real-time simulations. The senior design project challenges each student to integrate analytical and design

concepts from earlier courses to design a device or system to meet specified performance requirements.

The program recognizes that communication and interpersonal skills are essential to a successful career in any profession. Students in the program are required to take courses in history, writing and literature, as well as elective courses in the areas of humanities and social sciences. Those skills are also developed in team projects in design courses.

Students are taught by faculty familiar with current issues through sponsored research programs, such as those coordinated by Polytechnic's Center for Advanced Technology in Telecommunications (CATT), a World Wide Web lab and many research grants awarded to individuals or groups of professors.

The Electrical Engineering Program keeps abreast of market changes through the CATT Industrial Affiliates Program, hiring of professors and part-time adjunct teachers having industrial experience, frequent contacts with alumni, review of professional journals and encouraging faculty to work in industry part-time or while on sabbatical. Where possible, classroom work challenges students to apply their knowledge to current design situations. Students are also able to apply broad technical knowledge to practical problems through interdepartmental cooperation in photonics (with physics), in robotics (with mechanical engineering) and in smart materials (with materials science).

Industry's need for the system approach in engineering is also reflected in the curriculum by senior projects in areas such as control and robotics, advanced hardware design, imaging, wireless communications, power electronics and areas mentioned above. The economic aspects of engineering are addressed by allowing undergraduates to choose electives, such as macro/micro economics, psychology, ethics and management process. Cost evaluation is required in the design projects for EG 1004 Introduction to Engineering Design. Senior projects emphasize time management and planning.

Exceptional undergraduate students are given the opportunity for advanced study in two programs: (1) the BS/MS Honors

Program, which requires students to work on a research project equivalent to 6 or 9 credit hours, and (2) the summer junior research internship program, which allows undergraduates to work on research projects with graduate students and their advisers. Up-to-date information about program requirements, course offerings, senior project topics and research projects is available online from the Department of Electrical and Computer Engineering at www.ece.poly.edu.

UNDERGRADUATE DEGREE REQUIREMENTS

The undergraduate program in electrical engineering gives students broad-based preparation for a career in electrical engineering in any of its specialization and readies them for immediate employment in industry, business and government, or for further graduate education. The program is accredited by the Accreditation Board for Engineering and Technology (ABET).

The table at the end of this section outlining the Typical Course of Study for a BS shows a typical semester-by-semester program for students who enter as freshmen in fall 2005 or later. The notes identified by superscript numbers are an essential part of the table. Students are responsible for making themselves aware of changes that might be made in this program after the publication of this catalog. Those changes are posted outside the department advising offices and on the department's Web page. (Students who started their studies before fall 2005 should consult the previous edition of this catalog or the department's Web page for program and course requirement applicable to them.)

SENIOR DESIGN PROJECT

The two-semester senior Design Project allows each student to focus on one aspect of electrical engineering. In the first semester, students develop skills using specialized laboratory equipment and computer design packages, are introduced to techniques for planning projects and making effective presentations, and they learn to balance design requirements such as performance, safety, reliability, and cost effectiveness.

In the final semester, students design, build or simulate and test a device or system to meet prescribed engineering specifications.

Informal and formal written and public oral presentations help prepare stu-

dents for professional careers. Design project students frequently work in groups or pairs to develop interaction skills essential to good engineering.

SEQUENCES

Polytechnic students are required to complete a two-course, interdisciplinary 8-credit sequence. These sequences are normally taken in the last half of the junior year and the first half of the senior year. The Electrical and Computer Engineering Department currently offers one approved sequence in multimedia communications, consisting of the two courses, EE 3414 Multimedia Communication Systems I and EE 4414 Multimedia Communication Systems II. Additional sequences will be posted on the department Web site as they are developed and approved.

GRADUATION REQUIREMENTS

The University requires a 2.0 GPA 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 in writing, mathematics and programming, course credits by transfer and advanced placement and credit by examination.

To graduate, students must (1) have a C- grade or better in CS 1114, CS 2204, EE 2013, EE2024 and EE 3054 and (2) have a technical GPA of 2.0 based on all courses prefixed EE, CS or EL. Seniors may elect graduate courses labeled EL 5XX, but not CS 5XX. To enroll in other graduate courses, seniors must have a 2.7 GPA or better in related courses and adviser approval.

Students are expected to meet the degree requirements in effect at the time when they first enrolled in a Polytechnic program. Those requirements apply as long as the student remains in good standing and less than eight years have elapsed since entering the program. The period for unchanged requirements is proportionately less for a transfer student. (Students who started their studies before fall 2005 should consult the department's Web page for program and course requirement applicable to them.)

GOOD STANDING, PROBATION AND DISQUALIFICATION

Students who fail to meet University GPA requirements or other conditions of adequate progress toward completing a degree are put on probation. (See the "General University Requirements" sec-

tion in this catalog for more details.) Students on final probation may not register for courses in one semester until grades are available from their previous semester's courses, and they are limited to a reduced number of credits per semester. Students who improve their academic performance are removed from probation and returned to good standing. Continued poor academic performance can lead to final probation and, eventually, disqualification from the University.

To remain in good standing in the Undergraduate Electrical Engineering Program, students must (1) maintain, term-by-term and cumulatively, a technical GPA (based on EE, EL and CS courses) and a University GPA of 2.0 or better; (2) fail no courses; (3) earn a C- or better in each of the four courses specified above; (4) fulfill all course pre-/co-requisites; and (5) remove any incomplete I grades within 30 days of the last day of final exams. Occasionally an adviser may permit a third enrollment in a course for which a C- grade is required. In such cases, the student must earn a grade of a C or better in that course. Students facing difficulties, whether educational or personal, should consult their instructor or a departmental adviser at the earliest possible time.

Students who do not meet program conditions are placed on departmental probation. Probation conditions may require students to (1) repeat courses, including courses where they received transfer credit and courses where they received a C grade or less at Polytechnic; (2) specify their credit load and permissible withdrawals; or (3) take other remedial programs. Students who do not meet departmental probation requirements, fail twice to earn the required grade in any one course or do not conform to the University Student Code of Practice are subject to being disqualified from working toward a bachelor's in electrical engineering or taking any further electrical engineering courses. Actions taken depend on individual cases. Students who are disqualified may appeal in writing. Students may also apply for readmission after two terms (fall, spring or summer) have passed if they show evidence of an improved chance of success.

DUAL UNDERGRADUATE MAJORS

With departmental permission, students may earn a single bachelor's degree in electrical and computer engineering. This degree requires a total 142 credits rather than the usual 128 required for individual bachelor's degrees.

PART-TIME UNDERGRADUATE STUDY

In order to accommodate the need of some students to complete some of their studies on a part-time basis, some basic courses are offered in the evening (starting at 6PM or later). However, part-time students will have to take most of their courses during the day to complete their 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

Transfer credits for courses taken at other schools are based on evaluation of content and level. Students completing the same program at another school, but in different years, may receive different amounts of transfer credits. They should consult an 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. Transfer credits are awarded only for courses completed with C grades or better.

Qualified students from two-year pre-engineering programs, such as those at liberal arts and community colleges, may fulfill the requirements for the BS in Electrical Engineering in two additional years. Since pre-engineering programs vary, a prescribed program is not possible; consequently, students should consult with a Polytechnic undergraduate adviser at the beginning of their pre-engineering program.

Graduates of technology programs may be able to fulfill the requirements for the BS 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.

MINOR IN EE

Students may obtain a minor in electrical engineering by taking 15 credits of EE-prefixed courses. The courses may be any EE courses subject only to the prerequisite requirements. A grade of C- or better is required in EE 2013 and a GPA of 2.0 or better in the entire minor is required. A minimum of 8 credits in the minor must be taken at Poly. The EE minor is not open to CompE students.

THE BS/MS ACCELERATED HONORS OPTION

The BS/MS Accelerated Honors Option leads to the simultaneous awarding of a bachelor's and master's degree. Depending on the student's preparation and objective, the two degrees may be completed in as few as four years of study. Each program is individually designed in cooperation with the departmental BS/MS Accelerated Honors Option adviser to allow varied transfer and AP credits, co-op program participation, professional summer jobs and other goals consistent with the Honors Option.

Possible BS/MS combinations include BS in Electrical Engineering with a MS in Electrical Engineering, Telecommunications Networks or Computer Engineering. (See also the Computer Engineering Program section in this catalog.)

Incoming freshmen with superior admissions qualifications are invited to participate in the Accelerated Honors Program. Later admission may be considered after the student completes no more than one year at Polytechnic. Students must complete 16 to 20 credits each semester, maintain a 3.5 GPA overall and technical average, particularly in key courses, and display a record 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 for the senior Design Project II, and all curriculum footnotes apply. Required credits are the sum of the credits for the two degrees minus the 3 credits of senior Design Project II. Students in this program must complete a Master's Thesis (generally optional for other MS students).

Acceleration may be achieved through summer course work, extra course loads, careful course sequencing or credit by examination. Students may also achieve acceleration through advanced placement credit in such courses as calculus, computer science or physics.

GUIDANCE FOR UNDERGRADUATE STUDENTS

Instructors provide help for students in their courses during hours posted on their doors or by appointment. Students taking project or thesis courses work closely with faculty project advisers. Electrical engineering advisers in the undergraduate ECE office are 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.

SL 1010 Freshman Seminar introduces students to Polytechnic and its curricula. Fellow students are an excellent source of advice on adjusting to the University environment and the demands of an engineering program. In addition to meeting students in class, students are urged to meet students who can provide experienced advice by joining clubs such as the student branch of the Institute for Electrical and Electronics Engineers (IEEE) professional society, or religious or ethnic clubs.

Students are advised to meet with other students to study and to do homework. In this way they benefit both from explanations provided by others and by the deeper understanding they get when they explain a concept or technique to someone else.

INFORMATION

Undergraduate advising information is available on the Department of Electrical and Computer Engineering's Web page, www.ece.poly.edu. Students should consult that page for further details on honors, probation, approved electives, projects, elective concentrations, course offerings, senior project topics and other matters of interest. Curriculum and prerequisite changes, new courses, special sections and other last minute announcements are also posted on the bulletin boards outside both the undergraduate and graduate Office of Electrical and Computer Engineering Advising. All students are responsible for keeping informed about the latest procedures and regulations.

Descriptions of undergraduate courses in electrical engineering are found after the description of the graduate programs in EE.

GRADUATE PROGRAMS

The Department of Electrical and Computer Engineering offers a Graduate Electrical Engineering Program leading to graduate certificates and degrees Master of Science, Master of Engineering and Doctor of Philosophy.

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, stu-

dents should refer to the Department of Electrical and Computer Engineering Graduate Student Manual, which is revised annually and is available from the department's graduate office and online at www.ece.poly.edu.

Outstanding students should apply for financial aid in the form of research fellowships, teaching fellowships or partial tuition remission.

GOALS AND OBJECTIVES

The Master of Science program in Electrical Engineering prepares graduates for a professional career as a practicing engineer in industry, business or government at an advanced level or to pursue the PhD degree in electrical engineering. The three core courses, two one-year sequences and electives provide students with the opportunity to achieve both breadth and depth across a number of sub-disciplines within electrical engineering.

The Doctor of Philosophy program in Electrical Engineering prepares graduates for a research career in electrical engineering and/or teaching at the university level. The program provides students with a strong fundamental knowledge in several disciplines of electrical engineering, skills required to perform independent research activities in one of the sub-disciplines and the ability to prepare and defend a dissertation representing an original and significant contribution for publication in a recognized scientific or engineering journal.

CONCENTRATIONS

Wireless Communications

Wireless telecommunication has experienced explosive growth since the introduction of cellular telephones. Personal Communication Services (PCS) and other services such as wireless PBXs, wireless LANs, wireless local loops, blue tooth and HomeRF have also become popular. Major paradigm shifts from exclusive reliance on wired networks to an era of tetherless communications and from a fixed computing environment to a mobile computing environment is underway in the world of communications. The merging of Internet and mobile communications is igniting unprecedented growth and a revolution in information technologies.

Computer Engineering

Computer Engineering deals with various systems, devices and chips for computing, control and communication purposes. Computer engineers are involved in

designing supercomputers, ubiquitous personal and portable computers, communication equipments, networking units, intelligent control modules and all kinds of embedded hardware-software devices.

Telecommunications and Networking

Telecommunications and networking manages various communications systems such as telephone, television, radio transmission, radar, space communications, facsimile and image transmission and networks, including data networks, local area networks and the Internet. The range of the program's interests include the design of components, such as ATM switches and receivers, the design of systems and networks, performance, analysis, modeling and protocols.

Image Processing and Multimedia Technologies

Technologies currently being developed include digital television, including HDTV; medical imaging and teleradiology; and multimedia database and communications. All make use of digital image enhancement, filtering, analysis and compression techniques.

Signal Processing

Signal processing handles 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 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 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 VLSI

The discipline of electronics and VLSI involves the design and implementation

of circuits used in microcomputers, telecommunications, signal processing and control systems. Such circuits are being designed at Polytechnic using state-of-the-art computer facilities and design tools, and the circuits are being fabricated with modern technologies such as CMOS, bipolar and GaAs.

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. Applications include radar, microwave and optical communications and wireless technology.

Plasma and Atmospheric Physics

This area is involved with the 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 power electronics, ion plasmas for the generation of electrical energy and the realization of electromagnetic propulsion.

ADMISSION REQUIREMENTS FOR THE MASTER'S DEGREES

Master of Science

Admission to the Master of Science in Electrical Engineering Program requires a bachelor's 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. Students who want to obtain a Polytechnic BS in Electrical Engineering must do that before beginning studies for a master's.

Applicants who lack a BS in Electrical Engineering but 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.

ELECTRICAL ENGINEERING PROGRAM

A student with a BS in a field other than electrical engineering may also want to consider the departmental master's programs in computer engineering, electrophysics, system engineering, wireless innovation or telecommunication networks.

Master of Engineering

Admission to Master of Engineering programs requires a bachelor's degree in an appropriate preparatory discipline from an institution acceptable to Polytechnic. Candidates for the degree Master of Engineering must complete no less than 36 units of advanced study and/or research beyond the bachelor's degree in the program.

DEGREE REQUIREMENTS

To satisfy the requirement for the MS in Electrical Engineering, students must complete a total of 36 units of courses, as described below. An overall GPA of B in all graduate courses is required by the University. In addition, a B average is required in the combination of the five to seven courses offered to satisfy groups 1 and 2, as indicated below.

GROUP 1: Core Courses

Three courses from the following:

EL 547	Introduction to VLSI System Design
EL 611	Signals, Systems and Transforms
EL 625	Linear Systems
EL 630	Probability
EL 641	Advanced Electronics: Analog and High Frequency Amplifier Design
EL 671	Fields and Waves
EL 735	Communication Networks I

9 Units

GROUP 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

GROUP 3: Approved electives, which may include a thesis (9 units) and a reading course (3 units maximum). 15-21 Units

Minimum Total: 36 Units

At least 24 of the 36 units offered for an MS in Electrical Engineering must be in EL prefixed courses.

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. Students should consult the Department of Electrical and Computer Engineering

Graduate Student Manual for detailed rules and procedures, including student status, recommended one-year sequences, recommended electives, current areas of research, repetition of courses and disqualification for low grades. The manual also contains announcements of changes in degree requirements, if any, adopted by the faculty after the publication of this catalog.

Out-of-department courses (i.e., courses not carrying the departmental prefix EL): 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 allowed in accordance with Polytechnic regulations can be applied only toward the electives. Transfer credits may not be used to satisfy the core or sequence course requirements.

Validation credit: validation credits may be allowed in accord with Polytechnic regulations. In order to obtain credit, students must file an application with the Electrical and Computer Engineering Graduate Committee for permission to take the validation examination.

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.

ADMISSION REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY

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 PhD is awarded to students who complete the program of studies and research (described below) and prepare and defend a dissertation representing an original and significant contribution for publication in a recognized scientific or engineering journal. For a more complete description of the topics summarized here, please refer to the department's Graduate Student Manual.

Admission to Programs: entrance into the doctoral program of study and

research is contingent on candidates passing the departmental qualifying examination and forming a guidance committee (both described below). Students entering with a bachelor's degree 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 take the 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 PhD in Electrical Engineering are normally expected to have a master's in electrical engineering. Students holding a master's degree from Polytechnic in computer engineering, systems engineering, electrophysics, telecommunications networks or wireless innovation can also enter the program.

Qualifying Examinations: the PhD qualifying examinations are offered once each year. These examinations are divided into two sections: (1) a written examination requiring preparation through the first-year graduate level in several areas related to the student's principal area of interest and (2) an oral examination concentrating mainly on this principal area. Principal areas of concentration are communications, signal processing, systems and control, electro-optics, electromagnetics, networks, computer and network architecture and power/power electronics.

Details regarding allowed subject areas, recommended background courses, sample examination questions and the precise format for the coming year are available in the department's Graduate Student Manual.

Guidance Committee: upon passing the qualifying examination, graduate students must find a faculty member in their area of major interest who will become the dissertation adviser. Students work with their dissertation adviser to find an adviser for a minor outside of electrical engineering and a guidance committee of three or four faculty members, with the dissertation 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 Polytechnic. The minor adviser may be a member of the guidance committee. Students must submit the names of these guidance committee members to the Office of Graduate Programs for approval.

The dissertation 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, students should have the appropriate adviser certify this in writing to the Office of Graduate Affairs, with copies to the Department of Electrical and Computer Engineering's Graduate Office.

The guidance committee conducts the area examination and dissertation defense and approves the final dissertation.

Course Requirements: Polytechnic requires that candidates 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. Electrical engineering candidates 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. PhD 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. Students work with their thesis adviser to develop their major program of study. The major program should constitute a coherent, in-depth study 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.

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 PhD 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 dissertation requires the approval of the department's Graduate Committee.

Submission of the Dissertation and Final Examination: After completing the doctoral dissertation, candidates undergo 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 are made available to prospective examiners at a reasonable time in advance. The guidance committee chairman notifies the Office of Graduate Programs of the candidate's readiness so that the examination date may be scheduled. Students are advised to consult the Office of Graduate Programs regarding how to submit, reproduce and bind the final manuscript.

FIVE-COURSE GRADUATE CERTIFICATES

- Computer Engineering
- Image Processing
- Telecommunication Network Management
- Wireless Communications

GRADUATE CERTIFICATE IN COMPUTER ENGINEERING

Computer engineering is a rapidly growing profession and computer engineers are in the midst of exciting times with unlimited opportunities in all walks of life. For instance, computer engineers interact with and design large supercomputers as well as the ubiquitous personal and portable computers. Furthermore, computer engineers play a key role in networking computers with other computers and intelligent devices. Computer engineers are also involved in such varied projects as designing specialized computer hardware to reconstruct the human genome; monitoring and controlling industrial plants and the environment, computer graphics and robotics; and designing biomedical devices and computer networks. Finally, computer engineers design and develop hardware and embedded hardware-software systems. The graduate certificate in computer engineering is designed for working professionals who seek to acquire an in-depth understanding of the field. The program consists of three required courses and two elective courses.

Required Courses:

Course No.	Course Title	Units
EL 549	Advanced Hardware Design (VHDL)	3
EL 536	Principles of Communication Networks	3

CS 613 Computer Architecture I 3

Recommended Elective Courses (choose 2):

Course No.	Course Title	Units
EL 547	Intro. to VLSI Design	3
EL 548	Real-Time Embedded Systems	3
EL 649	Digital VLSI System Testing	3
EL 644	VLSI System Architectures	3
EL 645	VHDL-Based Behavioral Synthesis	3
EL 94X	Advanced Hardware Design Lab (VHDL + FPGA)	3
EL 641	Analog & High Frequency Amplifier Design	3
EL 643	Digital Integrated Circuit Design	3
EL 94X	VLSI CAD	3
CS 614	Computer Architecture II	3
CS 618	Fault-Tolerant Computers	3

Certificate Coordinator: for further information regarding the Computer Engineering Certificate, contact Professor Ramesh Karri at 718-260-3596 or send e-mail to ramesh@india.poly.edu.

GRADUATE CERTIFICATE IN IMAGE PROCESSING

Image processing covers some of the fundamental technology behind applications such as digital television; medical imaging and teleradiology; and multimedia database and communications. All make use of digital image enhancement, filtering, analysis and compression techniques. This certificate is designed for working professionals who seek to acquire an in-depth understanding of image processing and communication technology. The program consists of four required courses and one recommended elective course.

Required Courses:

Course No.	Course Title	Units
EL 512	Image Processing	3
EL 514	Multimedia Lab	3
EL 612	Video Processing	3
CS 664	Computer Vision & Scene Analysis	3

Recommended Elective Courses (choose 1):

Course No.	Course Title	Units
EL 536	Principles of Communication Networks	3
EL 611	Signals, Systems & Transforms	3
EL 630	Probability	3
EL 631	Applied Stochastic Processes	3
EL 713	Digital Signal Processing I	3
EL 716	Multiresolution Signal Decomposition	3
EL 995	Advanced Project I	3

Certificate Coordinator: For further information regarding the Image Processing Certificate, contact Professor Yao Wang at 718-260-3469 or yao@poly.edu.

GRADUATE CERTIFICATE IN TELECOMMUNICATION NETWORK MANAGEMENT

The explosive growth of data networks has brought with it the need for effective network management. The widespread deployment of standards-based solutions (e.g., SNMP) is but a first step in dealing with the complexity of network management. A thorough knowledge of network protocols and network management standards is necessary for any practitioner in this area. The program consists of four required courses and one recommended elective course.

Required Courses:

Course No.	Course Title	Units
EL 536	Principles of Communication Networks	3
EL 537	Internet Architecture and Protocols or	3
CS 684	Network Protocols I	3
EL 637	Local and Metropolitan Area Networks	3
CS 682	Network Management and Security	3

Recommended Elective Courses (choose 1):

Course No.	Course Title	Units
EL 736	Communication Networks II (Network Design and Algorithms)	3
CS 681	Information, Privacy & Security	3
EL 735	Communication Networks I (Performance Analysis and Modeling)	3

Certificate Coordinator

For further information regarding the Telecommunication Network Management Certificate, contact Professor Shivendra Panwar at 718-260-3740 or panwar@catt.poly.edu.

GRADUATE CERTIFICATE IN WIRELESS COMMUNICATIONS

Wireless telecommunication has experienced remarkable growth since the introduction of cellular telephones. With the licensing by the FCC of spectrum for Personal Communication Services (PCS) and other services such as wireless LANs, wireless local loops and the emerging wireless Internet, the rate of growth is expected to increase even further. In order to give those with an electrical engineering background the specific knowledge needed to work in this expanding market, Polytechnic has structured a series of five post-BS-level courses that cover the knowledge needed to compete successfully in this industry. The program consists of two required courses and three recommended elective courses.

Required Course:

Course No.	Course Title	Units
EL 630	Probability	3

Recommended Elective Courses (choose 3):

Course No.	Course Title	Units
EL 501	Wireless Personal Communication Systems	3
EL 536	Principles of Communication Networks	3
EL 601	Principles of Digital Communications: Modulation & Coding	3
EL 602	Wireless Communications: Channel Modeling & Impairments Mitigation	3
EL 603	Modern Wireless Communication Techniques and Systems	3
EL 606	Information Theory	3
EL 638	High-Speed Networks	3
EL 675	UHF Propagation for Wireless Systems	3
EL 930	Wireless Information Systems Lab	3
EL 9XX	Selected Topics Courses in Wireless	3

Certificate Coordinator: for further information regarding the Wireless Communications Certificate, contact Professor Frank Cassara at 631-755-4360 or cassara@rama.poly.edu.

UNDERGRADUATE COURSES

Students should consult departmental adviser postings, handouts and the department's web page for changes in required courses, course contents 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 1114 and of computational mathematics packages used in calculus courses are assumed in all EE courses.

Note: Elective courses whose identifiers have three numerical digits (e.g., EE 107) are listed after the courses having identifiers with four numerical digits. Courses with identifiers of the form EL XYZ that are available as senior electives are located in the list of graduate EE courses.

EE2013 Fundamentals of Electric Circuits I 3:0:1:3

Passive DC circuit elements. Kirchoff's laws. Electric power calculations. Analysis of DC circuits, Nodal and Loop analysis techniques. Voltage and current division, Thevenin's and Norton's theorems. Source free and forced responses of RL, RC and RLC circuits. Minimum of C- required to take other EE courses *Co-requisites: MA 2012, MA 2132 and PH 2004. ABET competencies a, b, c, e, g, k.*

EE2024 Fundamentals of Electric Circuits II 3:1:1:4

Continuation of EE2013. Sinusoidal steady-state response. Complex voltage and current and the phasor concept. Impedance, admittance. Average, apparent and reactive Power. Polyphase circuits. Node and mesh analysis for AC circuits. Use of Matlab for solving circuit equations. Frequency response; parallel and series resonance. Operational Amplifier circuits. Alternate-week laboratory. Minimum of C- required to take other EE courses. *Prerequisites: EE2013 with C— or better grade. ABET competencies a, b, c, e, g, k.*

EE 3054 Signals and Systems 3^h:1^h:1:4

Linear system theory for analog and digital systems. Linearity, causality, time invariance. Impulse response, convolution, stability. The Laplace and z- transforms and applications to Linear Time Invariant (LTI) systems. Frequency response, analog and digital filter design. Fourier Series, Fourier Transforms, the sampling theorem. There are weekly computer laboratory projects using analysis and design computer packages. Objectives: establish foundations of linear systems theory needed in future courses; use of math packages to solve problems and simulate systems; analog and digital filter design. *Prerequisites: EE 2024 (C- or better), MA 2012 and MA 2132. ABET competencies a, c, e, k.*

EE 3064 Feedback Control 3^h:1^h:0:4

Introduction to analysis and design of linear feedback control systems. Modeling of physical systems, performance specifications, 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 (lead/lag and PID controllers) to meet performance specifications. Analysis and design of control systems using math packages in alternate-week computer laboratory. Objectives: Establish foundation of feedback control theory for use in more advanced courses; introduce control systems design concepts and practices; develop facility with computer design packages for design and simulation. *Prerequisites: EE 3054 (C- or better) and PH 2004. ABET competencies: a, b, c, e, g, i, k.*

EE 3114 Fundamentals of Electronics I
3½:1½:1:4

Circuit models and frequency response of amplifiers. Op-amps, difference amplifier, voltage-to-current converter, slew rate, full-power bandwidth, common-mode rejection, frequency response of closed loop amplifier, gain-bandwidth product rule. Diodes, limiters, clamps, semiconductor physics. Bipolar Junction Transistors, small-signal models, cut-off, saturation and active regions, common emitter, common base and emitter follower amplifier configurations. Field-Effect Transistors (MOSFET and JFET), biasing, small-signal models, common-source and common-gate amplifiers, integrated-circuit MOS amplifiers. Alternate-week laboratory experiments on OP-AMP applications, BJT biasing and large signal operation, and FET characteristics. Objectives: to study design and analysis of operational amplifiers, small signal bipolar junction transistor and field effect transistor amplifiers, diode circuits, differential pair amplifiers and the fundamentals of semiconductor device physics. *Prerequisites: EE 2024 (C- or better) and PH 2004. ABET competencies a, c, e, g, k.*

EE 3124 Fundamentals of Electronics II
3½:1½:0:4

Differential and multistage amplifier, current mirrors, current sources, active loads. Frequency response of MOSFET, JFET and BJT amplifiers: Bode plots. Feedback amplifiers, gain-bandwidth rule, effect of feedback on frequency response. Class A, B, and AB output stages. Op-amp analog integrated circuits. Piecewise-linear transient response; determination of state of transistors. Wave shaping circuits. MOS and bipolar digital design: noise margin, fan-out, propagation delay; CMOS, TTL, ECL. Alternate-week laboratory experiments. Objectives: to study design and analysis of analog integrated circuits, frequency response of amplifiers, feedback amplifiers, TTL and CMOS digital integrated circuits. *Prerequisite: EE 3114. ABET competencies a, c, e, g, k.*

EE 3193 Introduction to Very Large Scale Integrated Circuits
3:0:0:3

Overview of integrated circuit design process: planning, design, fabrication, and testing. Device physics: PN junction, MOSFET, and Spice models. Inverter static and dynamic behavior and power dissipation. Interconnects: cross talk, variation,

transistor sizing. Logic gates and combinational logic networks. Sequential machines and sequential system design. Subsystem design: adders, multipliers, static memory (SRAM), dynamic memory (DRAM). Floorplanning, clock distribution, power distribution and signal integrity. Input/Output buffers, packaging, and testing. IC design methodology and CAD tools. Implementations: full custom, application specific integrated circuit (ASIC), field-programmable gate arrays (FPGA). Objectives: to provide students with the foundations of VLSI design and expose them to a custom VLSI-design methodology and state-of-the-art CAD tools. *Prerequisites: CS 2204 (C- or better) and EE 3114. ABET competencies: a, c, e, k.*

EE 3404 Fundamentals of Communication Theory
3½:1½:0:4

Bandpass signal representation and quadrature receivers. Noise in communication systems. Digital Modulation Schemes, coherent and non-coherent receivers. Fundamentals of coding. Block codes and convolutional codes. Higher order modulation schemes, QAM, M-PSK. Intersymbol interference and equalization techniques. Carrier and symbol synchronization. Alternate-week computer laboratory projects using analysis and design computer packages. Objectives: learn principles of various modulation and coding techniques and their relative effectiveness under the constraints of various transmission environments; use of math packages to analyze and simulate communication systems. *Prerequisite: EE 3054 (C- or better); computer engineering students may register with instructor's approval. Co-requisite: MA 3012. ABET competencies a, c, e, k.*

EE 3414 Multimedia Communication Systems I
4:0:0:4

Part I of an approved University Sequence in Multimedia Communications. Topics: speech and audio sampling and quantization, frequency domain characterization and processing of speech signals, speech and audio coding standards. Wired and wireless telephone systems, color perception and representation, basic image processing tools, image coding standards, basics of packet switching networks and Internet technology. Requires one-term project on a topic related to the course content by a team of two or more students. Objectives: to understand basic techniques for speech, audio and image pro-

cessing and principles of wired and wireless telephone systems and the Internet. *Prerequisites: CS 1114 and MA 1022. ABET competencies: a, b, d, g, h, k.*

EE 4144 Introduction to Embedded Systems Design
3½:1½:0:4

Architecture and operation of embedded microprocessors; microprocessor assembly language programming; address decoding; interfacing to static and dynamic RAM; Serial I/O, Parallel I/O, analog I/O; interrupts and direct memory access; A/D and D/A converters; sensors; micro-controllers. Alternate-week laboratory. Objectives: to provide students with foundations of embedded systems design and analysis techniques; expose students to system level design; and teach integration of analog sensors with digital embedded microprocessors. *Prerequisites: CS 2204 (C- or better) and EE 2024 (C- or better). ABET competencies: a, c, d, e, g, j, k.*

EE 4414 Multimedia Communication Systems II
4:0:0:4

Part II of an approved University Sequence in Multimedia Communications. Topics: analog and digital video format, properties of human visual systems, multiplexing of separate color components, video coding methods and standards, analog and digital TV systems. Policy and business issues in TV system development. Video conferencing systems, video streaming over the Internet, Internet protocols for real-time applications. Requires one-term project on a topic related to the course content by a team of two or more students. Objectives: to understand basic techniques for video processing and principles of television systems and real-time services over the Internet. *Prerequisites: EE 3414 or 3054, or sufficient knowledge of Fourier Transforms. ABET competencies: a, b, d, g, h, k.*

EE 3604 Electromagnetic Waves
3½:1½:0:4

Electromagnetic wave propagation in free space and in dielectrics is studied starting from a consideration of distributed inductance and capacitance on transmission lines. Electromagnetic plane waves are obtained as a special case. Reflection and transmission at discontinuities are discussed for pulsed sources, while impedance transformation and matching are presented for harmonic time dependence. Snell's law and the reflection and trans-

mission coefficients at dielectric interfaces are derived for obliquely propagation plane waves. Guiding of waves by dielectrics and by metal waveguides is demonstrated. Alternate-week laboratory. Objectives: Establish foundations of electromagnetic wave theory applicable to antennas, transmissions lines, and materials; increase appreciation for properties of materials through physical experiments. *Prerequisites: EE 2024 (C- or better) and MA 3112. ABET competencies: a, b, c, e, g, k.*

EE 3824 Electric Energy Conversion Systems 3½:1½:0:4

Introduction to electric energy sources, energy storage devices, energy economics, environmental issues, and electrical hazards. Principles of electric power systems—transmission and distribution. Basic electromechanical conversion systems—pulse and distribution transformers, induction rotating machines. Principles of electric energy conversion—static power supplies, static controllers and electric power quality. Fundamentals of power management—heat-sinks and cooling systems. Alternate-week experiments with basic electrical machines. Objectives: become familiar with energy sources, storage devices, and their economical and environmental management; analysis and design of transmission and distribution systems, basic electrical machinery, and power electronic converters. *Prerequisite: EE 2024 (C- or better). Co-requisite: EE 3604. ABET competencies: a, b, c, e, g, k.*

Electrical Engineering Design Project I (EE DP I)

The design project, required of all students, consists of two three-credit courses. The first course, EE DP1, is one of a number of specialty lab/project courses offered by the department in various sub-disciplines such as electronics, machinery, robotics, imaging, communications, etc. (EE 4113-4183, below). The purpose of DP1 is to provide students with a significant amount of background laboratory experience in their chosen area of concentration, to have students begin their independent project work by finding an adviser and initiating the independent project work, and to exercise their oral presentation and written communication

skills. *Prerequisite: completion of all junior-level technical courses. ABET competencies: a, b, c, e, f, g, k.*

EE 4113 EE DP I– Control and Robotics 0:6:1:3
Additional prerequisite: EE 3064. Additional co-requisite: EE 107.

EE 4123 EE DP I– Electrical Power and Machinery 1:3:1:3
Additional prerequisite: EE 3824.

EE 4133 EE DP I– Electromagnetic Waves and Applications 1:3:1:3
Additional co-requisite: EE 164.

EE 4143 EE DP I–Integrated Circuit Design 1:3:1:3
Additional prerequisite: EE 3124.

EE 4153 EE DP I–Multimedia 0:6:1:3

EE 4163 EE DP I–Signal and Image Processing 1:3:1:3

EE 4173 EE DP I–Telecommunication Networks 1:3:1:3
Additional prerequisite: EE 3404. Additional co-requisite: EE 136.

EE 4183 EE DP I–Wireless Communication 1:3:1:3
Additional prerequisite: EE 3404.

EE 4223 Electrical Engineering Design Project II 0:6:1:3

In this concluding phase of the Design Project, students continue working with an adviser on the independent project begun in the previous semester. The final project will build upon and the analytical and laboratory skills developed in the previous required and elective courses. The project may be an individual project, or may be carried out by a team of students working in conjunction with a faculty group adviser. The final capstone project may also be a multidisciplinary project carried out together with students from other departments. *Prerequisite: EE 41X3. ABET competencies: a, b, c, d, e, f, g, h, i, j, k.*

EE 4313 Computer Engineering Design Project I 1:3:1:3

Lectures and experiments will provide an introduction to computer hardware organization, assembly language programming and interfacing computer hardware to physical devices. This course will exer-

cise the student’s oral presentation and written communication skills and provide the background necessary for the student to begin independent project work by finding an adviser and a project for the DP II course. *Prerequisite: completion of all junior level technical courses, including minimum grade requirements. ABET competencies: a, b, c, e, f, g, k.*

EE 4323 Computer Engineering Design Project II 0:6:1:3

This course is the concluding phase of the student’s Capstone Project. In this phase the student works with a faculty adviser on an independent project. This project will build upon the analytical and laboratory skills developed in the previous required and elective courses. The project may be an individual project, or may be carried out by a team of students working in conjunction with a faculty group adviser. The project may also be a multidisciplinary project carried out together with students from other departments. Students will be required to make oral and written presentations. *Prerequisites: EE 4313 or CS 4513. ABET competencies: a, b, c, d, e, f, g, h, i, j, k.*

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 nonlinear systems. *Prerequisite: EE 3064. ABET competencies: a, b, c, e, k.*

EE 116 Communication Electronics 3:0:0:3

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. *Prerequisite: EE 3124. ABET competencies: a, c, e, k.*

EE 136 Communication Networks 3:0:0:3

This course develops the basic techniques used in communication networks. After protocol layering is introduced, algo-

gorithms and protocols are discussed for use in each of the five layers: physical, data link, network, transport and application. Specific protocols such as TCP/IP, ATM, SS7 will be included. *Prerequisite: junior status in electrical engineering, computer engineering or computer science. Co-requisite: MA 222 or MA 223. ABET competencies: a, c, e, j, k.*

EE 164 Electromagnetic Fields and Radiation 3:0:0:3

Review and mathematical interpretation of Maxwell's Equations; basic antenna theory and radiation, antenna parameters and arrays; rectangular metal waveguides; dielectric waveguides; and applications at radio and optical frequencies are discussed. *Prerequisite: EE 3604. ABET competencies: a, c, e, k.*

EE 210 Summer Honors Research Laboratory 0:6:0:3

An individual or small-group intensive 11-week research-oriented project, often related to current faculty research projects. Offered in the summer following the junior year. Students may use this course to satisfy the Technical Elective requirement or the Design Project II. A limited number of students are selected for this program based on application forms submitted in the preceding spring. (See "Research" on the Web page: www.ece.poly.edu). ABET competencies: a, b, c, e, f, g, i, j, k.

EE 371-6 Guided Studies in EE
1,2,3,4,5,6 credits, respectively.

EE 381-6 Guided Studies in CompE
1,2,3,4,5,6 credits, respectively.

GRADUATE COURSES

WIRELESS COMMUNICATIONS

EL 501 Wireless Personal Communication Systems 2½:0:0:3

Introduction to the technology and underlying principles of wireless communications. Elementary examination of the science and technology of wireless communications including radio signal propagation, interference-limited communications, coding, and modulation. Building blocks of wireless networks. Essential functions of all cellular telephone systems. Analysis of the different ways in which the world's four leading systems

perform these functions. *Prerequisite: EE 3404 or equivalent.*

EL 536 Principles of Communication Networks 2½:0:0:3

Or EL5364 Principles of Communication Networks 3:0:0:3.6
See course listings under Telecommunications and Networking.

EL 601 Principles of Digital Communications: Modulation and Coding 2½:0:0:3

Principles of M-ary communication: signal space methods, optimum detection. Fundamental parameters of digital communication systems, various modulation techniques and their performance in terms of bandwidth efficiency and error probability. Efficient signaling with coded waveforms. Block coding and convolutional coding. Joint modulation and coding. *Prerequisites: EE 3404 and EL 630 or EL 6304.*

EL 602 Wireless Communications: Channel Modeling and Impairment Mitigation 2½:0:0:3

Wireless communication channel models and practical techniques for mitigating transmission impairments. Channel Modeling Parameters: Path loss; Fading: long-term vs. short-term fading, flat vs. frequency selective fading, and slow vs. fast fading; Multipath spread parameters: delay spread, angular spread and doppler spread. Channel Parameter Estimation: training sequence and blind approaches. Mitigation: Mitigation of path loss and fading; Diversity, handoff and power control; Mitigation of intersymbol interference: rake receiver and equalizer; Mitigation of time variation: pilot symbols and dynamic tracking. Processing Techniques: LS, zero forcing, MMSE, LMS, etc. *Prerequisites: EE 3404, MA 3012 and programming skill in MATLAB or equivalent.*

EL 603 Modern Wireless Communication Techniques and Systems 2½:0:0:3

Multiple Access and Multiplexing Techniques; Spread spectrum and Code division multiple access (CDMA) techniques: Direct sequence, Frequency hopping; Multicarrier techniques: Orthogonal frequency division (OFDM) and Multicarrier CDMA (MC-CDMA).. *Prerequisites: EE 3404 and EL 630 or EL 6304.*

EL 6034 Modern Wireless Communication Techniques and Systems (ePoly Online Course) 3:0:0:3.6

This course is equivalent to EL 603. It includes the same topics and requirements, with the addition of the following subjects: Ultra Wideband communications, Wireless Fidelity (Wi-Fi), Radio Frequency Identification (RFID), Blue Tooth, etc. A report on one of these new miscellaneous wireless communication systems is required.

EL 606 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. *Prerequisites: graduate status and EL 630 or EL 6304.*

EL 607 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. *Prerequisites: graduate status and basic knowledge of probability and linear algebra.*

EL 630 Probability 2½:0:0:3
Or EL 6304 Probability 3:0:0:3
See course listings under Telecommunications and Networking.

EL 631 Engineering Applications of Stochastic Processes 2½:0:0:3
See course listings under Telecommunications and Networking.

EL 633 Detection and Estimation Theory 2½:0:0:3
See course listings under Telecommunications and Networking.

EL 642 RF Electronics for Wireless Applications 2½:0:0:3
See course listings under Computer Electronic Devices and Systems

ELECTRICAL ENGINEERING PROGRAM

EL 675 UHF Propagation for Wireless Systems 2½:0:0:3
See course listings under Electrodynamics, Wave Phenomena and Plasmas.

EL 930 Wireless Information Systems Lab 2½:0:0:3
See course listings under Telecommunications and Networking.

EL 901-909 Selected Topics in Wireless Communications each 2½:0:0:3

Selected topics of current interest in wireless communications. (See departmental mailing for detailed description of each particular offering.) *Prerequisite: specified when offered.*

SIGNAL PROCESSING

EL 512 Image Processing 2½:0:0:3

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, image coding techniques and standards, linear and nonlinear filtering, morphological operations, contrast enhancement, noise removal, image deblurring, image registration and geometric transformation, and edge detection. Students will learn to perform some basic image processing operations using MATLAB. *Prerequisites: EE 3054 and MA 3012; MA 2012 or knowledge of basic matrix algebra.*

EL 514 Multimedia Lab 2:3:0:3

Multimedia communications refers to integrated processing and communication of video, image, audio and computer-generated graphics and data. This course will provide students with hands-on experience in the acquisition, processing and communication of voice, image and video, as well as multimedia document creation and use of real-time multimedia interactive communications over a variety of channels. Each week includes a one-hour lecture and three-hour lab. *Prerequisites: graduate status or EE 3054 or instructor's permission.*

EL 611 Signals, Systems and Transforms 2½:0:0:3

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. *Prerequisites: graduate status.*

EL 6114 Signals, Systems and Transforms (ePoly Online Course) 3:0:0:3.6

This course is equivalent to EL 611. It includes the same topics and requirements, with the addition of the following subjects: Magnitude Characteristics of LTI systems, All-pass Systems and Properties.

EL 612 Video Processing 2½:0:0:3

This course introduces fundamental theory and techniques for efficient representation and processing of video signals, including introduction of analog and digital video systems, Fourier analysis of video signals, properties of the human visual system, video signal sampling and sampling rate conversion, motion estimation, video compression techniques, video communication standards, stereo video processing and compression, error control in networked video applications. A mini-project is required. *Prerequisites: EL 512, EL 630 or EL 6304, C programming skills and graduate status.*

EL 713 Digital Signal Processing 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 nonrecursive filters. Effects of finite precision arithmetic and round-off errors. Hardware realizations of digital filters. Introduction to spectral analysis. *Prerequisites: graduate status and EL 611 or EL6114.*

EL 7134 Digital Signal Processing (ePoly Online Course) 3:0:0:3.6

This course is equivalent to EL 713. It includes the same topics and requirements, with the addition of the following subjects: Spectral factorization. Multirate

systems, Introduction to basic speech compression, and Speech Filtering.

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 eigenstructure-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. *Prerequisites: graduate status, EL 611 or EL6114 and EL 631.*

EL 716 Multiresolution Signal Decomposition: Transforms, Subbands and Wavelets 2½:0:0:3

A unified treatments of signal decomposition methods for coding, compression and feature extraction. Orthonormal block transforms: sinusoidal and polynomial based transforms; decorrelation and compaction properties; and optimal quantizers. Subband filter banks: multirate sampling; decimation, interpolation, polyphase expansions; Mband filter banks for multichannel and multiresolution expansions; and alias-free and perfect reconstruction designs. Wavelets: time frequency localization, the short time Fourier and Gabor transforms; the orthonormal wavelet family; "Zoom-in" property; link to dyadic filter banks; and continuous and discrete wavelet transforms. *Prerequisites: graduate status and EL 713 or EL7134.*

EL 911-919 Selected Topics in Signal Processing 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.*

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. *Pre-/co-requisite: EE 3064 or equivalent. Also listed under ME 661.*

EL 525 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, canonic forms and minimax theorems for eigenvalues of hermitian pencils. *Prerequisites: MA 2012, MA 2132, MA 2112 and MA 2122. Also listed under MA 601.*

EL 621 System Theory and Feedback Control

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)*. *Prerequisites: graduate status and EE 3064.*

EL 623 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.* *Prerequisites: MA2012 or equivalent.*

EL 625 Linear Systems

2?:0:0:3

Basic system concepts. Equations describing continuous and discrete-time linear systems. Time domain analysis, state variables, transition matrix and impulse response. Transform methods. Time-variable systems. *Controllability, observability and stability.* *Prerequisites: graduate status and EE 3054. Also listed under ME 670.*

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; and the servo compensator problem.* *Prerequisites: graduate status and EL 625. Also listed under ME 671.*

EL 822 Applied Nonlinear Control

2½:0:0:3

Stability and stabilization for nonlinear systems: Lyapunov stability and functions, input-output stability, and control Lyapunov function. Differential geometric approaches for analysis and control of nonlinear systems: controllability, observability, feedback linearization, normal form, inverse systems, zero dynamics, stabilization, tracking, and disturbance attenuation. Output feedback designs. Various application examples for nonlinear systems including *robotic and communication systems.* *Prerequisites: graduate status, EE3064 and EL625. 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.* *Prerequisites: graduate status, EL 623 and EL 625. Also listed under 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 and EL 725 or instructor's permission. Also listed under ME 873.*

EL 921-929 Selected Topics in Control Engineering

each 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.*

TELECOMMUNICATIONS AND NETWORKING**EL 536 Principles of Communication Networks**

2½:0:0:3

An introductory course in data communications, computer communications and networking. Examples of networks. Data communications principles: transmission, digital and analog data and signaling and encoding. Data communication techniques: asynchronous and synchronous transmission, error detection, data link control and multiplexing. Circuit switching and packet switching, local and metropolitan area networks. TCP/IP and other high speed networks. Introduction to protocols, architecture, and Internetworking. *Prerequisites: MA 3012 or instructor's permission.*

EL 5364 Principles of Communication Networks (ePoly Online Course)

3:0:0:3.6

This course is equivalent to EL 536. It includes the same topics and requirements, with the addition of a project report on new networking technology.

EL 537 Internet Architecture and Protocols

2:3:0:3

This course introduces the student to some basic local area networking technologies and protocols in a set of lectures and laboratory experiments. Link level protocols. Local area networks: Ethernet, IEEE standards and protocols. The Internet protocol suite: IP, ARP, RARP, ICMP, UDP and TCP. LAN Interconnection: bridges, routers and gateways. Application protocols: SNMP, FTP, SMTP and NFS. *Prerequisites: graduate status and EL 536 or EE 136 or EL5364.*

EL 5374 Internet Architecture and Protocols (ePoly Online Course)

2:3:0:3.6

This course is equivalent to EL 537. It includes the same topics and require-

ments, with the addition of a report on an emerging Internet protocol or technology.

EL 630 Probability 2½:0:0:3

The axiomatic definition of experiment and probability. Conditional Probability. Bayes' Theorem, Notion of independence. Repeated trials. Bernoulli trials and their limiting forms. The concept of a random variable. Probability distribution and density functions. Probability mass functions. Examples of random variables: Normal (Gaussian), Poisson, Gamma, Exponential, Laplace, Cauchy, Rayleigh, etc. Bayes' Theorem revisited. Functions of one random variable and their density functions. Expected value of a random variable: Mean, Variance, Moments, Characteristic functions. Two random variables: Joint distribution and joint density functions of two random variables, Independence. One function of two random variables. Two functions of two random variables. Order statistics. Joint moments, Uncorrelatedness, Orthogonality, Joint characteristic function. Jointly Gaussian random variables. Conditional distribution and conditional expected values. The central limit theorem. The principle of maximum likelihood. Elements of parameter estimation. *Prerequisites: graduate status and MA 3012.*

EL 6304 Probability (ePoly Online Course) 3:0:0:3.6

This course is equivalent to EL 630. It includes the same topics and requirements, with the addition of the following subjects: Mean square estimations, System reliabilities and a project on System Parameter Estimation.

EL 631 Engineering Applications of Stochastic Processes 2½:0:0:3

Random Variables, Random vectors and Random processes; Second order characterization of stochastic processes, Autocorrelation and covariance functions, Special processes: Poisson process, Wiener process and White noise process. Stationary processes, Types of stationarity: Strict sense stationary and Wide sense stationary processes, Gaussian processes, Memoryless processes. Linear Systems with random inputs, Input-output Autocorrelation relations, Input-output Stationarity properties. Ergodicity and related results. Wide sense stationary processes, Autocorrelation function and

power spectra. Spectral theory for linear systems. Rational spectra, Hilbert transforms, shot noise, thermal noise. Discrete time processes, Spectral factorization, Matched filters. Integral equations and representation of stochastic processes: Karhunen Loeve (KL) expansion. Modulation, Band limited processes and sampling theory. Mean square estimation and the orthogonality principle. Linear Prediction and its Geometric interpretation. Mean square estimation and normality. Smoothing and prediction as applications of orthogonality principle. *Prerequisites: graduate status and EL 630 or EL 6304.*

EL 633 Detection and Estimation Theory 2½:0:0:3

Detection Theory: Binary Hypothesis Testing: Bayes' Criteria; Likelihood Ratio Test; Neyman-Pearson Tests; mini-max test; Receiver Operating Characteristics. Parameter Estimation Theory: Random parameter Estimation. Bayes' Procedure; Minimum Mean Square Error (MMSE) Estimator, Maximum A-Posteriori (MAP) Estimator. Nonrandom Parameter Estimation; MAP Estimator; Unbiased Estimators and Cramer-Rao (C-R) Bound; Higher Order Bounds. Uniformly Minimum Variance Unbiased Estimators (UMVUE); Sufficient Statistic; Rao-Blackwell Theorem. Multiple Parameter Estimation; Fisher Information Matrix. Composite Hypothesis Testing; Series Representation of Stochastic Processes with Rational spectra; Detection of distinct signals in white noise and colored noise; M-ary Detection and Estimation of signals in white noise and colored noise. *Prerequisites: graduate status and EL 630 or EL6304.*

EL 637 Local and Metropolitan Area Networks 2½:0:0:3

Introduction. Local Area Networks: CSMA/CD, Token Ring, wireless LANS: IEEE Standards, protocols and performance analysis. LAN interconnection: Bridges, Routers, Gateways. Metropolitan Area Networks, wireless ad hoc and personal area networks, DQDB: Standards and performance analysis. Higher Level Protocols used in LAN/MANs; LAN/MAN management, LAN/MAN interconnection: Emerging standards and protocols. Other current topics. *Prerequisites: graduate status and EL 536 or EE 136 or EL 5364.*

EL 638 High-Speed Networks 2½:0:0:3

This course addresses the basics, protocols, architectures, and technologies for high-speed networks. Topics to be included are: synchronous optical network (SONET), asynchronous transfer mode (ATM), ATM adaptation layer (AAL), Ethernet and Ethernet over SONET, quality of service control, admission control, traffic access control, flow and congestion control, integrated service (Intserv), differentiated service (Diffserv), resource reservation protocol (RSVP), constraint based routing, multiple protocol label switching (MPLS), and generalized MPLS (GMPLS). *Prerequisites: graduate status and EL 536 or equivalent.*

EL 658 Fiber Optic Communications

2½:0:0:3
See course listings under Electro-Optics, Quantum Electronics and Materials Science.

EL 735 Communication Networks I: Analysis, Modeling and Performance

2½:0:0:3
Analysis, modeling and performance of centralized and distributed data communication networks. Modeling of user traffic, communications link and processors. Queueing analysis. Packet-switched networks. Time delay analysis of networks. Capacity assignment. Concentration, multiplexing, polling and buffer analysis. Multiple access for broadcast networks-satellites, ALOHA, wireless, local area networks. Other applications: switch performance, video traffic modeling. *Prerequisites: graduate status, EL 630 or EL 6304 and EL 536 or equivalent.*

EL 736 Communications Networks II: Design and Algorithms

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, distributed network design, case studies. *Prerequisites: graduate status, EL 536 or equivalent and knowledge of data structures.*

EL 737 High-Performance Switches and Routers

2½:0:0:3
This course addresses the basics, the the-

ory, architectures, and technologies to implement high-performance high-speed large-scale routers and switches. The fundamental concepts and technologies of packet forwarding, classification, and switching learned in the class are useful and practical when designing IP routers, Ethernet switches, and optical switches. Topics to be included are: IP Route Lookup, Packet Classification, Packet Scheduling, Buffer Management, Basics of Packet Switching, Output-buffered Switches, Shared-memory Switches, Crosspoint-buffered Switches, Input-buffered Switches, Clos-network Switches, Multi-Stage Buffered Switches, Two-Stage Load-Balanced Switches, Optical Packet Switches, and ASIC for IP Routers. *Prerequisites: graduate status and EL 536 or equivalent.*

EL 930 Wireless Information Systems Lab 2?:0:0:3

This course will include hands-on experience including a combination of laboratory experiments, lectures and projects relating to spread spectrum code division multiple access (CDMA) wireless communication systems. Among the specific topics addressed include pseudo-noise codes, transmitters and receivers for direct sequence and frequency hopping systems, acquisition and tracking, CDMA wireless computer communications, UHF channel propagation characteristics including multipath time delay profiles and attenuation measurements, bit error rate measurements, phase locked loops and spectrum sharing with existing narrowband users. *Prerequisite: EE 3404 or equivalent.*

EL 931-939 Selected Topics in Telecommunications and Networking From Information Science each 2?: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.*

COMPUTER ELECTRONIC DEVICES AND SYSTEMS

EL 546 Introduction to RF/Microwave Integrated Circuits 2?:0:0:3

Introduction to microwave/RF components and integrated circuits, and the concept of noise in microwave circuits. Review of transmission lines. It follows

with the stability study and impedance match of a two port active network. The Smith chart, used for impedance match and stability analysis, and signal flow graph method, for network analysis, will be reviewed. These studies provide basis for the design of microwave amplifiers and oscillators, which will be exemplified and applied to microwave circuits. Practical microwave systems are discussed. *Prerequisite: EL 3604.*

EL 547 Introduction to VLSI Design 2?:0:0:3

This course will cover the following subjects: MOS transistor theory; CMOS-BiCMOS logic; CMOS processing technology; latchup; circuit characterization and performance estimation; static/dynamic circuit and logic design techniques; mixed (analog/digital) design, standard cells and gate arrays; clocking strategies; input/output structures; datapath, memory and control logic design. Advanced VLSI CAD tools will be used for layout; timing, functional and mixed mode simulations. *Prerequisites: senior or graduate status, CS 2204 and EE 3114.*

EL 548 Real Time Embedded Systems 2?:0:0:3

This course is designed to provide students with an overview of the unique concepts and techniques needed to design and implement computer systems having real-time response requirements in an embedded environment. It will contrast the concepts and techniques of real time and embedded systems with those of more traditional computer systems. Topics include: Basic concepts of real time and embedded systems, hardware features, programming languages, real time operating systems, synchronization techniques, performance optimization, and current trends in real time and embedded systems such as incorporating internet connectivity. *Prerequisites: Knowledge of "C", Pascal or other programming language and a basic understanding of computer architecture.*

EL 549 Advanced Computer Hardware Design 2:3:0:3cd

The use of hardware description language VHDL for computer hardware modeling, logic synthesis, register-level synthesis and simulation. The resulting design with hundreds or thousands of gates is then

ready to be downloaded to form FPGA chips or silicon cells. We plan to use programs such as QuickVHDL, modeling and simulation tools from Mentor Graphics or similar large-scale programs. Students will use X-terminals in the UNIX Lab and workstations in the VLSI lab for approximately four hours per week. A design project is required, and students will make a written and oral presentation. *Prerequisites: CS 1124, CS 2214 and EE 2024.*

EL 641 Analog and High Frequency Amplifier Design 2?: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 multistage broadband small-signal amplifiers, operational amplifiers, discrete and analog integrated circuits. *Prerequisites: graduate status, EE 3114 and EE 3124.*

EL 642 RF Electronics for Wireless Applications 2?: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 and EL 641 or equivalent.*

EL 643 Digital Integrated Circuit Design 2?: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. *Prerequisites: graduate status and EL 641 or equivalent.*

EL 644 VLSI System and Architecture Design 2:2:0:3

A continuation of EL 547, and covers top-down design using VHDL: structural design, modeling, algorithmic and register level design, synthesis; FPGAs; case studies; design for testing. This course provides students with a solid background and hands-on experiences on full-custom VLSI chip design using CMOS technologies. Several design examples of prototyped VLSI chips in high-speed net-

working are described in the class. Each student or each group (with two students per group) needs to submit a project proposal at the beginning of the semester that outlines the project objective, system and chip architectures, specification of the chip, and approaches and schedule to complete the project. The project includes the design and simulation of a VLSI lab: partitioning, placement and routing, automated synthesis and standard cells. Chips that are designed completely will be sent to foundry for fabrication. Students are supposed to finish and present the project at the end of the semester. The grade will depend on the completion and the presentation of the project. *Prerequisite: EL 547 or instructor's permission.*

EL 645 VHDL-Based Behavioral Synthesis *2½:0:0:3*

The outline of this course is as follows: Behavioral VHDL Descriptions; Synthesizable VHDL subset; Design Representation at the behavioral level (control data flow graphs); Operation scheduling algorithms; Module allocation; Register allocation; Interconnect binding; Controller synthesis; Arithmetic and control data flow graph transformations; Synthesis approaches for high performance (pipelining and retiming), low power, testability and fault tolerance. In this course, students write behavioral VHDL models and use behavioral compiler scripts (an industrial standard behavioral synthesis system) to understand the various synthesis algorithms. The course has a significant project component. *Prerequisite: CS 2204. Co-requisite: EL 549.*

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, interconnection and packaging to final tests. Study of impact and process on design rules. *Prerequisites: graduate status and EE 3124. Also listed under MT 709.*

EL649 Digital VLSI Systems Testing *2½:0:0:3*

This course discusses the following topics: Fault Modeling, Logic Simulation, Fault Simulation, Testing for stuck-at and bridging faults, functional testing, design for testability, Built-in self test. *Prerequisite: CS 2204, EL 547 or CS 580*

EL 941-949 Selected Topics in Computer Electronic Devices and Systems *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 and optical detection. *EL 551 prerequisite: graduate status and EE 164 or equivalent. EL 552 prerequisites: graduate status and EL 551.*

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 phenomena. Treatment of fluctuation and transport phenomena. Density matrix formalism of quantum statistical mechanics. Many-body problems. *Prerequisites:*

graduate status and 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 ultrashort pulse generation. Non-linear optics: Harmonic generation, parametric interactions Raman and Brillouin nonlinearities. Fundamental noise properties of laser oscillators. *EL 653 prerequisite: graduate status. 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 Schroedinger'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*

Introduction to the basic principle of Fiber Optic Communications Systems. Description of the system components including optical fiber, light source, and photodetector, as well as of the Integrated Optic Components and Optoelectronic Integrated Optics (OEICs). Discussion on the bandwidth of the Communications Systems. Wavelength-Division Multiplexing Basics and Modulation Formats. System design principle and examples illustrating the analog and digital system design. *Prerequisite: graduate status.*

EL 951-959 Selected Topics in Electro-Optics, Quantum Electronics and Materials Science *each 2½:0:0:3*

Topics of current interest dealing with the interaction of matter with electromagnetic fields. (See department mailing for detailed description of each particular offering.) *Prerequisite: specified when offered.*

POWER ENGINEERING**EL 561 Introduction to Electric Power Systems** 2½:0:0:3

Single and three-phase circuit calculations; transmission lines parameters: resistance, inductance, capacitance; transformers; and generators; lumped-component pi-equivalent circuit representation; per-unit normalization; symmetrical phase components; power-flow analysis. *Prerequisite: EE 2024 or equivalent.*

EL 567 Electronic Power Supplies

2½:0:0:3

Review of power relationships. Power semiconductor switching devices. Rectifiers. Basic PWM dc-dc switching cells. Nonisolated and isolated PWM dc-dc converters. Control of PWM converters. Resonant and soft-switching converters. PWM inverters. Applications to computer equipment, distributed power systems, uninterruptible power supplies, and electric drives. Power quality and EMI issues. American and international standards. *Prerequisite: EE 3824 or equivalent.*

EL 568 Electric Drives 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. *Prerequisites: EE 3824 or equivalent.*

EL 660 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 and commutation. Power inverters. *Prerequisites: graduate status and EE3824 or equivalent.*

EL 662 Power Systems Economics and 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. *Prerequisites: graduate status and EL 561 or equivalent.*

EL 663 Transients, Surges and Faults 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 integrated systems. *Prerequisites: graduate status and EL 561 or equivalent.*

EL 664 Relay Fault Protection 2½:0:0:3

Protective relay functions and classification. Electromechanical relay types, operating principles and basic characteristics. Communication channels for relaying. Current and voltage transformers, transducers. Protection of 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. *Prerequisites: graduate status and EL561 or equivalent.*

EL 665 Power System Stability 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 3064 and EL 561 or equivalent.*

EL 666 Distributed Generation Systems 2½:0:0:3

Benefits and limitations; classification of small generating systems; principles of operation and electrical equivalent circuits of fuel cells, solar cells, micro-turbines, reciprocating engines, wind turbines and gas turbines; fault conditions; reactive power support; power quality issues. *Prerequisites: EE 3824 and EL 561 or equivalent.*

EL 961-969 Selected Topics in Power Engineering each 2½:0:0:3

Topics of current interest in electric power engineering. (See departmental mailing for detailed description of each particular offering.) *Prerequisite: specified when offered.*

ELECTRODYNAMICS, WAVE PHENOMENA AND PLASMAS**EL 573 RF and Microwave Systems Engineering** 2½:0:0:3

Review of EM theory and transmission lines. Printed transmission lines. S, Z, Y, ABCD parameters, network theory, signal flow graphs, CAD methods. Excitation of waveguides. Single and multisection impedance transformer, power divider, directional coupler, hybrid circuits. Microwave resonator: series, parallel resonators, stubs and cavities. Filter theory and designs, coupled-line filters, Kuroda identities, Chebychev and maximally flat filters. *Prerequisite: EL 3604.*

EL 575 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. Plasmas for practical applications. *Prerequisites: EE 3604.*

EL 671 Electromagnetic Theory and Applications 2½:0:0:3

Course introduces Maxwell's equations, which underlie electromagnetic wave propagation. The properties of freely propagating plane waves are derived, as well as waves guided by structures, including various two-wire transmission lines, hollow waveguides, and dielectric waveguides. A unified treatment of wave propagation is given in terms of the transmission line representation with examples drawn from microwaves, integrated circuits and optics. *Prerequisites: graduate status and EE 3604.*

ELECTRICAL ENGINEERING PROGRAM

EL 672 Electromagnetic Radiation and Antennas 2½:0:0:3

The electromagnetic fields radiated by current elements are derived from Maxwell's equations. From these results, the fields radiated by many types of antennas are derived, including various types of dipoles, arrays, aperture, frequency independent, and traveling wave antennas. Concepts such as radiation resistance and pattern, directivity, gain, effective area, reciprocity are discussed. *Prerequisites: graduate status and EL 671, or EL 3604 with grade B or better.*

EL 675 UHF Propagation for Wireless Systems 2½:0:0:3

UHF radio applications for cellular mobile radio telephones, wireless local area networks and personal communications networks. Propagation characteristics of UHF radio signals over a flat earth, buildings in cities and within buildings: basic physical principles underlying propagation and diffraction; signal behavior; theoretical models for predicting propagation characteristics; Huygens' principle; Fresnel zone and diffraction theory; and mathematical models of propagation. *Prerequisites: graduate status and undergraduate electromagnetics course.*

EL 970 Microwave Engineering Laboratory/Project 1:4:0:3

Design, fabrication, testing of passive circuits (couplers and filters), active circuits (amplifier and oscillator) and antennas using printed circuits. Design and simulation using microwave CAD tools (Supercompact, Touchstone, Puff, PCAAMT), HP-8510 automated network analyzer measurement, frequency and time-domain measurements, antenna pattern measurement, printed circuit layout and photoetching. *Prerequisite: EE 3604. Co-requisite: EL 545 or EL 571.*

EL 971-979 Selected Topics in Electrodynamics, Wave Phenomena and Plasmas each 2½:0:0:3

Aspects of plasmas, electromagnetic and acoustic wave propagation, diffraction and radiation of current interest, including wave interactions with plasmas, materials and special mathematical and numerical techniques. (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. (Contact the Department of Electrical and Computer Engineering for detailed description of each particular offering.) *Prerequisite: specified when offered.*

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. *Prerequisite: degree status.*

EL 992 Summer Graduate Internship each 1 unit

This course provides graduate students majoring in electrical engineering, computer engineering, electrophysics, systems engineering, wireless innovation or telecommunication networks the opportunity to gain practical training off campus. Such training will enhance and strengthen the students overall educational experience by obtaining practical experience in currently active areas in industry. Adviser approval is required. *Prerequisite: graduate status and more than one semester of course work with the ECE.*

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 fields, generally consists 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 999 Dissertation for Degree of Doctor of Philosophy in Electrical Engineering each 3 units

Original investigation of electrical engineering problem. Must demonstrate creativity and include features of originality and utility worthy of publication in recognized journal. Candidate must successfully defend dissertation orally. Registration of 24 units required (continuous dissertation required). *Prerequisite: passing qualifying examination. Registration beyond 12 units requires passing of area examination.*

ePOLY ONLINE COURSES

An increasing number of Polytechnic's graduate courses in electrical and computer engineering are available online for convenient study. These courses are designated with a 4-digit course number, the first three digits indicating the classroom equivalent and the 4th digit being "4". While online courses are considered equivalent to classroom counterparts in terms of similar topics and requirements, online courses introduce supplementary topics or projects which require additional class time and study.

Polytechnic offers the following electrical engineering courses online:

EL 5364	Principles of Communication Networks
EL 5374	Protocols for Local Area Networks
EL 6014	Principals of Digital Communications: Modulation & Coding
EL 6024	Modulation & Coding
EL 6034	Modern Wireless Communication Techniques & Systems
EL 6114	Signals Systems & Transforms
EL 6304	Probability Theory
EL 6374	Local & Metropolitan Area Networks
EL 6384	High-speed Networks
EL 7134	Digital Signal Processing
EL 7354	Communication Networks I

Typical Course of Study for the Bachelor of Science in Electrical Engineering

FRESHMAN YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EG 1004	Intro. Engineering & Design	1	3	2	4	
CS 1114	Intro. Prog. & Problem Solving ¹	3	3	0	4	
MA 1024	Calculus I	4	0	0	4	
EN 1014	Writing & Humanities I ³	4	0	0	4	
SL 1010	Freshman Seminar	1	1	0	0	
					16	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
PH 1004	Introductory Physics I	4	1½	1	4	
CS 1124	Object-Oriented Programming	3	3	0	4	
MA 1124	Calculus II	4	0	0	4	
EN 1204	Writing & Humanities II	4	0	0	4	
					16	

SOPHOMORE YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
PH 2004	Introductory Physics II	4	1½	1	4	
EE 2013	Fundamentals of Electric Circuits I ¹	3	0	1	3	
MA 2012	Linear Algebra I (½ semester)	4	0	0	2	
MA 2132	Ordinary Diff. Equ. (½ semester)	4	0	0	2	
HI 2104	Modern World History	4	0	0	4	
					15	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
CM 1004	General Chemistry	3	2	1	4	
CS 2204	Dig Logic & State Mach Design ¹	3	3	0	4	
MA 2112	Multi. Calculus A (½ semester)	4	0	0	2	
MA 2122	Multi. Calculus B (½ semester)	4	0	0	2	
EE 2024	Fundamentals of Electric Circuits II ¹	3	1	1	4	
					16	

JUNIOR YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 3114	Electronics I ³	½	1½	1	4	
EE 3054	Signals & Systems I	3½	1½	1	4	
MA 3112	Complex Variables I (½ semester)	4	0	0	2	
MA 3012	Intro. Probability I (½ semester)	4	0	0	2	
	HU/SS Elective ⁴	4	0	0	4	
					16	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 3604	Electromagnetic Waves	3½	1½	1	4	
	EE Restricted Elective ⁵	3½	1½	1	4	
	EE Restricted Elective ⁵	3½	1½	1	4	
	Sequence Elective I ⁶				4	
					16	

SENIOR YEAR

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 4XX3	Design Project I ⁷	1	3	1	3	
	EE/EL Elective ⁸				3	
	EE/EL Elective ⁸				3	
	HU/SS Elective ⁴	4	0	0	4	
	Sequence Elective II ⁶				4	
					17	

		Hours/Week				
Course No.	Course Title	Class	Lab.	Rec.	Cr.	
EE 4223	Design Project II	0	6	1	3	
	EE/CS/EL Elective ⁸				3	
	EE/CS/EL Elective ⁸				3	
	EE/EL Elective ⁸				3	
	HU/SS Elective ⁴	4	0	0	4	
					16	

Total credits required for graduation: 128

- Grade of C- or better is required.
- Students who are placed by examination or by an adviser into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1024.
- Students who are placed by examination or by an adviser into EN 1080 must subsequently register for EN 1034, rather than EN 1014.
- Choice of HU and SS electives must conform to the established requirements of the HU/SS Dept.
- Restricted Electives must be chosen from the following: EE 3124, EE

3404, EE 3824 and EE 3064.

- A list of approved Sequence Electives is available from the department.
- One first semester Design Project course is selected from the following areas: wireless communication, electrical power and control and robotics.
- Elective courses must include at least one two-semester sequence (beginning and advanced courses) in an approved subject area. The first course may be a Restricted Elective. Any Restricted Elective may be used as an EE Major Elective course. One or two major elective courses may be a CS course.

ELECTROPHYSICS PROGRAM

Program Director: Dariusz Czarkowski

Polytechnic offers a program of study leading to the degree Master of Science in Electrophysics. Students entering the program typically have an undergraduate background in electrical engineering or physics, a strong interest in physical phenomena and/or applied mathematics and a desire to participate in research.

The Department of Electrical and Computer Engineering administers the Electrophysics Program.

The program comprises basic courses in wave propagation, electromagnetic theory and electro-optics. Traditional areas of active research covered include propagation modeling for wireless communications, propagation and scattering of waves, antennas, microwave networks, plasmas and solid-state devices. Areas of modern optics covered include lasers and optical communications. Additional areas covered are nonlinear wave propagation, ultrasonic waves in solids and waves in the earth's ionosphere. Polytechnic's electrophysics faculty has made significant contributions to each of the areas cited above. Students in the program are exposed to some of the most current technical developments in each area and can be guided in research at the forefront of these areas. Students wishing to continue graduate study toward a PhD in the area of electrophysics may do so in the Electrical Engineering Program.

GOALS AND OBJECTIVES

The Master of Science program in Electrophysics 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, electro-optics and plasmas. For students entering the program with an undergraduate degree in physics, the program provides a view of engineering applications and requirement, as well as an advanced view of the physical processes of interest. Students who are interested in furthering their understanding of these topics may do so by continuing in the PhD program in Electrical Engineering.

Students entering the MS program in Electrophysics gain a deep understanding of the basic physical principles in one or more of the following areas: (a) electromagnetic wave propagation, (b) microwave devices and networks and (c) lasers and electro-optics for communications.

Students learn the engineering applications and performance measures of the physical principles in the different areas and are able to apply their knowledge to device and system design problems.

For those interested in PhD-level studies, the MS in Electrophysics prepares them for independent research that advances the knowledge of engineering applications of physical principles.

REQUIREMENTS FOR THE MASTER OF SCIENCE

The entrance requirements for a 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 remedy 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 an MS in Electrophysics, students must complete a total of 36 units of courses, as described below, and retain a B grade in all graduate courses. In addition, a B average is required in specific groups of courses, as indicated below.

GROUP 1: Core Courses

Three courses from among the following:

EL 551	Electro-Optics I
EL 575	Introduction to Plasma Engineering
EL 611	Signals, Systems and Transforms
EL 651	Statistical Mechanics I
EL 653	Quantum Electronics I
EL 671	Fields and Waves

9 Units

GROUP 2: Two one-year sequences, which may include the above courses. Both of these one-year sequences must be in electrical engineering or physics courses, and at least one must be an EL sequence.

6-12 Units

GROUP 3: Approved electives

15-21 Units

Minimum 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 an EL prefix.

An overall B average is required in the combination of five to seven courses offered to satisfy groups 1 and 2 above.

Students should consult the Department of Electrical and Computer Engineering's Graduate Student Manual (www.ece.poly.edu) for more detailed rules and procedures, including student status, transfer credits, recommended electives, one-year sequences, current areas of research and disqualification for low grades. Descriptions of graduate electrical engineering courses used in the Electrophysics Program are located in the Electrical Engineering Program section of this catalog.

GRADUATE COURSE

EP 997 Thesis for Degree of Master of Science in Electrophysics *each 3 units*

Independent research project demonstrating professional maturity, performed under guidance of an adviser. An oral thesis defense and formal bound thesis volume are required. Registration of 9 units required (continuous thesis registration is required). *Prerequisite: degree status.*

ENVIRONMENT-BEHAVIOR STUDIES PROGRAM

Academic Adviser: Richard E. Wener

The department of Humanities and Social Sciences offers a Master of Science degree (36 units) and a Certificate in Environment–Behavior Studies (15 units).

This field applies the methods and knowledge of the behavioral sciences to understand the relationship between people and the built or natural environment. This program is aimed at training students to be capable of addressing socio-technical problems in a variety of research and applied settings. Students with training and expertise in design, technical or scientific areas are encouraged to apply.

GOALS AND OBJECTIVES

Specific objectives of the Master of Science program in Environment–Behavior Studies are to accomplish the following:

- Provide academic courses for the life-long learning of design and planning professionals
- Offer specialized training in human needs for design and planning professionals
- Develop a unique approach to the field through interdisciplinary synergy with other Polytechnic programs (e.g., Transportation Planning, Software Design and Organizational Management)

REQUIREMENTS FOR THE MASTER OF SCIENCE

A total of 36 units is required for the master's degree. Normally, students start by taking introductory courses (600 and 601) and then proceed to more advanced courses and seminars. Students are encouraged to take 9 units of work in related fields outside the program. To qualify for a degree, students may elect to write either a comprehensive examination or a thesis embodying appropriate and substantive research. If students choose the former, examinations may be taken in the term in which courses are completed. Students choosing the thesis

may apply up to 12 units of thesis course work toward requirements for the degree. Acceptance of a thesis involves an oral presentation and defense.

Core Courses (15 units)

PS 908	Experimental Psychology I
PS 909	Experimental Psychology II
PS 920	Seminar in Psychology
PS 926	Environmental Psychology
MG 505	Probability and Managerial Statistics

Thesis (up to 6 units):

SS 997	Master's Thesis (can be repeated once)
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Electives (15 Units):

Students may take up to three graduate psychology elective courses and two from any department, chosen in consultation with their adviser.

REQUIREMENTS FOR ADVANCED CERTIFICATE

Students may take a five-course sequence for a Certificate in Environment–Behavior Studies. The program is available as a minor for students in other programs or for students applying directly for the certificate.

ADMISSION CRITERIA

Students are required to have a bachelor's degree from an accredited institution. An introductory course in computer science or equivalent demonstrated knowledge is also a prerequisite for admission to the program. Preference will be given to those with a minimum of three years of experience in a professional or managerial position related to software development, or with a background in industry-based behavioral research.

All students will be required to submit the following: (1) a formal application for admission to the program; (2) two letters of recommendation, one from a current or recent employer and one from a person acquainted with the student's performance in an academic setting; and (3) an official transcript of undergraduate work and any graduate work.

COURSES

PS 905 Psychology: Applied 2½:0:0:3

This course demonstrates how various problems, particularly in work, can be solved through the judicious use of psychological principles. Phenomena addressed include human-machine interaction and other engineering-behavior interactions, smoking, study habits, memory, creative thinking, group interaction, raising children, influencing people, self-control and specific problems brought up in class by students. Students learn to employ the method of behavioral analysis in gaining an understanding of various problems. They select a problem, do a behavioral analysis and, finally, modify it as a class project. Prerequisite: PS 2104.

PS 906 Human Cognition and Information Processing 2½:0:0:3

Human cognitive capabilities including natural language and information processing. Memory, internal representation of knowledge, concept information, symbol manipulation, language acquisition, reasoning and problem solving. Artificial intelligence approaches to natural language learning and acquisition of cognitive skills. Prerequisite: PS 2104.

PS 907 Human-Computer Interaction 2½:3:0:3

This course introduces students to human behavioral issues in the design and use of interfaces for information systems. Basic issues of behavioral research and evaluation methods are discussed. Sensory systems and memory and learning theory relevant to human factors systems are reviewed and related to specific interface issues, such as interaction devices, dialogue design and reference material. The focus is on understanding the issues involved in creating systems amenable to human use. Prerequisite: SPS 2104 or equivalent.

PS 908 Experimental Psychology I
2½:3:0:3

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 perform a series of experiments with human and animal subjects. Prerequisite: PS 2104.

PS 909 Experimental Psychology II
2½:3:0:3

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. Prerequisite: PS 2104.

PS 910 Theories of Learning *2½:0:0:3*

Programmed learning, behavior therapy, attitude function and social interaction. All students are required to perform one experiment on learning under guidance of instructor. Available to undergraduate majors in social science. Prerequisite: PS 2104 or equivalent.

PS 911 Psychology of Language and Communication
2½:0:0:3

Methodological problems in analysis of language, verbal behavior in animals, anatomical and physiological aspects of speech apparatus, operant and respondent conditioning of verbal behavior, semantics, statistical approaches and mathematical models, contextual factors and pathology of speech. All students are required to perform one experiment under guidance of instructor. Available to undergraduate majors in social science. Prerequisite: PS 2104 or equivalent.

PS 912 Sensation and Perception
2½:0:0:3

Review of different sensory systems: vision, audition, taste, smell, touch, temperature sensitivity, vestibular and kinesthetic senses and their relations to non-sensory controlling stimuli such as states of the organism, learning and social psychological variables. Techniques for obtaining psychophysical data on each sensory system and relations of these techniques to theories of discrimination. Available to undergraduate majors in social science. Prerequisite: PS 2104 or equivalent or instructor's permission.

PS 913 Physiological Psychology
2½:0:0:3

Physiological and anatomical bases of behavior. Memory, motivation, emotion, sleep reward mechanisms, psychosurgery and higher cortical functions. Prerequisite: PS 2104.

PS 915 Behavioral and Societal Aspects of Transportation *2½:0:0:3*

Behavioral analyses of transportation decision-making and travel characteristics. User needs in design of transportation systems: crowding, social isolation, crime, comfort and convenience. Social impacts of transport systems on communities. Prerequisite: undergraduate introductory psychology or equivalent.

PS 920 Proseminar in Psychology
2½:0:0:3

Major areas of psychology required of all MS candidates. History and systems, sensation and perception, learning, developmental and abnormal.

PS 925 Social Impact Assessment
2½:0:0:3

How physical changes in urban or rural settings affect social systems and group and individual behavior. Measuring quality of life and social responses to technology; uses of alternative futures paradigms. Students do an analysis of a problem in social impact and report finding to class.

PS 926 Environmental Psychology
2½:0:0:3

Critical issues in person-environment relations, including privacy, crowding and environmental design. Work includes a term paper and a major research project, emphasizing applications of psychological research methods to practical design problems or specific environmental issues.

PS 928 Advanced Topics in Environmental Psychology *2½:0:0:3*

This course varies from year to year depending on the needs and interests of students and instructors. Potential subjects include social impacts of transportation systems; stress and the environment; aversive environmental factors; laboratory assessment of environmental effects on animal learning; effects of pollution; human factors of software design; assessing the built environment including the office; and applied behavioral analysis.

PS 997 Thesis for Degree of Master of Science
up to 6 units

Independent research project demonstrating scientific competence performed under the guidance of advisers.

ENVIRONMENTAL ENGINEERING AND SCIENCE PROGRAM

Academic Adviser: Alan Molof

The Department of Civil Engineering offers graduate programs in environmental engineering and environmental science leading to the following degrees with environmental designation:

- Master of Science in Environmental Engineering
- Master of Science in Environmental Science

The department also offers the following graduate programs with environmental engineering majors, but with civil engineering designation:

Master of Science in Civil Engineering
Doctor of Philosophy in Civil Engineering

Programs with environmental engineering and environmental science designations are described below. Programs with civil engineering designations are described in the Civil Engineering Program section of this catalog.

Master of Science programs are practice-oriented with a strong foundation in underlying principles and methods. The PhD is intended for students with a strong research interest and a desire to advance the state-of-the-art as a result of that research.

Environmental science and environmental engineering are multidimensional professions dealing with preserving, protecting and remedying air, water and soil environments. The programs' emphasis is on preparing graduates to be immediately employed to meet the challenges of next century or to proceed directly to advanced graduate studies.

ADMISSION REQUIREMENTS

Applicants for the Master of Science in Environmental Engineering should hold an undergraduate or graduate degree in environmental or civil engineering or equivalent from an acceptable institution. Students may be accepted with other appropriate backgrounds, but should, as a

minimum, have one year of chemistry and physics, and basic courses in calculus and differential equations. Such students may be asked to take up to 15 credits of undergraduate courses to complete their preparation.

Applicants for the Master of Science in Environmental Science typically have undergraduate or graduate degrees in the physical or biological sciences. Undergraduate courses may be recommended or required by the adviser to make up for deficiencies in academic preparation.

Admission to the PhD program requires a suitable MS degree from an acceptable institution. A minimum GPA of 3.5 in master's level work is generally required for admission into the PhD program. For more information concerning the PhD in Civil Engineering, consult the "Civil Engineering" program section of this catalog.

GRADE REQUIREMENTS

To earn graduate degrees or certificates, Polytechnic requires that students have a 3.0 GPA 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 this average.

ANALYTIC BACKGROUND

All applicants for MS or graduate certificate programs in environmental programs must show evidence of quantitative analytic ability, generally including a minimum of two years of college mathematics and a college-level course in statistics.

PhD applicants are expected to have superior quantitative analytic background. In addition, they must take at least one course in graduate level statistics, regression analysis or design of experiments as part of their studies.

ADVISING

Each student in the graduate program is assigned a faculty adviser. It is important that students maintain frequent contact with their adviser throughout the course

of their studies.

Students must meet with their academic adviser prior to each registration and at any other time they need advise or consultation. Students must have a detailed program of study formally approved by the adviser prior to registration. Advisers also handle requests for waiver of certain degree requirements where warranted. Such waivers must be approved in writing and must be entered into the student's departmental file. Where specific courses are waived, permission of the course instructor is also required. When 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, projects, theses, dissertation) are assigned project advisers for each such activity. The project adviser may or may not be the same as the student's academic adviser, depending upon the subject matter selected. To register for any guided study activity, students must submit written proposals for the topic(s) to be covered to an appropriate project adviser before registration. To register, students must obtain the written approval of the project adviser and the academic adviser.

Doctoral students may not register for dissertation credits until they have passed the PhD qualifying examination.

In addition to academic and project advisers, students studying under research or teaching fellowships are assigned fellowship advisers. Normally, these would be either the principal investigator of the research effort funding the fellowship or the director of the academic area in which the teaching fellowship is awarded.

While academic advisers consult and give advice to students, it is the student's responsibility to ensure that all degree requirements are fulfilled, and to submit all proper forms and application when necessary.

TRANSFER CREDITS

The minimum number of units students must take at Polytechnic to be awarded a graduate Polytechnic degree is 27 for an MS degree. All units for a graduate certificate must be taken at Polytechnic.

Students may transfer up to 9 units of acceptable courses toward an MS degree, subject to the approval of the academic adviser. To be transferred, the course(s) must be relevant to the program and from an acceptable institution. A grade of B or better is required for granting of transfer credit. Courses graded on a pass/fail basis are not considered for transfer unless accompanied by a detailed written evaluation by the instructor of the course. All transfer requests must be accompanied by an official transcript from the transferring institution. Applications for transfer credits are accepted only after student have earned 12 units at Polytechnic.

MASTER OF SCIENCE IN ENVIRONMENTAL ENGINEERING

GOALS AND OBJECTIVES

The primary goal of the MS in Environmental Engineering is to prepare professionals to plan, functionally design, control, operate and manage municipal and industrial systems of pollution prevention. Specific objectives of the program are to provide the skills necessary to:

- Fundamentally understand the science and engineering of natural and man-made environmental systems
- Functionally design air, water and waste treatment systems and components
- Control and operate environmental facilities
- Understand the modeling and simulation of environmental systems
- Actively participate in a multidisciplinary teams to solve environmental problems

Students are exposed to a learning atmosphere that provides a meaningful mix of theoretical and practical approaches. Courses include a mix of presentations, project exercises and practical problem solutions.

PROGRAM REQUIREMENTS

Course No	Course Title	Units
CE 996*	Project for the Master of Science or	3
CE 997*	Master's Thesis and	6
CE 723	Ground Water Hydrology	3
CE 737	Environmental Chemistry & Microbiology I	3
CE 739	Environmental Chemistry & Microbiology II	3
CE 742	Water & Wastewater Treatment I	3
CE 743	Water & Wastewater Treatment II	3
CE 747	Analysis of Stream & Estuary Pollution	3
CE 770	Solid Waste Management	3
	9 or 12 units of approved electives**	9/12
Total		36 Units

**Students may opt for a thesis option instead of the project option*

***All electives are subject to adviser approval*

MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

GOALS AND OBJECTIVES

The primary goal of the MS in Environmental Science is to prepare professionals to:

- Fundamentally understand the science and applied engineering of natural and man-made environmental systems
- Evaluate the interactions between man and the environment
- Control adverse impacts of pollution on ecological systems
- Understand the monitoring and laboratory analysis of the environmental systems

Actively participate in a multidisciplinary team of professionals to solve environmental problems

PROGRAM REQUIREMENTS

Course No	Course Title	Units
CE 996*	Project for the Master of Science or	3
CE 997*	Thesis for the Master of Science and	6
CE 737	Environmental Chemistry & Microbiology I	3
CE 739	Environmental Chemistry & Microbiology 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
	9 or 12 units of approved elective courses*	9/12
Total		36 Units

**Students may opt for a thesis option instead of the project option*

***All electives are subject to adviser approval*

GRADUATE CERTIFICATE IN HAZARDOUS WASTE MANAGEMENT

The certificate program is designed to provide practicing engineers and environmental professionals with current engineering practices and management techniques, and to provide the framework to understand and interpret environmental law applicable to hazardous waste management. Students must take two core courses and three elective courses to complete the certificate requirements.

Core Courses

CE 753	Hazardous/Toxic Waste Management
CE 754	Hazardous Site Remediation

Elective Courses

CE 722	Hydrology
CE 723	Groundwater Hydrology & Pollution Control
CE 755	Environmental Toxicology
CE 756	Environmental Law
CE 849	Environmental Geotechnology
CE 7XX	Approved Special Topic Courses

Students in certificate programs may apply for transfer to degree programs without any loss of credits assuming they are admitted to the degree program and that the courses are appropriate to the degree. Admission to a certificate program does not guarantee admission to a full degree program.

DOCTOR OF PHILOSOPHY IN CIVIL ENGINEERING

Students who wish to pursue a doctoral degree in the area of environmental engineering may do so under the PhD in Civil Engineering. For detailed information on this program, please consult the Civil Engineering program section of this catalog.

GRADUATE COURSES

CE 737 Environmental Chemistry and Microbiology I *1½:1½:0:3*

Introduction to the chemistry of drinking water, polluted and natural waters, including laboratory application of principles developed.

CE 739 Environmental Chemistry and Microbiology II *1½:1½:0:3*

Advanced topics in chemistry and microbiology of polluted and natural wastewater treatment. *Prerequisite: CE 737 or equivalent*

CE 742 Water and Wastewater Treatment I *2½:0:0:3*

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-requisite: CE 737.*

CE 743 Water and Wastewater Treatment II *2½:0:0:3*

Continuation of CE 742. Topics include sedimentation, adsorption, aerobic and anaerobic biological treatment, sludge treatment and disposal. *Co-requisite: CE 739.*

CE 745 Water and Wastewater Treatment Laboratory *1:2:0:3*

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 and aerobic and anaerobic biological treatment systems. Warburg analysis of waste. *Co-requisite: CE 743.*

CE 746 Industrial Waste Treatment *2½:0:0:3*

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 *2½:0:0:3*

Dispersal and decay of contaminants introduced into lakes, streams, estuaries and oceans. Effects of pollutants on chemical quality and ecology of receiving waters.

CE 748 Sanitary Engineering Design *1:2:0:3*

Design of water supply and wastewater treatment systems. Topics of special interest. *Co-requisite: CE 743.*

CE 751 Environmental Health Engineering *2½:0:0:3*

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 and other subjects affecting public health.

CE 752 Air Pollution *2½:0:0:3*

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 *2½:0:0:3*

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 754 Hazardous/Toxic Site Management *2½:0:0:3*

Treatment and disposal technologies for hazardous waste site remediation. In-situ and ex-situ processes. Physico-chemical processes, stabilization and solidification; biological processes including aerobic and anaerobic systems for degradation and detoxification; thermal processes and incineration; storage, land disposal and containment. Remediation planning and technology selection for hazardous waste containment and clean up for typical case studies. Decision-making framework and technology selection will be a key course component. The course will also involve case studies and a class project.

CE 755 Environmental Toxicology *2½:0:0:3*

This course stresses basic concepts essential to the understanding of the action of exogenous chemical agents on biological systems. The course will cover the principles of absorption and the effects of chemical agents on metabolism. The pathways of metabolism of these compounds and the principles of elimination from biological systems will be discussed. Toxicokinetics, types of toxic responses and the current experimental methods of toxicity will also be discussed.

CE 756 Environmental Law *2½:0:0:3*

This course presents legal principles and issues relating to environmental law. Historical perspectives and case laws will be considered. The Clean Water Act, non-point sources and water quality laws, Clean Air Act and its amendments, the National Ambient Air Quality and National Environmental Policy Act will be covered in this course. The above legislation and its impact on policy and technology will also be discussed.

ENVIRONMENTAL ENGINEERING AND SCIENCE PROGRAM

CE 758 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, SO, CO, etc.) and of aerosols and other particulates. *Prerequisite: adviser's approval.* Also listed under CH 752.

CE 767 Environmental Impact Evaluation *2½:0:0:3*

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 *2½:0:0:3*

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 Selected Topics in Environmental Engineering I/II *each 2½:0:0:3*

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: instructor's permission.*

FINANCIAL ENGINEERING PROGRAM

Academic Director: Frederick Novomestky

GOALS AND OBJECTIVES

The goals of the Financial Engineering Program are to educate financial market professionals and technology managers for fast-moving, highly rewarding careers that create value enabled by finance, technology and mathematics.

THE MASTER OF SCIENCE PROGRAM

The Master of Science in Financial Engineering (FE) is designed to provide the skills required to operate at the cutting-edge of financial engineering in today's financial services industry. Separate tracks make it possible to pursue careers in capital markets, in financial technology or computational finance. The program is rigorous, demanding and selective. Graduates of the Capital Markets Track are expected to seek positions in financial risk management groups, on trading and arbitrage desks, in product structuring groups, in derivatives groups, in investment banking departments and in the information-technology firms that support the trading operations of financial institutions. Graduates of the Financial Technology Track are best viewed as information technologists who are actively involved in the development and implementation of the entire spectrum of software applications, databases and networks used in modern financial services firms.

The Computational Finance Track has a strong emphasis on quantitative finance for those individuals with academic or applied business research interests in cutting-edge investment science and finance. In quantitative finance, the tasks of modeling, simulation and optimization are essential. The methodologies associated with these tasks are similar to those used in other program domains addressed by operations research and management science. Candidates who pursue this track must demonstrate a high level of academic scholarship and performance as well as a strong aptitude for applied mathematics. The Computational Finance Track is a graduate honor program that integrates

selected courses from the Department of Mathematics and the Department of Electrical and Computer Engineering. Graduates of the Computational Finance Track will be qualified to continue their education in PhD programs as well as work in research and advanced product development departments of financial firms and consulting organizations.

Graduates are expected to seek positions in commercial banks, investment banks, thrifts, insurance companies, investment companies, pension funds, finance companies, consulting firms, energy marketing firms, accounting firms with consultancy practices and so forth.

Polytechnic's Master of Science in Financial Engineering brings together three key areas: finance and related business disciplines, quantitative analysis (mathematics and statistics) and information technology (telecommunications and computer science). Polytechnic has long been recognized as a leader in both advanced mathematics and information technology. Now, through its FE program and associated research and curriculum development, Polytechnic has positioned itself to be a leader in the financial technology on which financial institutions increasingly depend for their revenue streams. The financial component has been further strengthened by developing a large and versatile adjunct faculty consisting of leading financial market practitioners from major Wall Street firms. The adjunct faculty works closely with Polytechnic's full-time faculty.

GRADUATE CERTIFICATES

The Graduate Certificate Program is an "add-on" to Polytechnic's existing graduate program in financial engineering. Graduating students seeking employment in the financial services industry and possessing this certificate should have a sizable advantage over job seekers lacking such a credential.

The Graduate Certificate Program prepares participants for the challenges of today's financial services industry. Completion of the certificate program offers students the means to implement dynamic strategies in the complex and

developing capital markets and financial technology divisions of investment and commercial banks, corporate treasury offices, government agencies, financial advisory firms, consulting firms, energy marketing firms and other modern financial institutions.

Financial Engineering Certificates are offered in the following fields:

- Financial Engineering
- Financial Technology Management
- Risk Management

Visit www.fe.poly.edu for the most current information.

ACCELERATED HONORS PROGRAM

BS MATHEMATICS/MS FINANCIAL ENGINEERING

Jointly offered by the Department of Mathematics and the Department of Management, a new accelerated Bachelor of Science in Mathematics and a Master of Science in Financial Engineering Honors Program addresses an educational and professional need within the financial services industry. This program is geared to attract outstanding high school students interested in pursuing careers in mathematics, in general, and job opportunities in the financial services industry, in particular.

The program is comparable to BS/MS programs in computer science, electrical engineering and organizational behavior offered by the Department of Management. Students receive both degrees at the end of either a four-year or a five-year track.

Students in the BS Mathematics/MS Financial Engineering Honors Program must meet all University requirements to complete each degree. Both degrees are awarded at the end of either four years or five years.

For more information on the BS in Mathematics, contact Erwin Lutwak at 718-260-3366 or lutwak@poly.edu. For more information on the MS in Financial Engineering, contact Frederick Novomestky at 718-260-3436 or fnovomes@poly.edu.

Admission Policy

The admission policy for the BS Mathematics/MS Financial Engineering Honors Program is similar to that used by the Othmer Institute for Interdisciplinary Studies' Honors College (more information on the Othmer Institute's Honors College is included in Part I "Polytechnic University Profile"). Admission to the program includes the following:

- Essay(s) submitted with application
- Two letters of recommendation
- SAT score of at least 1350
- High school diploma with a minimum 90 grade average (or equivalent letter grade)*
- Results of Regent and Advanced Placement (AP) exams are taken into consideration
- Personal interview will be considered with advisers from the Departments of Mathematics and Management

Students who take AP calculus courses equivalent in subject matter to MA 1012 and MA 1022 will be considered for the four-year track.

* For high school juniors, a minimum 90 grade average is required.

CENTER FOR FINANCE AND TECHNOLOGY (CFT)

The Center for Finance and Technology (CFT), under the auspices of the Department of Management, is a unique resource, addressing the evolving financial—and technology-enabled—innovation needs of the financial services industry. CFT is a research hub as well as a laboratory for generating new ideas and tools for the industry. CFT also undertakes collaborative research projects to provide ideas, methods and tools with scholarly and practical applications. For more information, contact Frederick Novomestky at 718-260-3436 or fnovomes@poly.edu, or visit <http://www.fe.poly.edu>.

ADMISSION

Admission to the Financial Engineering Program requires a baccalaureate from an accredited institution and two letters of recommendation. Additionally, the applicant must satisfy the admissions criteria. The admissions criteria incorporates students' undergraduate GPA and either the Graduate Management Admission Test (GMAT) or the Graduate Record Exam (GRE). For admission, students must score a minimum of 1250 points under the following formula.

$$\text{Score} = (160 \times \text{GPA}) + (9.6 \times (\text{GMAT or GRE percentile}))$$

For example, students who score in the 82 percentile on the GRE and have a 3.1 undergraduate GPA would have a total score of 1283 and could be admitted in the program.

$$\text{Score} = (160 \times 3.1) + (9.6 \times 82) = 1283$$

Additionally, applicants must demonstrate a sufficient level of proficiency and aptitude in mathematics. This may be demonstrated by grades earned in relevant course work and/or standardized examinations.

Students already holding a graduate degree will be admitted under the same criteria as students holding a baccalaureate, but their graduate GPA may be substituted for the undergraduate GPA in the formula above at the applicant's choice.

In addition to the criteria above, foreign students must demonstrate a proficiency in the English language or successfully complete a series of ESL courses in order to commence formal study.

The graduate certificates have the same application requirements and prerequisites as the Master of Science degree. Admission to the program requires a baccalaureate from an accredited institution. Candidates to the graduate certificate program are not required to take the GRE/GMAT, but should have obtained a minimum GPA of 3.0.

Conditional Admission: Applicants who wish to commence immediate study but who cannot complete the required graduate exams (GRE or GMAT) before the start of a semester may be admitted, at the discretion of the FE program academic director, on a conditional basis based on GPA alone.

Additionally, the academic director, at his discretion, may admit individuals to the program who do not qualify under the regular admission criteria if the academic director concludes that the applicant has adequate preparation to perform well in the program and that the standard admission criteria do not accurately reflect the applicant's ability. Such persons enter on a conditional basis.

The Computational Finance Track is not available to all the students in the Master of Science in Financial Engineering program. Students interested in pursuing the Computational Finance Track must make a formal request for acceptance after they have completed a

specified number of core classes, maintained at least a 3.65 cumulative grade-point average in those core courses and have demonstrated proficiency in the probabilistic/statistical/stochastic approach to modeling that is widely used in modern finance. This proficiency will be established either by taking a course such as FE 608 Quantitative Methods in Finance, or by taking an examination. Full-time students taking at least 9 units of courses per semester will meet these requirements at the end of their first semester. Part-time students taking 6 units per semester will meet these requirements at the end of their second semester.

Special Status: Applicants requesting admission for study only in a particular course or group of courses are given this status, which permits registration, generally for a limited duration, in those courses indicated on the approval of admission. This status is also given to applicants with advanced degrees who are entering a new professional area and desire extended education but not for degree purposes. Registration is limited to 6 units per semester. If additional courses are desired after the end of the specified period, a new admission request must be filed through the admissions office. Special status students who later apply for and receive regular status may transfer with full credit up to 9 units taken while special status students. Although special status students must hold a bachelor's degree from an approved institution, some admission requirements, such as letters of recommendation, will usually be waived. The academic director may, at his discretion, admit students to the program under the University's provisions for special students. After completing 9 units, the special student must either (1) matriculate under the regular admission criteria, (2) matriculate, based on an evaluation by the academic director of the student's records and performance in completed courses or (3) leave the program.

CURRICULUM

Program Prerequisites

Economics	EC 2524 or equivalent
Calculus	MA 1122 or equivalent
Probability	MA 2312 or equivalent
Statistics	MA 2222 or equivalent

Students in the Capital Markets Track have the following prerequisites:

Linear Algebra: MA 2012* or equivalent
 Linear and Nonlinear Programming
 Numerical Analysis
 Advanced Statistics

* Knowledge of spread sheets expected. Some exposure to computer programming languages.

- Students may satisfy this requirement by**
1. Demonstrating completion of a formal course
 2. Demonstrating completion of the essential components of this course from the contents of other courses
 3. Passing a proficiency examination

Core Classes for MS in Financial Engineering

	Units
FE 600 Financial Accounting	3
FE 603 Money, Banking & Financial Markets	1½
FE 605 Microeconomic Foundations of Finance	1½
FE 611 Investment Banking & Brokerage	1½
FE 620 Financial Theory with Corporate Applications	3
FE 621 Financial Market Regulation	1½
FE 655 Accounting for Financial Products	1½
MG 695 Economics for Business Decisions	1½

Required Classes for the Capital Markets Track

	Units
FE 608 Quantitative Methods in Finance	3
FE 627 Valuation of Equity Securities & Financial Statement Analysis	1½
FE 640 Valuation of Fixed Income Securities & Basic Interest Rate Derivatives	3
FE 650 Basic Derivatives Valuation & Applications	3
FE 670 Portfolio Theory & Applications	3
FE 671 Market Risk Measurement & Management	1½

Core Courses: 15
 Required Courses: 15
 Electives Units: 6
 Total Units: 36

Required Classes for the Financial Technology Track

	Units
FE 613 Clearing & Settlement of Financial Transactions	1½
FE 615 Foundations of Financial Technology	1½
FE 629 Introduction to Futures, Options & Swaps	1½
FE 675 Operational Risk Measurement & Management	1½
CS 606 Software Engineering	3
CS 608 Principles of Software Engineering	3
CS 681 Information, Privacy & Security	3
CS 684 Computer Networking	3

Core Courses: 15
 Required Courses: 18
 Electives Units: 3
 Total Units: 36

Required Courses for Computational Finance Track

	Units
FE 672 Dynamic Asset Pricing Theory	3
FE 674 Financial Optimization	3
EL 625 Linear Systems	3
MA 665 Numerical Analysis	3

Choose **one** of the following two courses:
 EL 723 System Optimization Method 3
 MA 614 Optimization: Linear and & Nonlinear Programming 3

Choose one of the following two courses
 MA 666 Numerical Solutions of Partial Differential Equations 3
 MA 668 Partial Differential Equations of Mathematical Physics 3

Core Courses: 15
 Required Courses: 18
 Elective Courses: 3
 Total Units: 36

Electives

The three tracks allow for 3-6 elective units. For students obtaining waivers from core or required courses, additional electives must be taken. Permission of their adviser is required in making selections. Additionally, it is students' responsibility to be certain that they have satisfied all course prerequisites when taking elective courses. With permission of their adviser and appropriate department head, students may take additional courses as electives in mathematics, computer science, electrical engineering and financial engineering.

GRADUATE CERTIFICATE PROGRAMS

Graduate Certificate Program in Financial Engineering

Program Prerequisites

Economics EC 2524 or equivalent
 Calculus MA 1122 or equivalent
 Statistics MA 2222 or equivalent
 Linear Algebra MA 2012* or equivalent
 Optimization: Linear and & Nonlinear Programming MA 614 or equivalent
 Microeconomic Foundations of Finance FE 605 or equivalent

* Knowledge of spreadsheets expected. Some exposure to computer programming languages.

Required Courses	Units
FE 608 Quantitative Methods & Finance	3
FE 620 Financial Theory with Corporate Applications	3
FE 640 Valuation of Fixed Income Securities & Basic Interest Rate Derivatives	3

FE 650 Basic Derivatives Valuation & Applications	3
FE 670 Portfolio Theory & Applications	3
Total Units:	15

Graduate Certificate Program in Risk Management

Program Prerequisites

Economics EC 2524 or equivalent
 Calculus MA 1122 or equivalent
 Statistics MA 2222 or equivalent
 Linear Algebra MA 2012* or equivalent
 Optimization: Linear & Nonlinear Programming MA 614 or equivalent
 Microeconomic Foundations of Finance FE 605 or equivalent

* Knowledge of spreadsheets expected. Some exposure to computer programming languages.

Required Courses	Units
FE 608 Quantitative Methods in Finance	3
FE 627 Valuation of Equity Securities & Financial Statement Analysis	1½
FE 640 Valuation of Fixed Income Securities & Basic Interest Rate Derivatives	3
FE 650 Basic Derivatives Valuation & Applications	3
FE 670 Portfolio Theory & Applications	3
FE 671 Market Risk Measurement & Management	1½
FE 673 Credit Risk Measurement & Management	1½
FE 675 Operational Risk Measurement & Management	1½
Total Units:	18

Graduate Certificate Program in Financial Technology Management

To obtain this graduate certificate a GPA of a B (3.0) or better is required.

Program Prerequisites

Financial Accounting: FE 600 or equivalent
 Economics: EC 2524 or equivalent
 Probability and Statistics: MG 505 or equivalent

Required Classes	Units
FE 613 Clearing and Settlement of Financial Transactions	1½
FE 615 Foundations of Financial Technology	1½
FE 617 Management of Financial Institutions	1½
FE 620 Financial Theory with Corporate Applications	3
FE 629 Introduction to Futures, Options & Swaps	1½
MG 650 Management of Information & Information Technology	3
MG 750 Management of Electronic Business	3
MG 820 Project Assessment & Management	3
Total Units:	18

GRADUATE COURSES

Most often, the half-semester courses, when taken in the correct sequence, can substitute for full-semester requirements.

FE 600 Financial Accounting 2½:0:0:3

Provides a solid foundation in the construction and interpretation of financial statements. Topics include accounting terminology, financial statement preparation and analysis, liquidity and credit risk ratios, depreciation calculations, revenue recognition, accrued liabilities and asset valuation. Also covered are the effects of equity transactions, cash flow, and various accounting methods on financial statements.

FE 603 Money, Banking and Financial Markets 1¼:0:0:1½

Studies how the interactions among money, the financial system and the economy determine interest rates and asset returns. It utilizes a consistent approach based in economics to explain the role of the financial system in matching savers and borrowers and in providing risk-sharing, liquidity and information services in efficient financial markets. Students study why and how financial markets and financial instruments evolve as a function of transactions and information costs, adverse selection and moral hazard problems, and summarize economic arguments for and against regulation. Finally, they examine the money supply process and monetary policy, in particular the link between monetary authorities and the macro-economy through a transmission mechanism involving banks and the non-financial public.

FE 605 Microeconomic Foundations of Finance 1¼:0:0:1½

Summarizes key insights from financial economics as the methodological and conceptual basis of financial engineering. It draws on results from general equilibrium analysis, information economics and the theory of contracts, and concentrates on individuals; consumption and portfolio decisions under uncertainty and their implications for the returns on and the valuation of financial assets in efficient markets. *Prerequisite: MG 695 or its equivalent offered in the evening MSM and TIM programs.*

FE 608 Quantitative Methods in Finance 2½:0:0:3

Develops the theory of continuous-time stochastic models as applied to the valuation of options and other derivative securities. Brownian motion and related stochastic processes, stochastic integration, Ito's formula and other aspects of stochastic calculus are treated with substantial rigor. The theory is balanced with concrete numerical applications. The course also covers multivariate statistical methods to include maximum likelihood estimation procedures. *Prerequisite: Students are expected to have knowledge in calculus, probability and statistics.*

FE 611 Investment Banking and Brokerage 1¼:0:0:1½

Provides an introductory overview of Wall Street, general brokerage operations, investment banking and capital markets. The subjects covered are essential to the understanding of how products, once created, are actually distributed and sold. The course relies heavily on *The Wall Street Journal* and other important trade publications. Topics covered include a brief history of Wall Street, an understanding of the major securities laws and how they have changed over time, basics of equity and debt securities, creation of debt and equity securities, pricing and sale of debt and equity securities. One of the major objectives of this course is to understand how and where opportunities for the creation of new securities arise. A second major objective is to position financial engineering in perspective with the overall Wall Street picture.

FE 613 Clearing and Settlement of Financial Transactions 1¼:0:0:1½

Focuses on issues involved in the processing of financial transactions from order execution to final settlement of transactions. The course examines the procedures and market conventions for processing completed transactions, verifying transactions, confirming transactions, resolving conflicts, decisions involved in developing one's own clearing operations or purchasing clearing services, the role played by the clearing houses, and numerous issues associated with cross border transactions.

FE 615 Foundations of Financial Technology 1¼:0:0:1½

Every year, financial institutions spend billions to exploit the latest development in information technology. This course introduces a framework within which to understand and leverage on information technology. The technology components covered include telecommunications, groupware, image and document processing, artificial intelligence and object-oriented analysis and design. The course also covers the entire technological planning process specifically for financial institutions.

FE 617 Management of Financial Institutions 1¼:0:0:1½

Focuses on managing return and risk in modern financial institutions and describes both the theory and practice of financial institutions from a financial management perspective. By analyzing the factors that define the dynamics of the rapidly changing financial services industry, it explores the normative consequences on financial management decision-making to create shareholder value. *Prerequisites: FE 603 and FE 605.*

FE 619 Advanced Topics in Financial Technology 1¼:0:0:1½

Complements FE 615 by providing in-depth treatment of specific current topics in this rapidly changing field or by providing a structured forum for dealing with relevant issues in current practice. *Prerequisite: FE 615.*

FE 620 Financial Theory with Corporate Applications 2½:0:0:3

The modern corporation, as issuer of financial securities and end-user of financial risk management products, is one of the major participants in financial markets and the economic counter-party to investors and financial intermediaries. Whereas the mechanism of financial markets and the valuation of instruments are studied in further detail elsewhere, in this course the "tools of the trade" of financial economics will be applied specifically to the financial decision-making process in the firm. Upon successful completion of this course, students will know how to contribute to optimal financial decisions in a corporation: valuation, capital budgeting, risk, capital structure, dividend pol-

icy, long-term financing, risk management, mergers and acquisitions.

FE 621 Financial Market Regulation

1½:0:0:1½

Considers the role and forms of regulation in the U.S. financial markets. The role of the Securities and Exchange Commission (SEC), the Commodity Futures Trading Commission (CFTC), the Federal Reserve, the Office of the Controller of the Currency (OCC), and self-regulating organizations (SROs) such as the National Association of Securities Dealers and the National Futures Association are examined. Also studied are the roles of the state insurance commissions and the Department of Labor. *Prerequisite: FE 603.*

FE 627 Valuation of Equity Securities and Financial Statement Analysis

1½:0:0:1½

Provides a detailed examination of the tools and techniques for analyzing financial statements for the purposes of evaluating credit, forecasting, identifying merger candidates, enhancing the efficiency of decision making, and diagnosing problem areas within the firm before crisis situations develop. Students are taught to use financial ratios to conduct duPont (i.e., decomposition) analysis, a methodology to track down sources of poor performance through interrelationships among a firm's financial ratios. *Prerequisites: FE 600 and FE 620.*

FE 629 Introduction to Futures, Options and Swaps

1½:0:0:1½

A half-semester course that covers basic derivatives including futures contracts, forward contracts, option contracts and swap contracts. The principal focus of the course is on the use of these instruments by financial institutions. Basic valuation concepts are discussed. The use of derivatives for speculative purposes, hedging purposes and arbitrage are discussed. The specifics of the contracts and the markets in which they trade are also discussed. The main focus is to give students in the Financial Technology Track a general understanding of the derivatives market and risk management. *Prerequisites: FE 600, FE 605 and FE 620.*

FE 640 Valuation of Fixed Income Securities and Basic Interest Rate Derivatives

2½:0:0:3

Examines the body of analytical tools and measures that constitute modern fixed income markets. The valuation of interest-rate sensitive cash flows is the unifying theme. Major topics covered include theories of term structure, institutional aspects of fixed income markets and analytical techniques for managing interest rate risk. Bond refunding, defeasance, corporate bonds, forwards, futures, options and interest rate swaps are discussed. The course also provides an overview of the major classes of fixed income securities and the markets in which they trade. Among the major classes of fixed income instruments discussed are Treasury and agency securities, asset-backed securities, municipal securities, floating and inverse floating rate securities. *Prerequisites: FE 605, FE 608 and FE 620.*

FE 649 Municipal Finance

1½:0:0:1½

Provides an overview and analysis of the market for the debt obligations of state and local governments. The course treats the micro structure of the market, including the types of debt issued, as well as the characteristics of the buyers. Federal and state taxation of munis are discussed, along with the regulatory structure of the industry. Bond structure, risk assessment, and risk management utilizing cash bonds, futures and options are covered. *Prerequisite: FE 640.*

FE 650 Basic Derivatives Valuation and Applications

2½:0:0:3

A full-semester course that covers exchange traded and over-the-counter (OTC) derivatives including futures contracts, forward contracts, option contracts, swap contracts, and structured securities having embedded derivatives. The principal focus of the course is on financial engineering applications. Basic valuation concepts are discussed, but detailed valuation methodology is not covered in this course. The use of derivatives for speculative purposes, hedging purposes and arbitrage is discussed. The specifics of the contracts and the markets in which they trade are also discussed. The main focus is on financial derivatives such as currency and equity contracts, but some brief discussion of commodity con-

tracts and specialty contracts such as insurance derivatives and macroeconomic derivatives may also be discussed, at the instructor's discretion. *Prerequisites: FE 605, FE 608 and FE 620.*

FE 655 Accounting for Financial Products

1½:0:0:1½

Addresses accounting issues as they pertain to innovative financial products, risk management strategies, tax driven strategies and other manifestations of financial engineering, particularly those in which derivative financial instruments play an important role. Accounting and tax rules are reviewed and applied. *Prerequisite: FE 600.*

FE 658 Securitization: Mortgage- and Asset-Backed Securities

2½:0:0:3

This course provides students with a good understanding of the complexities, advantages and risks involved in the issuance and investment in mortgage-backed and asset-backed securities. Beginning with the history and motivation for the creation of this asset class, the course delves in the calculations of mortgage cash flow, prepayment modeling, yield-curve, OAS models, total-return analysis, scenario analysis and return attribution. The Yield Book Fixed-Income Analytics System is used extensively, both in class discussions and for homework assignments. Students build a number of complex spreadsheet models for generating mortgage cash flows under a range of prepayment assumptions, allocating cash flows to derivative instruments (such as CMO's) and calculating various yield, risk and return measures. Students are also involved in simulations of MBS portfolio construction, risk measurement and return analysis. *Prerequisites: FE 640 and FE 650.*

FE 662 Derivatives: Advanced Applications and Analysis

2½:0:0:3

Focuses on advanced financial engineering applications using derivative securities in combination with other financial instruments. When possible, the course is taught by a financial engineering team from the derivatives trading desk of a major dealer. In addition to complex financial engineering structures, students also consider reverse engineering of structures. Cases presented are from recent deals. Examples of applications

might include tax arbitrage, the construction of equity collars on restricted stock, the alteration of the investment characteristics of large portfolios and the creation of synthetic financial instruments. *Prerequisites: FE 640 and FE 650.*

FE 664 Term Structure Modeling and Advanced Interest Rate Derivatives
2½:0:0:3

Covers an assortment of numerical valuation techniques in substantial detail. Possible topics include term structure models, the term structure of volatility, interest-rate processes with time-dependent volatility and mean reversion, a closer look at path-dependent securities including sinking fund bonds and options with look-back features, multi-factor models and multinomial methods of discrete numerical implementations. Course readings are drawn from current literature. *Prerequisite: FE 640; students are expected to have knowledge in numerical analysis and numerical methods as covered in MA 665.*

FE 668 International Finance: Markets and Strategies
2½:0:0:3

Covers the international dimensions of finance. Course focuses on markets, players and instruments and explores the main theoretical insights into the workings of the foreign exchange, international currency and bond markets, as well as how their integration serves to price securities. While a detailed study of the institutions that frame these markets and international macro-economics is beyond scope of this lecture series, students must nevertheless examine some of these concepts in order to understand the fundamental determinants of exchange rates and links between different countries' interest rates. A number of parity conditions that prevent arbitrage as well as the role of expectations contribute to an understanding of the level and the volatility of international asset prices. Theory and institutional description are complemented by analyzing the mechanics of international financial instruments. The Value-at-Risk methodology is employed to illustrate pricing and use of the financial instruments in the context of international risk measurement and management. *Prerequisites: FE 640 and FE 650.*

FE 669 Credit Derivatives Valuation and Applications
2½:0:0:3

Credit derivatives have emerged as an area of significant interest in global derivatives and risk management practice. These instruments have the potential to revolutionize the management of credit risk in banking and capital markets. This course introduces students to the full range of products available in today's marketplace, the economic value of credit derivatives, valuation techniques and guidelines on using them to manage and control risk. *Prerequisites: FE 640 and FE 650.*

FE 670 Portfolio Theory and Applications
2½:0:0:3

An in-depth examination of modern portfolio theory and investment selection. Course considers the mathematics of portfolio analysis, single-period risk and return measures, and the process of optimal portfolio selection. The basic portfolio model is extended to consider alternative risk concepts and multi-period portfolio horizons. Single-factor and multi-factor models are also discussed. Optimization techniques, such as linear programming and quadratic programming are applied. The basic portfolio model is extended to explain hedging theory and to build firm-wide risk management models. *Prerequisites: FE 640, and FE 650; students are expected to have knowledge in mathematical programming or quantitative methods as covered in MA 614 or MG 610, respectively.*

FE 671 Market Risk Measurement and Management
1½:0:0:1½

Addresses financial risk management with particular focus on Value-at-Risk (VaR), a method of assessing risk that uses standard statistical techniques routinely employed in other fields. Value-at-Risk exploits the principles and methodology of modern portfolio analysis. Portfolio theory is a prerequisite for taking this course. VaR analysis has rapidly become a standard methodology that is demanded by bank and corporate managers, and by financial market regulators. *Co-requisite: FE 670.*

FE 672 Dynamic Asset Pricing Theory
2½:0:0:3

A course on the theory of asset pricing and portfolio selection in multi-period settings. These asset-pricing results are unified with two key concepts, state prices and martingales. Similarities between discrete and continuous time models are emphasized as are alternative approaches to the valuation of concrete debt. Also, while much of the continuous time portion of the theory is based on Brownian motion, this course introduces jumps—for example, those associated with Poisson arrivals—in order to accommodate surprise events such as bond defaults. Applications include term structure models, derivative valuation and hedging methods and dynamic programming algorithms for portfolio choice and optimal exercise of American options. Numerical methods covered include Monte Carlo simulation and finite-difference solvers for partial differential equations. *Prerequisites: MA 665, FE 605 and FE 620.*

FE 673 Credit Risk Measurement and Management
1½:0:0:1½

A specialty course intended for those individuals who feel they might become involved in credit risk measurement or management and related areas in which credit issues are important. Such issues arise in credit rating activity, credit extension by banks and other financial services firms, and in derivative markets where counterparty risk is perceived to be an important management issue. *Co-requisite: FE 670.*

FE 674 Financial Optimization
2½:0:0:3

The main objective of this course is to illustrate the historical, current and growing role of practical optimization ideas in computational finance. Emphasis is on practical computational aspects. A secondary objective is to introduce students with optimization backgrounds or interests to the area of computational finance. Computational finance is a field experiencing dramatic growth of importance and popularity. Moreover, any important finance strategy questions may be phrased as optimization questions. The course's purpose is to illustrate and describe the role of optimization in computational finance. The course also intro-

duces stochastic programming as a methodology that deals with discrete time optimization under certainty. *Prerequisites: FE 672 and MA 614 (or EL 723).*

FE 675 Operational Risk Measurement and Management

1½:0:0:1½

The operational difficulties faced by financial institutions have created a need for tools to measure and manage operational risk. An accurate appreciation of risks, exposures and controls is critical to managing risk effectively in today's dynamic global business environment. Course examines the effects of transaction processing, liquidity management, organizational structure, personnel and compliance on the nature of operational risk. Qualitative and quantitative measures of operational risk are discussed.

FE 680 Financial Engineering (research course)

2½:0:0:3

A research/case course. It can be handled a number of different ways at the discretion of the faculty supervisor. It may involve (1) a series of cases that are dissected and analyzed, (2) teaming of students with industry personnel for proprietary or non-proprietary research projects or (3) developing thesis-type research. Generally, students work under the supervision of a faculty member, but the course is intended to be largely self-directed within the guidelines established by the supervising faculty member. A significant written research component is required.

Prerequisites: Should be taken during students' final semester. Prerequisites will vary depending on students' track and nature of project undertaken. Note: This is a 3-unit course the first time students register for it. In the event that they do not receive a final grade from the FE adviser, students must receive permission from the FE adviser to formally register continuously for this course for 1½ units per semester for a maximum of two semesters. After this time period has expired, a final grade must be submitted by the course adviser or else it will automatically turn into an F and the student will need to retake this course for 3 units.

FE 682 Empirical Methods in Finance

2½:0:0:3

The use of quantitative methods in financial engineering requires strong foundations in statistical techniques applied to problems in portfolio management, trading, derivatives pricing, etc. Students learn how to estimate the parameters that are used in valuation models and other financial models. The uncertainty accompanying estimated parameters is of particular importance in financial applications, and appropriate significance tests will be reviewed. Topics covered include the following: a brief review of stationary time series models in the traditional ARIMA framework; the properties of stochastic time series, test for trends and unit roots; estimation and forecasting with single-equation time series models; measuring the "performance" of forecasts, which is useful in the evaluation of trading strategies; event analysis general-

ized to intervention analysis in the context of multi-equation time-series models; estimation of transfer functions; and the identification of impulse response functions in the implementation of Value at Risk (VaR) models. Time-varying volatility is an important empirical characteristic of economic time series, and students will learn how to estimate a variety of autoregressive conditional heteroskedastic (ARCH) models. An important area of implementing and forecasting these models is risk management. Depending on the background and the interest of students, greater emphasis is given to selected topics, while stressing software-based applications throughout the course. While understanding the underlying theory is indispensable, this course stresses application of the econometric tools to real projects. *Prerequisites: FE 640, FE 650 and FE 671.*

FE 780-789 Special Topics in Financial Engineering

3 units

Topics of current interest to financial engineers. *Prerequisite: Specified when offered.* Contact the FE program director for more information.

FE 790-799 Special Topics in Financial Engineering

1½ units

Topics of current interest to financial engineers. *Prerequisite: Specified when offered.* Contact the FE program director for more information.

HISTORY OF SCIENCE PROGRAM

Academic Adviser: Romualdus Sviedrys

The Master of Science in the History of Science was the first of its kind to be offered in the New York City area. The need for advanced study of the growth of science and technology and their interactions with human society and values has become increasingly evident. Intense specialization has further heightened the need for understanding among various branches of science and the humanities.

In considering ideas, time, process, transfer and social changes in the history of science, students are able to explore the elusive connections that exist between science and engineering and the social sciences and humanities. Prospective teachers of science and engineering subjects are able to increase their effectiveness through knowledge of the history of their own and related disciplines. Polytechnic's Dibner Library contains many important and rare works on the history of science, which may be used for original research.

GOALS AND OBJECTIVES

The objectives of the Master of Science in History of Science are:

- To survey the record of scientific discovery, especially in modern times, and to consider the impact of science upon political and economic culture;
- To investigate the complex interactions between science and technology in industrial and pre-industrial contexts;
- To help students develop a coherent world view that takes proper account of the role science and technology have played in the shaping of the modern world

REQUIREMENTS FOR THE MASTER OF SCIENCE

A total of 36 units is required for the master's degree. Normally, students start by taking introductory courses SS 600 and SS 601 and then proceed to more advanced courses and seminars. In all

cases, programs are constructed in consultation with advisors, taking into consideration individual backgrounds and interests. Students are encouraged to take 9 units of work in related fields outside the program, for example, in philosophy, mathematical logic, Renaissance history or one of the sciences or engineering. To qualify for degrees, students may elect to write either a comprehensive examination or a thesis embodying appropriate and substantive research. If students choose the former, examinations may be taken in the term in which courses are completed. Students choosing the thesis may apply up to 12 units of thesis course work toward requirements for the degree. Acceptance of a thesis involves an oral presentation and defense. In addition to these requirements, students must demonstrate reading knowledge of one foreign language, whether French, German, Russian or Spanish.

GRADUATE COURSES

SS 600 Antiquity to the Scientific Revolution 2?:0:0:3

Biological and physical sciences from antiquity to the Renaissance. Issues, aims and tools of historians of science working in these periods.

SS 601 Scientific Revolution to Darwin 2½:0:0:3

Biological and physical sciences from the scientific revolution to Darwin. Issues, aims and tools of historians of science working in these periods.

SS 602 Seminar in History of Science 2½:0:0:3

Advanced problems in history of science: development of quantification, historiography of science, history of ecology, science and social thought. Main topic chosen by students and instructor. Training in methods of archival research. Required regular reports leading to a major paper. Course may be taken twice for credit with

different topical emphasis and instructor's permission.

SS 616 Guided Reading in History of Science 2½:0:0:3

Independent studies of leading interpretive works and sources in history of science. Regular tutorial sessions and periodic student-teacher colloquia. Course may be taken twice for credit with different topical emphasis and instructor's consent. Comprehensive written examination.

SS 625 History of Technology: Antiquity Through Early Industrial Revolution 2½:0:0:3

Science and technology, beginning with the Neolithic period; ancient Greece from the pre-Socratics to Euclid; the Copernican revolution; the role of science and technology in the expansion of Europe; influence of science on the development of European thought, from Lavoisier to the origins of the theory of evolution, Galileo and Newton; the organization of scientific inquiry; the impact of scientific thought on society in the 17th, 18th and early 19th centuries. *Prerequisite:* SS 600 or equivalent.

SS 626 History of Technology: Industrial Revolution to the Present 2½:0:0:3

The course involves the evolution of techniques and tools used in man's attempts to master the environment. Reciprocal relationships between technology and other facets of society's economic and social structures, political policies; general cultural manifestations. Technological bases of historical changes and interactions of science and technology. *Prerequisite:* SS 601 or equivalent.

SS 635 History of Psychology 2½:0:0:3

Survey of psychology against a background of periods in which principal modern schools and issues emerged. Early psychology as speculative discipline, essentially part of philosophy.

Differentiation of psychology into various fields. *Prerequisite: PS 2104 or equivalent or HI 2260 or equivalent.*

SS 640/641 Environmental Studies Seminar 3:0:0:3

This seminar provides an opportunity to investigate environmental issues by focusing on a specific topic each year. The aim is to cultivate a more holistic understanding of human societies in their ecological settings. Attention is given to such factors as weather, technology, population, social organization and political structure. All students are responsible for a seminar paper. Guest participants on special topics. *Prerequisite: PS 3324 or other appropriate environmental studies course or instructor's permission.*

SS 672 Technological Forecasting 2½:0:0:3

Introduction to problems associated with technology forecasting. Short-range, intermediate and long-range forecasting methodologies. Forecasting social and economic consequences of adopted innovations. Students prepare a forecast on a topic of their choice. *Prerequisites: HI 2104 and one introductory history of science or technology course or instructor's permission.* Also listed under MG 672.

SS 675 Technology Transfer Among Nations 2½:0:0:3

Social, ecological and economic factors in the selection, transfer and use of technology. Mechanisms of technology transfer and criteria of success. Case studies of successful and unsuccessful technology transfers. *Prerequisites: HI 2104 and one introductory history of science or technology course or instructor's permission.* Also listed under IE 757 and MG 757.

SS 676 Human Resource Development in Developing Countries 2½:0:0:3

Spectra of technology-related manpower needs in less-developed countries. Education of engineers, technicians and skilled mechanics. Uses of foreign personnel, foreign schools and "brain-drain" problems. Economic consequences. Comparisons of educational systems of Western, Eastern and developing countries. Designs of curricula to suit national needs. Roles of technical assistance programs. Forecasting of human resource needs. Also listed under IE 758.

SS 866 Technology Policy 2½:0:0:3

This course focuses on the macro-environment influencing and relevant to technology decision making, strategy and innovation in firms, government agencies, non-for-profit institutions and other organizations. Primary concerns include introducing effective approaches for analyzing and evaluating societal-wide factors that influence innovation; assessing various attempts and policies for stimulating innovation in a city, region, nation or on a global basis; exploring the role of technology and innovation in diverse managerial, economic and social contexts (e.g., advanced economies, rapidly emerging economies and Third World economies); the relationship between business-government and NGOs in promoting and sustaining innovation; the impact of global rivalry and global cooperation in the technology and innovation arena; and the place of technology and innovation in the post-Cold War era and in the early 21st century. Also listed under MG 866.

INDUSTRIAL ENGINEERING PROGRAM

Program Director: William R. McShane

The Department of Mechanical, Aerospace and Manufacturing Engineering offers a program in industrial engineering at the 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 applied include analytic modeling, system simulation, queuing 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 multidiscipline 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
- Management of technology

Graduate advisers work with students 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. Industrial engineering encompasses 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. 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 analyzing and designing productive systems to managing 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.

GOALS AND OBJECTIVES

The objectives of the Master of Science program in the Industrial Engineering are for students to:

- Develop and apply a systems point of view to the effective supply of quality products and services
- Understand how to adapt, integrate and exploit existing technologies in manufacturing and services, including the application of analytic modeling, system simulation, queuing systems, work design, facilities design and quality management and control
- Learn how to measure and allocate the resources of an enterprise optimally
- Become aware of today's industrial drivers and learn tools and techniques to analyze problems and improve performance

- Acquire a broad knowledge base through the choice of a concentration of courses in Industrial engineering and related fields to suit the career needs of our students
- Obtain hand-on experience through internships in local industry and develop the basis of a master's report

REQUIREMENTS FOR THE MASTER OF SCIENCE

The general Polytechnic requirements for the degree Master of Science 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. Student not meeting these requirements are 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 (and have an appropriate substitute designated) for all required courses in which they can demonstrate competence, so that they can use their time most effectively.

Prerequisite Courses (or equivalent knowledge)

Students must be computer literate and have knowledge of engineering economy and probability and statistics. If prospective students lack the relevant knowledge, they may satisfy the requirement by taking the following:

- Probability and statistics (MA 651 or equivalent)
- Computer literacy (ME 2114 or equivalent)

Up to 3 units of graduate courses in this category of prerequisite knowledge can be counted for degree unit as electives, although the electives needed for the student's concentration must also be satisfied.

Required Core Courses 18 units

IE 611	Quality Control and Improvement
IE 619	Production Planning and Control
IE 620	Project Planning and Control
IE 621	Facility Planning and Design
IE 682	Factory Simulation
MN 789	Production Science

Other Courses 18 units
Total 36 units

Students should elect other appropriate courses in consultation with their adviser. Concentrations in areas suited to students' career interest are encouraged (e.g., manufacturing, mechanical engineering, operations management, construction management and management of technology). Courses from computer science (such as databases or EDI) or from management (such as new enterprise and small business management) may supplement such a concentration. Courses such as IE 776 Manufacturing Resource Planning or IE 775 Industrial Safety Engineering may also be used.

CERTIFICATE PROGRAM

The department offers a certificate program 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 must hold a bachelor's degree. Students are issued a certificate after completing a sequence with a B average or better. Students who are later admitted to study for a master's degree are usually able to apply all certificate courses toward the master's degree.

If student have taken the equivalent of any required courses as an undergraduate, or more than one as a graduate student, then they may substitute courses in consultation with the adviser. Additional information is available from the department. The certificate program is shown below.

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

GRADUATE COURSES**IE 611 Quality Control and Improvement** 2½:0:0:3

The goal of this course is to provide the student with a solid foundation in the cost of quality, quality assurance and quality management. Emphasis is placed on the basic tools of quality control such as control charts and their use, the concept of "out of control," acceptance sampling, variables and attributes charts, and producer's and consumer's risk. A unique aspect of this course is the demonstration of the power of teams of people with different expertise to improve quality. A course project is required. *Prerequisite: MA 651 or familiarity with the concepts of probability and statistics. Also listed under MN 611.*

IE 612 Quality Engineering Using Robust Design 2½:0:0:3

The goal of this course is to provide a broad review of the procedures involved in improving the quality of manufacturing. By employing both Taguchi techniques, such as the use of signal-to-noise ratio representations, and other techniques less sensitive to parameter interactions, a full spectrum of robust design methods are presented. Applications of these procedures are reviewed including online trouble-shooting methods to assure quality in manufacturing. *Prerequisite: IE 611. Also listed under MN 612.*

IE 619 Production Planning and Control 2½:0:0:3

A survey course in basic and advanced manufacturing planning and control systems covering short-term forecasting systems, master production scheduling, material requirements planning, inventory management, capacity management, production activity control and just-in-time.

IE 620 Project Planning and Control (Project Management) 2½:0:0:3

Discussion of the knowledge and process required to manage a project throughout its life cycle from concept to completion. Topics include engineering analysis, screening and selection, configuration and total quality management, scheduling using PERT and CPM, budg-

eting and resource management, computer support and software. Case studies are used to illustrate the process. Also listed under MG 810 and CE 828.

IE 621 Facility Planning and Design 2½:0:0:3

Topics covered include facilities design for global competitiveness, strategic master site planning, site selection, factory layout and design, facility management systems, and materials handling and storage planning. Guidance on selecting alternative facility plans and application of queuing methods and computer modeling for facility design and evaluation are presented.

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 682 Factory Simulation 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. *Prerequisite: computer literacy.*

IE 776 Manufacturing Resources Planning (MRP II) 2½:0:0:3

Computerized systems to effectively run a manufacturing business are discussed as well as the process of software specification, evaluation, selection and implementation. Topics include MRP logic, enterprise resource planning, manufacturing execution systems, inventory management and bill of materials. Several different software systems and their features are highlighted. Also listed under MN 776.

IE 785 Computer Integrated Manufacturing Systems (CIMS) 2½:0:0:3

The basic concepts of manufacturing complex products with complex process-

INDUSTRIAL ENGINEERING PROGRAM

es relying heavily on computer and data processing technologies are introduced. All aspects relative to products and processes—planning, design, manufacturing and shipping—are addressed from a variety of perspectives. Techniques for managing and optimizing manufacturing productivity are explored. Also listed under MN 785.

IE 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 under MN 788.

IE 792 Design for Manufacturability (DFM) *2½:0:0:3*

Concepts and techniques for the economic, functionally sound and high-quality product design for manufacture are introduced. Emphasis is placed on designing for easy assembly, both robotics and manual, and on the effective use of plastics for manufacturing cost reduction. Managerial and organizational approaches and case studies of successful designs are reviewed. Also listed under MN 792.

IE 911/912 Selected Topics in IE *each 2½:0:0:3*

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 997/998 Thesis for the 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 6 units require separate approval. *Prerequisites: degree status and approval of supervising professor, adviser and department head.*

THE FOLLOWING COURSES ARE OFFERED IRREGULARLY IN RESPONSE TO INDUSTRY DEMAND

IE 600	Engineering Economy
IE 606	Work Design and Measurement
IE 618	Inventory Models
IE 627	Operations Research: Deterministic Models
IE 628	Operations Research: Stochastic Models
IE 650	Queuing Systems I
IE 685	System Reliability
IE 765	Human Factors in Engineering Design
IE 775	Industrial Safety Engineering

INFORMATION SYSTEMS ENGINEERING PROGRAM

Program Director: Robert Flynn

The Masters of Science in Information Systems Engineering (ISE) Executive Program is designed for professionals who want to be leaders in designing, developing and running today's information systems and systems based on information using the latest software tools, middleware and technologies.

The program provides rigorous training in computer science, management and electrical engineering with an emphasis on the field of information systems engineering.

Much of the infrastructure is in place for today's enterprise information systems. Incompatible software and protocols, however, often separate applications on networked systems. In a web-based world, information systems designers need core skills in understanding machine organization, operating systems and networking. They need enabling training in software engineering, databases and groupware. They need to understand the role of middleware and the role of management.

It is important to understand not just how to design software systems but how to lead the efforts of people who will accomplish the design. The viability of solutions and understanding the associated human interface issues are not luxuries any more.

Students selected to participate in the program are experienced working professionals in computing or telecommunications with two or more years of working experience.

Polytechnic University started this Master of Science program in 1987 as a joint effort between the Department of Computer and Information Science and New York State's Center for Advanced Technology in Telecommunications (CATT). It is a rigorous two-year, four-semester program consisting of 13 courses and an independent project.

The program is given in an executive format; classes meet every other weekend

for two full days, Friday and Saturday, at Polytechnic's Westchester Graduate Center in Hawthorne, New York. Breakfast, lunch and coffee breaks are provided. All classes are videotaped, with the tapes made available for viewing either at home or on campus.

An all-inclusive fee covers tuition, fees, textbooks and other educational material, meals on class days and access to videotape of classes and lectures.

GOALS AND OBJECTIVES

The ISE Program has as its goal the production of information systems designers and integrators who can lead the development of heterogeneous systems that are aware of new software tools and interfaces. Its objective is to provide people with management and technology skills to facilitate their leadership in the integration of software component into complex systems.

ADMISSION REQUIREMENTS AND APPLICATION INFORMATION

Admission to the program requires a baccalaureate degree with a superior undergraduate academic record and a demonstrated familiarity with and exposure to the issues associated with the development of complex information systems. Applicants must have two years of relevant work experience in the field of computing and/or telecommunications.

Applications are accepted throughout the year, but admission is for the fall semesters only. Admission is contingent on an interview with the director or designee. Because enrollment is limited, early application is strongly recommended.

DEGREE REQUIREMENTS AND CURRICULUM

The general requirements for a Master of Science, stated elsewhere in this catalog, apply to this program. The curriculum

consists of 13 courses, including two half courses totaling 36 units, plus an independent research project, which must be completed in the second year of the program. Courses may change or new courses substituted in response to changes in technology.

The courses currently constituting the curriculum appear below:

FALL

First Semester

CS 606	Software Engineering
CS 613	Computer Architecture
MG 690	Management Process & Decision Making

SPRING

Second Semester

CS 608	Databases
EE 536	Principles of Communications Networks
MG 691	Leadership, Motivation & Communications

FALL

Third Semester

CS 684	Network Protocols
CS 690	Groupware

Two of the following four half-semester courses:

CS 914	Usability Engineering
CS 919	Selected Topics in Information Systems
MG 694	Project Management
MG 695	Economics for Business Decisions

SPRING

Fourth Semester

CS 623	Operating Systems
CS 682	Network Management & Security
CS 691	Integrated Development Environments

A project course, CS 996, is also required for the degree. The project is typically begun after the second semester and completed at the end of the fourth semester. The project is generally conducted in cooperation with the student's employer. Its goal is to integrate the techniques and the tools of the program in ways that reward the student and the employer.

THE FOLLOWING COURSES ARE OFFERED AS PART OF THE INFORMATION SYSTEMS ENGINEERING PROGRAM:

CS 690 Groupware *2½:0:0:3*

Middleware is software that allows different applications on, typically distributed, computer systems to interact. Groupware is middleware that is designed to allow many people to work together. It often incorporates business processes with communication in order to support the policies of enterprises. In dealing with the general issue of group software, one can address the objects of collaboration and sharing. Thus, one may include here a discussion of multimedia interfaces, XML, SOAP, web services, information sharing and object technologies. Prerequisite: regular graduate status.

CS 691 Integrated Development Environment *2½:0:0:3*

This course includes methodologies for systematically developing distributed and centralized information systems. Both two- and three-tier systems are discussed. Relevant standards, such as J2EE, CORBA, Active X, OpenDoc and web-based tools may be covered. The relationship of the standards and tools to the design and the software architecture are considered. Prerequisite: regular graduate status.

CS 914 Usability Engineering*2½:0:0:1½*

The World Wide Web is both a network and a human interface. The usefulness of the interface it presents can be measured. This course presents the role of cognitive psychology in computer interface design. It combines both human factors and engineering tools in its approach to effective interface design and usability.

For additional course descriptions, also see the sections “Computer and Information Science,” “Electrical Engineering” and “Management” in this catalog.

MG 690 Management Process and Decision Making *2½:0:0:3*

Introduction to issues and concepts in organizational and administrative behavior with an emphasis on continually changing organizations in the information sectors. Management processes for flexible and innovative information businesses. The evolution of technology-intensive industries and information business organizations. The role of information technology in the growth of the modern firm. Human resource management and organization development in information-intensive firms.

MG 691 Leadership, Motivation and Communication *2½:0:0:3*

Organizational and individual behavior. Managing technical professionals. Teams, communication and group decision making. Leadership. Conflict and negotiation. Organizational development and culture. Managing change and creating innovative environments.

INTERDISCIPLINARY STUDIES IN ENGINEERING PROGRAM

GOALS AND OBJECTIVES

The program Interdisciplinary Studies in Engineering leads to the Master of Engineering degree. It is intended for students seeking in-depth knowledge in fields requiring courses from multiple disciplines, especially disciplines taught by different academic departments. The degree meets the needs of many companies seeking professionals who must integrate knowledge from different fields and create new knowledge through research at the interface of different fields.

REQUIREMENTS

To obtain the degree, students must satisfactorily complete a total of 36 units in graduate courses with a capstone experience and at least one 15-unit graduate advanced certificate in an engineering department or in the Department of Computer and Information Science.

This is the first such graduate interdisciplinary program at Polytechnic University or in the New York City metropolitan area. The advanced certificates and courses required already exist at the university; new ones will be created and approved as the program evolves to meet the needs of students and industry.

Admission to the program requires a bachelor's degree from an accredited institution, with a superior academic record and completion of all prerequisite courses. Applicants who are otherwise sufficiently prepared for admission may nevertheless be required to take specific undergraduate and introductory level graduate courses. Such graduate courses may count towards the master's degree, depending on the practice of the department offering the advanced certificate.

To administer this interdisciplinary program, each academic department will assign an adviser (one more than one if needed as the program grows). These advisers will form an advisory team to evaluate applicants for admission to the program. Based upon a student's section of the first certificate, an adviser from the appropriate department will become the student's adviser. Advisers will help students select appropriate courses and determine their progress.

To satisfy the requirements for the Master of Engineering degree, students must complete a total of 36 units of courses, as described below, and maintain a B average for each certificate.

1. Certificate 1 (required): a 15-unit advanced certificate in any engineering department or in the Department of Computer and Information Science.
2. Additional courses agreed upon by the student and adviser to total 36 units. One or more courses in management are generally encouraged. A student may also choose to complete a second certificate as part of these additional courses.

The majority of the 36 units must be from engineering disciplines and the first advanced certificate included in the degree must be from one of the advanced certificates listed below. Prospective students must specify the first advanced certificate as part of the application process.

There is no option for a thesis in this degree program. An average of B is required in all graduate courses taken at Polytechnic for graduate credit.

No more than 9 of the 36 units may be transferred as part of this degree, based upon prior work at other acceptable institutions in subject matter relevant to this degree. A maximum of 3 transfer units may be applied toward each certificate, and up to 6 units may be applied toward the additional courses outside of a certificate program described in No. 2 above.

The degree shall include a capstone experience in one of the following ways: (a) a capstone course within at least one of the advanced certificates included in the degree; (b) a for-credit internship that builds on the program of study within the degree and is monitored by a faculty adviser*; or (c) an advanced design course that builds on the program of study and is explicitly designated by the adviser as the capstone course for the student's program of study. Where feasible, Polytechnic will designate in the University catalog a capstone course within each of the advanced certificates. It will generally be a laboratory or design project course or include a major design project. Where this is not done (b) or (c) will be the preferred mode of completing the degree.

** There is a general requirement for an intern experience as part of the Master of Science or Master of Engineering degree at Polytechnic. See Academic Policies and Degree Requirements in this catalog.*

INTERDISCIPLINARY STUDIES IN ENGINEERING PROGRAM

ENGINEERING ADVANCED CERTIFICATES

Examples of engineering advanced certificates currently available for the first certificate from Polytechnic's departments include the following:

Department of Civil Engineering

- Executive Construction Management (Exec 21)
- Traffic Engineering

Department of Computer and Information Science

- Software Engineering

Department of Electrical and Computer Engineering

- Wireless Communications
- Image Processing
- Computer Engineering
- Telecommunications Network Management

Department of Mechanical, Aerospace and Manufacturing Engineering

- Achieving World Class Quality
- Industrial Engineering
- Manufacturing Engineering and Production Science
- Manufacturing Excellence by Design: Holistic Approach

A second advanced certificate (optional) may be selected from among the first group or may include:

Department of Civil Engineering

- Hazardous Waste Management
- Transportation Planning
- Transportation Management and Economics

Department of Electrical and Computer Engineering

- Telecommunication Network Management

Department of Humanities and Social Sciences

- Environment-Behavior Studies
- Technical Communications

Department of Management

- Construction Management
- Financial Engineering
- Human Resource Management
- Organizational Behavior
- Technology Management
- Telecommunications Management

In addition, some departments offer specific "course sequences" that may appropriately be applied toward the Master of Engineering program.

WIRELESS INNOVATION

Below is a selection of courses focused on wireless innovation that fulfills requirements for a Certificate in Wireless Communications and for the degree Master of Engineering in Interdisciplinary Studies in Engineering.

EL 630	Probability
EL 501	Wireless Personal Communication Systems
EL 601	Principles of Digital Communications: Modulation & Coding
CS 915	Mobile Computing
EL 536	Principles of Communication Networks
EL 930	Wireless Information Networks Lab
EL 602	Wireless Communications: Channel Modeling & Coding
CS 681	Information, Privacy & Security
	Wireless Innovation Capstone Project

Choose 9 units of electives in management, computer science or electrical and computer engineering from among the following:

MG 867	Technology Strategy
MG 607	Marketing
MG 783	New Frontiers in Electronic Business
MG 9XX	Management & Innovation in Wireless e-Commerce
CS 682	Network Management & Security
EL 604	Wireless & Mobile Networking Protocols
EL 675	Radio Propagation for Wireless Systems
EL 775	Antenna Theory: Antennas & Arrays for Wireless Communications

INTRODUCTORY DESIGN AND SCIENCE CORE PROGRAM

The Introductory Design and Science Core Program incorporates the former General Engineering, Introductory Physics and Introductory Chemistry Programs.

Engineering is a wide-ranging field of many disciplines with the common objective to apply science and technology toward the betterment of humanity. Although today's challenges are new as a result of rapidly changing technology, the basic study of engineering remains focused on application of the basic laws of nature. The realization that the work of the engineer touches all aspects of society has broadened the pursuit now to include political, social and human considerations as well as the ability to communicate one's ideas. With these things in mind, the goal of EG 1004 Introduction to Engineering and Design is to introduce students to engineering through a hands-on experiential learning process.

Chemistry concerns the knowledge of the structures, properties and reactions of matter and evolving theories to explain observations, predict chemical behavior and suggest experiments. Undergraduate students are introduced to this basic science in CM 1004 General Chemistry for Engineers.

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. Most undergraduate students are required to take a sequence of two calculus-based courses in physics, PH 1004 Introductory Physics I and PH 2004 Introductory Physics II.

Please Note: For advanced chemistry and physics courses, please consult the Chemistry Program and Physics Program, respectively, in this section.

UNDERGRADUATE COURSES

CM 1004 General Chemistry for Engineers 3:2:1:4

A one-semester introductory course in general chemistry. Chemical equations, stoichiometry, thermodynamics, gases, atomic and molecular structure, periodic table, chemical bonding, states of matter, chemical equilibrium, organic, inorganic and polymeric materials, electrochemistry.

EG 1004 Introduction to Engineering and Design 1:3:2:4

An introduction to selected aspects of the history, philosophy, methodology, tools, and contemporary topics in engineering. Basic engineering experimentation and data analysis. Team design project. Analysis and presentation of engineering data and designs.

PH 1004 Introductory Physics I 4:1½:1:4

First of two introductory courses in general physics. One-dimensional motions. Vectors and two-dimensional motions. Newton's laws of motion. Conservation of energy and momentum. Rotational motions. Gravity. Statics and elasticity. Fluids. Oscillations. Heat and the laws of thermodynamics. *Prerequisite: MA 1024 or an approved equivalent. Co-requisite: MA 1124 or an approved equivalent.*

PH 2004 Introductory Physics II 4:1½:1:4

Second of two introductory courses in general physics. Electric forces and fields. Electric potential and capacitance. Electric current. Magnetic forces and fields. Faraday's law and inductance. Maxwell's equations. Mechanical and electromagnetic waves. Geometrical optics. Interference and diffraction. *Prerequisites: PH 1004, MA 1124 or an approved equivalent.*

LIBERAL STUDIES PROGRAM

Academic Adviser: James P. Lewis
Program Director: Harold P. Sjursen

Liberal Studies is an interdisciplinary liberal arts degree that emphasizes the role of technology in world civilization and provides students interested in science and technology a place to pursue a practical degree program with greater breadth and flexibility than is possible in an engineering degree. Working closely with academic advisers, students develop majors or concentrations that reflect their interests and career goals. The core of the Liberal Studies Program is a series of seminars that look at technology from different perspectives—history, the arts, cultural studies, politics, philosophy and literature. Students focus on a concentration of their choice and combine traditional liberal arts learning with technologically focused career education.

The Bachelor of Science in Liberal Studies is offered by the Department of Humanities and Social Sciences. All students must complete an interdisciplinary major that includes a core concentration in one of the following focus areas:

- Digital Media
- History
- History of Technology and Science
- Literature
- Philosophy
- Psychology

All students can choose, with the consultation of an academic adviser, a second major or professional concentration in almost any field represented in the entire Polytechnic curriculum. In addition to the above areas it is possible to concentrate in the following areas of study:

- Behavioral Science
- Information Design
- Interdisciplinary Physics
- International and Global Studies
- Legal and Political Studies
- Technical Communication
- Urban Studies

GOALS AND OBJECTIVES

The objectives of the Liberal Studies Program are to:

- Foster literacy regarding science and technology in their social, cultural and historical settings
- Produce broadly educated citizens ready to assume leadership positions in a technologically driven world
- Provide practical education for non-engineering students that will lead to meaningful and rewarding careers

DEGREE REQUIREMENTS

All candidates for a BS in Liberal Studies are required to complete the Liberal Arts core courses (52 credits), the Interdisciplinary Liberal Arts major (36 credits comprising six focus courses and three seminars) and additional courses to total 128 credits.

Second majors and professional concentrations (40 credits) may be developed by students in consultation with the program academic adviser.

A description of second majors is available from the program adviser.

Liberal Studies students may also earn a minor in any of the subject areas.

Liberal Arts Core Program Courses

Course No.	Course Title	Credits
EN 1014/1034	Writing & the Humanities I	4
EN 1204	Writing & the Humanities II	4
HI 2104	Main Themes in Contemporary World History	4
	Liberal Arts Electives	8
	Advanced Liberal Arts Elective	4
CS 1114	Intro. to Programming & Problem Solving	4
MA 1114	Mathematics for Liberal Studies	4
	Natural Science Sequence (CM, PH, LS or others as approved by adviser)	8
LA 1014	Introduction to the History & Philosophy of Technology	4
LA 1024	Computers, Technology & Values	4
LA 2014	Technology & the Human Condition	4
	Liberal Studies Focus Courses in the area of primary concentration (as approved by adviser)	24
	Liberal Studies Seminars	12
	Professional concentration or free electives	40
TOTAL		128

UNDERGRADUATE COURSES

ANTHROPOLOGY

AN 3134 Introduction to Physical Anthropology 4:0:0:4

Biosocial bases of human conduct seen in evolutionary perspective; elementary genetic, demographic, and ecological models necessary for understanding human behavior; biology as an evolutionary complex extending from Prosimian revolution through the Neolithic revolution.

AH 3144 North American Indians 4:0:0:4

Social evolution from the hunting and gathering band through state society; consideration of variation and developmental trends in several institutions: kinship, economic organization, warfare, politics, religion and technology.

AN 3404 Chinese Art and Civilization 4:0:0:4

A basic discussion of the structure of Chinese civilization with a review of important art forms from Neolithic times to the present, with emphasis on visual documentation.

AN 3504 Special topics in Anthropology 4:0:0:4

Focus on a special topic in anthropology completed under the guidance of a faculty member. May be repeated for credit on a different topic. *Prerequisite: instructor's permission.*

AN 3604 Independent Study in Anthropology 4:0:0:4

Independent or small group work under supervision of instructor, by special arrangement. *Prerequisites: for Liberal Studies/Integrated Digital Media majors only and instructor's permission.*

AN 4504 Senior Project in Anthropology 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project advisor. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: Liberal Studies seniors only and by departmental permission.*

ART HISTORY

The Art History electives are divided into two levels: introductory (2000-level) and advanced (3000-level). The fourth-credit hour for all Art History courses take the form of an increased communication component: at least four graded writing assignments, regular informal writing and individual or group presentations. All Art History electives have a final exam.

AH 2114 Introduction to Art History 4:0:0:4

An introduction to Western art in different historical periods, with a focus on pre-20th century art. Objectives: to sample important periods and themes in European art history, from archaic Greece to the present; and enhance cultural, social and aesthetic understanding through intensive engagement with a variety of visual forms in different historical periods. *Prerequisite: EN 1204.*

AH 2124 Modern Art 4:0:0:4

Western art from the late 19th century to the present. Objectives: to sample important periods and themes in modern art; and enhance cultural, social and aesthetic understanding through intensive engagement with a variety of visual forms in different historical periods. *Prerequisite: EN 1204.*

AH 3114 Studies in National Traditions in the Visual Arts 4:0:0:4

Study of a particular national tradition or several related national traditions in the visual arts. Objectives: to study the emergence of a national traditional within the visual arts; and enhance cultural, social and aesthetic understanding through intensive engagement with a variety of visual forms in different his-

torical periods. *Prerequisite: one 2000-level AH course.*

AH 3124 Special Topics in Art History 4:0:0:4

Independent or small group work, under supervision of instructor, by special arrangement. *Prerequisites: Liberal Studies majors only and instructor's permission.*

AH 3404 Independent Study in Art History 4:0:0:4

Focus on a special topic in the history of art. May be repeated for credit for different topics. Objectives: to study a particular aspect of art history and enhance cultural, social and aesthetic understanding through intensive engagement with a variety of visual forms in different historical periods. *Prerequisite: one 2000-level AH course.*

AH 4504 Senior Project in Art History 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project adviser. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: Liberal Studies seniors only and by departmental permission.*

ECONOMICS**EC 2504 Basic Economics** 4:0:0:4

An introduction to the field of economics. Covering both micro- and macroeconomics, it includes such concepts and specific areas of study as supply and demand, income distribution, national output, money and banking, fiscal and monetary policy and international trade. In general, the course introduces the way economists approach economic questions by focusing on five interrelated economic areas: (1) economic theory and methodology; (2) the sources and reliability of economic data; (3) economic institutions, such as the Federal Reserve or the IMF; (4) the role of government in the economy; and (5) the historical contexts of contemporary economic questions.

EC 2514 Microeconomics 4:0:0:4

An advanced course in microeconomics. Theory is presented in all its elegance along with a variety of illustrative applications. Designed for students concentrating in economics or management, those intending to go on to graduate programs in economics or business administration and others interested in the field of economics. *Prerequisite: EC 2504.*

EC 2524 Managerial Microeconomics 4:0:0:4

An advanced course in microeconomics for students with appropriate mathematical background. This course presents microeconomic analysis and its application to business decision making. Fundamentals of the theory of the firm, the theory of the consumer and market structure and competition are presented, including both theoretical models and quantitative analysis techniques. Advanced topics in information asymmetries and externalities are presented. *Prerequisite: required for students in the Business and Technology Management Program; MA 1112; does not satisfy general education requirements in Humanities and Social Sciences.*

EC 2534 Macroeconomics 4:0:0:4

An advanced course in macroeconomics. Presents macroeconomic theory and applies it to the US macroeconomy in the post-World War II period. Course focuses on macroeconomic phenomena and macroeconomic problems, including unemployment, inflation and recessions. It pays special attention to the role of government in this area. Finally, it introduces economic data and their inherent problems. Designed for students concentrating in economics or management, those intending to go on to graduate programs in economics or business administration and others interested in the field of economics. *Prerequisite: EC 2504.*

EC 3254 Economic Issues 4:0:0:4

Building on the foundation provided in the introductory course in economics, course examines a number of contemporary economic issues in greater depth. The specific issues studied vary and depend on student interests, professor's interests and the availability of appropriate reading material. Occasionally a text

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is used, although usually reading material from a variety of sources is assigned. Issues focused on include: government regulation of safety, regulation and testing of pharmaceutical drugs by the FDA; potential use of the market for organ transplants; alternative tax proposals; and social security “reforms”; NAFTA; racial and sexual discrimination and alternative medical plans. *Prerequisite: EC 2504.*

EC 3264 American Economy: Boom and Bust 4:0:0:4

An advanced macroeconomic course that examines the nature of the fluctuations in aggregate economic activity, the so-called “business cycle”, that have characterized capitalist growth in general and the American economy in particular. The course focuses on recent decades, especially the period since 1993. In doing so, it studies the changing features of the American economy since then and the problems that have accompanied these changes, such as unemployment, inflation, recessions and the budget and trade deficits. Within this context, much time is spent in careful analysis of government’s role in the economy, in particular, the role of the Federal Reserve, but also the impact of the fiscal policy of the federal government on macroeconomic stability. *Prerequisite: EC 2504.*

EC 3404 Special Topics in Economics 4:0:0:4

Focus on a special topic in Economics, completed under the guidance of faculty member. May be repeated for credit on a different topic. *Prerequisite: instructor’s permission.*

EC 3504 Independent Study in Economics 4:0:0:4

Independent or small-group work, under supervision of instructor, by special arrangement. *Prerequisites: Liberal Studies majors only and instructor’s permission.*

EC 4504 Senior Project in Economics 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project advisor. In addition,

students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: Liberal Studies seniors only and by departmental permission.*

ENGLISH AND LITERATURE

Basic English and Writing Courses:

EN 1080	Reading and Writing in English
EN 1090	Introductory Composition
EN 1014	Writing and the Humanities I
EN 1034	Writing and the Humanities I
EN 1204	Writing and the Humanities II

The English/Literature offerings are divided into two levels: introductory (2000-level) and advanced (3000-level). The introductory literature courses are designed to introduce students to intensive reading and research in either a particular literary genre or in survey courses.

In a genre course such as poetry, other forms of cultural expression such as painting or nonfiction prose may be considered when appropriate, or the instructor may choose to include poetry from a range of national literatures.

Advanced studies courses are designed to allow students to explore at a more advanced level specific cultural, aesthetic, and historical questions through (1) reading and writing about literary texts from specific national and cultural traditions, or (2) exploring the interrelations between literary expression and other forms of cultural, social and political discourse. May be repeated for credit, provided that the topic differs.

The fourth credit hour for all literature courses takes the form of an increased communication component (at least four graded writing assignments, regular informal writing and individual or group presentations) and an intercultural/interdisciplinary component. For example, in a Shakespeare survey course, the intercultural/interdisciplinary component might be readings in Renaissance philosophy, history or art history. In an American literature survey course, this component might be readings in American and European political history.

All literature courses include a final exam or final project.

GENRE (2000 level) Prerequisite: EN 1204

EN 2114	Poetry
EN 2124	The Short Story
EN 2134	The Novella
EN 2144	The Novel
EN 2154	Drama
EN 2164	Science Fiction

SURVEY (2000 level) Prerequisite: EN 1204
EN 2214 World Literature
EN 2224 English Literature
EN 2234 American Literature
EN 2444 Shakespeare

ADVANCED LITERATURE (3000+ level) Prerequisite: one 2000-level EN course.

EN 3114	Advanced Studies in World Literature
EN 3124	Advanced Studies in English Literature
EN 3134	Advanced Studies in American Literature
EN 3214	Gender and Literature
EN 3224	Media Studies
EN 3234	Science, Technology and Literature
EN 3244	Literature and the Arts
EN 3254	Special Topics in Literature
EN 3404	Independent Study
EN 4504	Senior Project

EN 1014 Writing and the Humanities I 4:0:0:4

An introduction to the humanities and to effective techniques of college-level writing. The course examines basic concepts, form and techniques of philosophy, art and literature, with emphasis on fluency, precision and imaginative use of source materials in writing. *Prerequisite: SAT essay score (beginning fall 2006) or placement examination administered by the Department of Humanities and Social Sciences, or EN 1090. EN 1080 only with the recommendation of the student’s EN 1080 instructor; approved by the director of writing curriculum.*

EN 1034 Writing and the Humanities I (English as a Second Language) 4:0:0:4

An introduction to the humanities and to effective techniques of college-level writing. Designed for students for whom English is a second language. The course examines basic concepts, forms and techniques of philosophy, art and literature, with emphasis on fluency, grammar, syntax, precision and imaginative use of source materials in writing. *Prerequisite: SAT essay score (beginning fall 2006) or placement examination, or EN 1080. EN 1090 only with the recommendation of the student’s EN 1090 instructor; approved by the director of writing curriculum.*

EN 1080 Reading and Writing in English as a Second Language 6:0:0:0

An intensive course for non-native speakers of English, taught at the high

intermediate level. Students develop grammatical and syntactical control in writing, improve their comprehension of college-level texts and learn to organize an essay in the American academic idiom. The course includes some practice in listening and speaking for academic and professional purposes. *Prerequisite: SAT essay score (beginning fall 2006) or placement examination administered by the Department of Humanities and Social Sciences.*

EN 1090 Introductory Composition

4:0:0:0

An intensive course in reading comprehension and composition skills for students who have not been adequately prepared for college composition and reading. Designed for native speakers of English or non-native speakers with a high-level of experience communicating in American English. Emphasis is on improvement of control of standard grammar and syntax in American English and on fluency in writing. Students develop grammatical and syntactical control in writing, improve their comprehension of college-level texts and learn to organize an essay in the American academic idiom. *Prerequisite: SAT essay score (beginning fall 2006) or placement examination administered by the Department of Humanities and Social Sciences.*

EN 1204 Writing and the Humanities II

4:0:0:4

An introduction to the humanities and to advanced techniques of writing. Thematic emphasis on change and continuity in the humanities is presented, as well as an exploration of the interrelationship of the humanistic disciplines through the study of works of art, philosophy, literature and, in some sections, music. Advanced work is given to stylistic options and more complex forms of writing, including the longer critical study, the formal report, and, especially, the research paper. In some cases, this course may be presented as an introduction to literature. *Prerequisite: EN 1014 or EN 1034. In the interest of maximizing the student's potential for success, advanced placement and transfer credits accepted as prerequisites pending the results of a placement test and approval by the director of writing curriculum. Under no circumstances will transfer credit be given for EN 1204 in the absence of approved*

transfer credits for its prerequisite, EN 1014 (or EN 1034).

EN 2114 Poetry

4:0:0:4

An introduction a range of poetic forms and an exploration of the relation between poetry and other forms of cultural expression. Objectives: to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about a range of poetic forms. *Prerequisite: EN 1204.*

EN 2124 The Short Story

4:0:0:4

An introduction to the themes, structures and techniques of the short story. Objectives: to introduce the short story as a literary form; promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about short fictional texts. *Prerequisite: EN 1204.*

EN 2134 The Novella

4:0:0:4

An introduction to the themes, structures and techniques of the short story. Objectives: to introduce the novella as a literary form; to promote research and critical reading and thinking skills; to promote written and oral communication skills; and enhance cultural, social and aesthetic understanding through intensive reading of and writing about literary texts. *Prerequisite: EN 1204.*

EN 2144 The Novel

4:0:0:4

An introduction to the history, themes, structures and techniques of the novel. Objectives: to introduce the novel as a literary form; to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about literary texts. *Prerequisite: EN 1204.*

EN 2154 Drama

4:0:0:4

An introduction to the themes, structures and techniques of dramatic writing. Objectives: to explore the purpose of theater and investigate techniques of modern

drama, its language and its subject matter, and to generate a critical discourse around selected dramatic masterpieces; to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social, and aesthetic understanding through intensive reading of and writing about literary texts. *Prerequisite: EN 1204.*

EN 2164 Science Fiction

4:0:0:4

A survey of science fiction. Definitions and development of the genre, scientific and historical contexts, contemporary and future visions. Promote understanding of the relationship between science and literature and of the conventions and special concerns of this genre. Objectives: to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading and writing about literary texts. *Prerequisite: EN 1204.*

EN 2214 World Literature

4:0:0:4

A survey of forms, ideas and changes in world literature, emphasizing a comparative approach. Objectives: to read literary works from Europe and other continents and explore the meaning of literary traditions through works written in English and in other languages and translated into English; to study the structural differences and parallels of great works of diverse cultures; to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about literary texts. *Prerequisite: EN 1204.*

EN 2224 English Literature

4:0:0:4

A survey of British literature from the medieval period to the present. Objectives: to introduce the themes, forms and historical contexts of British literature; to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about literary texts. *Prerequisite: EN 1204.*

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EN 2234 American Literature 4:0:0:4

A survey of American literature from the Puritans to the present. Objectives: to introduce the themes, forms, and historical contexts of American literature; to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about literary texts. *Prerequisite: EN 1204.*

EN 2244 Shakespeare 4:0:0:4

Representative tragedies, comedies, histories. Cultural and literary influences. Textual problems, recent criticism, Elizabethan theater. Objectives: to introduce the works of William Shakespeare and to explore their aesthetic, cultural and historical contexts; to promote research and critical reading and thinking skills; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about literary texts. *Prerequisite: EN 1204.*

EN 3114 Advanced Studies in World Literature 4:0:0:4

Focus on a special topic in world literature; may include comparative and intercultural studies. May be repeated for credit for different topics. Objectives: to promote research and critical reading and thinking skills; to enhance cultural, social and aesthetic understanding through intensive reading of and writing about literature from a non-western and/or non-English-speaking culture. *Prerequisite: 2000-level EN course.*

EN 3124 Advanced Studies in English Literature 4:0:0:4

Focus on special topic in literature of Great Britain. May be repeated for credit for different topics. Objectives: to promote research, critical reading and thinking skills; and to enhance cultural, social and aesthetic understanding through study of texts from Great Britain. *Prerequisite: 2000-level EN course.*

EN 3134 Advanced Studies in American Literature 4:0:0:4

Focus on special topic in literature of the United States. May be repeated for credit

for different topics. Objectives: to promote research, critical reading and thinking skills; and to enhance cultural, social and aesthetic understanding through study of particular issues in American Literature. *Prerequisite: 2000-level EN course.*

EN 3214 Gender and Literature 4:0:0:4

Explores literary, philosophical, social, and cultural questions related to gender and sexuality. May be repeated for credit for different topics. Objectives: to promote research, critical reading and thinking skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about texts concerned with gender issues. *Prerequisite: 2000-level EN course.*

EN 3234 Science, Technology and Literature 4:0:0:4

Study of literary texts and other forms of cultural expression in relation to issues in science and technology. May be repeated for credit for different topics. Objectives: to promote research, critical reading and thinking skills; and to enhance cultural, social and aesthetic understanding through intensive reading of and writing about cultural expression in relation to issues in science and technology. *Prerequisite: 2000-level EN course.*

EN 3244 Literature and the Arts 4:0:0:4

Study of the interrelation of literary texts and other forms of cultural expression, particularly music and/or visual arts. May be repeated for credit for different topics. Objectives: to promote research, critical reading and thinking skills; and to enhance cultural, social and aesthetic understanding through study of the possible connections among a variety of representative and aesthetic forms. *Prerequisite: 2000-level EN course.*

EN 3254 Special Topics in Literature 4:0:0:4

Study of a special topic in literature. May be repeated for credit for different topics. Objectives: to promote research, critical reading and thinking skills; and to enhance cultural, social and aesthetic understanding through study of a special topic in literature. *Prerequisite: 2000-level EN course.*

EN 3404 Independent Study in Literature 4:0:0:4

Independent or small group work, under supervision of instructor, by special arrangement. *Prerequisites: Liberal Studies majors only and instructor's permission.*

EN 4504 Senior Project in Literature 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project advisor. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: Liberal Studies seniors only and departmental permission.*

HISTORY

HI 2104 Modern World History 4:0:0:4

Required course for all students. An introduction to the history of the late 18th, 19th and 20th centuries from a global perspective. It begins with a consideration of the democratic and industrial revolutions in the West and the rise of nationalism. A good part of the course is spent on the 20th century, with attention to the world wars, the Great Depression, the Cold War, revolutionary technological and political change and globalization. The important political ideologies of the 19th and 20th century are discussed: liberalism, socialism, communism and fascism. Specific sections may take an intercultural approach and compare Western history to Chinese history, for example. Emphasis is placed on the reading of primary texts and in-depth secondary texts. Analytic reading of a variety of media, and the writing of reasoned arguments based on evidence are an important part of the course. *Prerequisite: none.*

HI 2214 Introduction to the History of Science 4:0:0:4

General introduction to issues in science and society through the perspective of history. The course's approach is to look at a scientific world view in its varying social contexts as it developed over several hundred years. The mechanical world view emerged during the scientific

revolution and led to an understanding of planetary motion, the ability to go to the moon and the power to harness nuclear energy. Topics include social context of the scientific revolution, Copernicus, Galileo, science and the Church, Newton, Bohr and atomic structure and nuclear energy and the decision to drop the atomic bomb. *Prerequisite: HI 2104.*

HI 2224 Science and Industry in the Modern World 4:0:0:4

Examines science and industry in the 19th and 20th centuries, a time when science and technology became very closely bound. Course covers areas where significant advances occurred that brought large societal changes. For example: (1) the development of new forms of communication like the telegraph, radio and telephone and (2) the development of a theoretical basis for mechanical computing and the computer revolution. Course pays close attention to the political and business contexts of these developments. *Prerequisite: HI 2104 and one of the following: HI 2214, HI 2224, PL 2104, PL 2094, PL 2064, EN 2164 or instructor's permission.*

HI 2314 United States History from Colony to Empire 4:0:0:4

Surveys the history of the United States, focusing on the history of British North America, the American Revolution, the development of capitalism in the early republic, the conflict over slavery caused by the schism between capitalist and liberal values and the resulting cataclysm of southern secession and civil war. How and why did the United States become the world's leading military and industrial power in the 20th century. Topics include the re-unification of the United States as nation-state after the Civil War, the social, technological and economic effects of the "second industrial revolution," the closing of the frontier and the subsequent push for U.S. territorial expansion in the Pacific Ocean and the Caribbean Sea, immigration and nativism, the era of Progressive reform and the catastrophic wars and depressions of 1914-1945. The course reaches into the post-1945 world to explore the Cold War and examine American participation in the wars in Indochina, 1941-1975, and the attempt to create a "new world order" under US leadership. *Prerequisite: none.*

HI 2414 Europe from 750-1700 AD 4:0:0:4

Introduces Europe in world perspective before the industrial revolution. Covers European society from the atomization of society and the fall of the Western Roman Empire to the emergence of Europe as a center of world trade. Topics include feudalism, the rise of European cities, the Renaissance, the Reformation and the relationship of trade, the state and exploration. Compares European society to other complex civilizations of the pre-modern era. Course based on readings, lectures and discussion. *Prerequisite: HI 2104.*

HI 2424 20th Century Eastern Europe 4:0:0:4

Covers Eastern Europe, including the Soviet Union, from the end of empires at the end of World War I to the collapse of Communism and the period of transition. Includes surveying how problems of economic underdevelopment, socioeconomic conflict, war and ideology affected a region at once central and peripheral during the 20th century. Looks at conflict between nationalism and Communism and the continuing quest to create a modern society on a par with Western Europe. Course based on readings, lectures and discussion. *Prerequisite: HI 2104*

HI 2514 History of the City of New York 4:0:0:4

Advanced level undergraduate course covers the history and development of the city of New York from its exploration by Giovanni de Verazzano in 1524 to the present. Major themes include the evolution of the city's political economy, political and economic influences on the use of land and space and ethnic and class conflict in the urban environment, the consolidation of Greater New York. *Prerequisite: HI 2104.*

HI 2624 American Civil Liberties 4:0:0:4

Examines the development of civil rights beginning with their roots in early modern England, through the latest Supreme Court decisions in the field. Builds on students' basic legal research skills by teaching them how to read, discuss and write about complicated constitutional cases, and how to transcend the narrow

boundaries of legal discourse by placing cases in historical context. *Prerequisite: HI 2104 or instructor's permission.*

HI 2714 Modern Asia 4:0:0:4

Explores the major civilizations in Asia from the mid-17th century to the present with attention to their interaction with the West. Primary emphasis on Chinese, Indian and Japanese history. Topics include the colonialism and imperialism, the Opium Wars, the 20th-century revolutions in China, India under the British, Gandhi, the modernization of Japan, the rape of Nanking, Mao Zedong, Deng Xiaping, the Asia-Pacific Economic Zone, French Indo-China, Ho Chi Minh and Islamic revolutions in Iran and Afghanistan. *Prerequisite: HI 2104.*

HI 3034 History of the Urban Infrastructure 4:0:0:4

This course examines the history of New York City's infrastructure, concentrating on water, sanitation and public health, transportation, electrical and communications systems, the development of housing and real estate, the security infrastructure and plans for it future. The broad question the course addresses is how the political economy of the city has shaped its physical environment, and more particularly the technological innovations that have made the city modern, and post-modern. *Prerequisite: HI 2104.*

HI 3214 Early Modern Science 4:0:0:4

Covers the development of modern science from the Renaissance through the Enlightenment. Sets the stage for the scientific revolution. Looks at the contribution of the Arab world, the Renaissance in the West and the importance of voyages of discovery to the New World. Takes a comprehensive look at the scientific revolution by considering its revolutionary nature, the social and professional contexts within which it took place and the experimental practices and theoretical ideas that brought it to fruition. Course concludes with the work in electricity and magnetism, chemistry and encyclopedic understanding of the Enlightenment. *Prerequisites: HI 2104 and one of the following: HI 2214, HI 2224, PL 2104 or instructor's permission.*

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HI 3404 Special Topics in History 4:0:04

Independent or small group work under supervision of instructor, by special arrangement. *Prerequisites: Liberal Studies majors only and instructor's permission.*

HI 3414 Nations and Nationalism 4:0:0:4

Examines the power of nationalism in the modern world. Topics include the relationship between ethnic groups and modern nations and the dispute over the origins of nations, scholarship and national identity, the relationship between state and nation, the nature of the nation-state, and the nation and industrial society and nations as tools for inclusion and exclusion. The course is based on readings, lectures and discussion. *Prerequisites: HI 2104 and introductory level history course or instructor's permission.*

HI 3604 Independent Study in History 4:0:0:4

Independent or small group work under supervision of instructor, by special arrangement. *Prerequisites: Liberal Studies majors only and instructor's permission.*

HI 3714 Seminar in American Foreign Relations and International History 4:0:0:4

Examines selected topics in the history of American foreign relations from the American Revolution through the Cold War, including the diplomacy of the revolution, the rise of territorial expansion, overseas imperialism, American nationalism and the attempts by American elites to lubricate the movement of global capital that dominated 20th century U.S. foreign relations. Assigned readings in relevant area studies balance internalist readings of U.S. foreign policy with "international history" approaches. *Prerequisite: HI 2104. Note: together with HI 4724, this course fulfills the sequence requirement for juniors and seniors.*

HI 4724 Seminar in International History since 1945 4:0:0:4

An advanced interdisciplinary course in international history since 1945. The goal of the course is to deconstruct the field of

cold war studies by exploring the history of international relations since 1945 from the perspectives of ideology, technology and culture in the developed world and the problems of relations between the third world and the superpowers. This is not a traditional history course in the sense of a chronological progression of events. It is assumed that students are generally familiar with the historical events under discussion. Instead, attempting to understand a fragmented world, the course explores a series of topics and techniques for understanding international relations, including modernization and dependency theories and their critics; and international organizations and other transnational regimes for global management, including the United Nations, the Bretton Woods Accords and the economic recovery of Western Europe. *Prerequisites: HI 3714 and another 3000 or higher level history course or instructor's permission.*

HI 4504 Senior Project 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project advisor. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: Liberal Studies seniors only and by departmental permission.*

LAW AND TECHNOLOGY

The Law and Technology Sequence is an 8-credit sequence designed to fit with the requirements of engineering and computer science majors. It is intended to give undergraduates some exposure to law, legal methods and intellectual property so that they can:

1. Better understand the legal implication of their work as computer scientists and engineers
2. Evaluate their potential for law school admission and their possible interest in a legal career

The sequence consists of LW 3104 Introduction to Legal Writing and Research and LW 4104 The Law of the Internet.

LW 3104 Introduction to Legal Writing and Research 4:0:0:4

This course acquaints students with a basic knowledge of how laws and regulations are passed and how competing interests are adjudicated by the three branches of government. Emphasis on the administrative and judicial processes. Students learn how to read judicial and administrative decisions and the basics of legal writing. *Prerequisite: none.*

LW 4104 The Law of the Internet 4:0:0:4

This course is a general survey of legal regulation of the Internet, including an outline of intellectual property law relevant to the Internet, the law of commercial transactions on the Internet and computer crime. *Prerequisite: LW 3104.*

LW 4533 Construction Law 3:0:0:3

This course introduces students to the areas of the law that they are most likely to encounter in construction. Following an introduction to the legal system and from of legal analysis, areas to be addressed include contracts, procurement, scope definition, delays and acceleration, site conditions, warranties, termination, tort claims, dispute resolution and ethics. *Prerequisite: students must be enrolled in the Construction Management Program.*

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All liberal studies courses are required for students in the Liberal Studies Program. LA courses can NOT be applied toward a humanities or social sciences course requirement.

LA 1014 Introduction to the History and Philosophy of Technology 4:0:0:4

Introduces students to important issues, historical and contemporary, related to technology from a variety of social, political and philosophical viewpoints. Course serves as a foundation for the interdisciplinary approach of the Liberal Studies Program. *Prerequisite: none.*

LA 1024 Computers, Technology and Values 4:0:0:4

Introductory examination of the social, cultural and political impact of networked computers in the contemporary world. *Prerequisite: none.*

LA 2014 Technology and the Human Condition 4:0:0:4

This course provides an understanding of the human species and human technological output from the interdisciplinary perspectives of biology, psychology, anthropology and ethics. Through readings, lectures, discussions and field trips, the inter-relationship between human growth, development, evolution and technology and the impact and implications of technology for both the human species and the ecosystem are analyzed. *Prerequisite: LA 1014.*

LA 3014 Seminar in Liberal Studies I 4:0:0:4**LA 3024 The Design of Cities** 4:0:0:4

The course is intended to help students discover different ways of looking at and understand what cities are and how they work to effect people and institutions, largely from the perspective of environmental social sciences. Course topics address methodological approaches to observing and studying city spaces, the historical context of urban life, including the role of preservation in maintaining a sense of community. Course addresses sustainable approaches to creating urban spaces, including “smart growth” strategies; the special role of the arts in urban life and development; the relationship between urban settings and natural environments; and the role of design in crime and crime prevention. Students work as teams to conduct a case study of a local urban setting, assessing its context, design and impact as an urban development. *Prerequisite: LA 1014.*

LA 4014 Seminar in Liberal Studies II 4:0:0:4**LA 4024 Seminar in Liberal Studies III** 4:0:0:4**MUSIC**

The Music electives are divided into two levels: introductory (2000-level) and advanced (3000-level). The fourth credit hour for all music courses takes the form of an increased communication component: At least four graded writing assignments, regular informal writing and individual or group presentations. *Prerequisite: EN 1204.*

MU 2114 Understanding Music 4:0:0:4

A survey of Western classical music from the early Middle Ages through 19th-century Romanticism. Objectives: to introduce students to ways of listening to classical music; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive engagement with musical expression. *Prerequisite: EN 1204.*

MU 2124 Modern Music 4:0:0:4

A survey of modern music, from the Late Romantics to contemporary composers. Objectives: to introduce students to ways of listening to modern music; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive engagement with musical expression. *Prerequisite: EN 1204.*

MU 2134 Introduction to Opera 4:0:0:4

A survey of the opera form. Objectives: to introduce students to ways of listening to opera; to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive engagement with musical expression. *Prerequisite: EN 1204.*

MU 3114 Studies in National Traditions in Music 4:0:0:4

Focus on a particular national tradition in music. Objectives: to promote written and oral communication skills; and to enhance cultural, social and aesthetic understanding through intensive engagement with traditions in national music. *Prerequisite: one 2000-level MU course.*

MU 3124 Special Topics in Music 4:0:0:4

May be repeated for credit for different topics. Objectives: to promote written and oral communication skills, and to enhance cultural, social and aesthetic understanding through intensive engagement with a special topic in music. *Prerequisite: one 2000-level MU course.*

PHILOSOPHY**Course List**

The philosophy electives are divided into two levels: introductory (2000-level) and advanced (3000-4000 levels).

Introductory Level

PL 2014	Symbolic Logic
PL 2024	Ancient Philosophy (I, II, III)
PL 2034	Philosophy of Religion (I, II)
PL 2044	Social Philosophy (I, II)
PL 2054	Ethical Theories (I, II)
PL 2064	Ethics and Technology (II, IV)
PL 2074	Asian Philosophy (I, II, III)
PL 2084	Science and Society (II, IV)
PL 2094	Space and Space-time (I, III, IV)
PL 2104	Magic, Medicine and Science (I, III, IV)
PL 2114	Philosophy of Relativity (III, IV)
PL 2124	Philosophy of Quantum Mechanics (III, IV)
PL 2164	Modern Philosophy (I, II, III)

Advanced Level

PL 3014	Metalogic (IV)
PL 3034	Critical Theory (II, III)
PL 3044	Political Philosophy (I, II)
PL 3054	Philosophy of Art (II)
PL 3064	Philosophy of Technology (IV)
PL 3074	Philosophy of Mathematics (III, IV)
PL 3094	Philosophy of Science (III, IV)
PL 3104	Metaphysics and Epistemology (I, III)
PL 4052	Business Ethics
PL 4062	Computer Ethics
PL 4113	Special Topics

Requirements for the Philosophy Major in the Liberal Studies Program (six courses, 24 credits)

The BS in Liberal Studies allows students to major in philosophy. The following are requirements for such a concentration:

PL 2014 Symbolic Logic

One course from each of the following categories, totaling four courses: (1) history of philosophy, (2) philosophy and society, (3) metaphysics and epistemology, (4) science and technology

One additional course.

Total credit hours: 24

(1) History of philosophy: Ancient Philosophy, Modern Philosophy, Philosophy of Religion; Social Philosophy; Ethical Theories; Asian Philosophy; Philosophy of Space-time; Magic, Medicine and Science; Political Philosophy; Metaphysics and Epistemology

(2) Philosophy and society: Ancient Philosophy; Philosophy of Religion; Social Philosophy; Ethical Theories; Ethics and Technology; Asian Philosophy; Science and Society; Modern Philosophy; Critical Theory; Political Philosophy; Philosophy of Art

(3) Metaphysics and epistemology: Ancient Philosophy; Asian Philosophy; Philosophy of Space-time; Philosophy of Relativity; Philosophy of Quantum Mechanics; Magic, Medicine and Science; Modern Philosophy; Critical Theory; Philosophy of Mathematics; Philosophy of Science; Metaphysics and Epistemology

(4) Science and technology: Ethics and Technology; Science and Society; Philosophy of Space-time; Philosophy of Relativity; Philosophy of Quantum Mechanics; Magic, Medicine and Science; Philosophy of Technology; Philosophy of Mathematics; Philosophy of Science; Metalogic

Introductory Level

PL 2014 Symbolic Logic 4:0:0:4

An introduction to the methods and applications of first-order symbolic logic, including both sentential logic and predicate logic (up to and including relational predicate logic with identity). Logic is the study of arguments; in particular, the study of the conditions under which the premises of an argument adequately support its conclusion; i.e., the conditions under which an argument is valid. There is more than one flavor of validity; the kind of validity courses are concerned with is called deductive validity. Course covers methods of testing arguments for deductive validity and deductive invalidity, as well as methods for identifying tautologies, contradictions and logical equivalence. *Prerequisite: none.*

PL 2024 Ancient Philosophy 4:0:0:4

An introduction to ancient philosophy in the Western tradition. Works covered include the pre-Socratic philosophers, Plato, Aristotle, Seneca, Marcus Aurelius and the Roman Stoics. The goal of this course is to bring these philosophers into dialogue with each other, highlighting their similarities and differences in an attempt to show their importance in the history of philosophy and their relevance to society today. *Prerequisite: none.*

PL 2034 Philosophy of Religion 4:0:0:4

An investigation of the concepts, belief systems and practices of religions. By analyzing central concepts of religion—such as God, faith, revelation, salvation

and the relationship between religion and science, morality and art—both the believer and non-believer may achieve a more sophisticated understanding and appreciation of religions. Class addresses such topics as religious experience, faith and reason, arguments for God's existence, the problem of evil, religious language, life and the after-life and the conflicting claims of different religions. *Prerequisite: none.*

PL 2044 Social Philosophy 4:0:0:4

The social sciences deal specifically with human subjects and institutions rather than the natural world and phenomenon. As opposed to the natural sciences, which are explanatory, the social sciences are interpretive. This interpretive turn raises a number of questions: What exactly is an interpretation? What makes an interpretation correct or better than another interpretation? Are interpretations universal or relative to culture? Class examines the relationship between individuals and societies in order to form a better understanding of who we are, how we should live together, how we investigate societies and social phenomena, what constitutes a personal identity, what constitutes a political identity, what is race, what is gender. *Prerequisite: none.*

PL 2054 Ethical Theories 4:0:0:4

Ethics, or moral philosophy, endeavors to establish rational principles of right conduct that can serve as decision-making guides for individuals and groups. It also prescribes the characteristics and personality traits that enable individuals to live well in communities with others. Class attempts to achieve a systematic understanding of the nature of ethics and what it requires of us. Discussion of historical sources such as Plato, Aristotle, Hobbes, Mill, and Kant, ethical theories (moral relativism, egoism, utilitarianism, justice and rights, virtue, ethics, and feminist transformations of moral theory) and contemporary moral problems (abortion, euthanasia, economic justice, animal rights, the death penalty and affirmative action). *Prerequisite: none.*

PL 2064 Ethics and Technology 4:0:0:4

Students consider how technology shapes and patterns—and, in turn, how it is shaped and patterned by—human activi-

ties from a moral point of view. The focus of this course is on the ways in which the technologically textured world changes human life, individually, socially and culturally, for better or worse. Students consider several views of technology and several ethical theories for evaluating technology. The aim is to understand the structures of change and transformation and to develop critical forms of thought so as to be able to understand, evaluate, appreciate and criticize technological development. *Prerequisite: none.*

PL 2072 Bioethics 4:0:0:2

Bioethics is a critical, reflective examination of the impact, effects and transformations of biotechnology upon human activities. The use of biotechnology is becoming an increasingly important feature of society. Biotechnologies are more than mere things that do nothing in themselves; instead they affect the very ways people act, perceive and understand. The class examines the relationship between biotechnology and ethics and politics, questioning the limits of what are its just and appropriate uses. *Prerequisite: none.*

PL 2074 Asian Philosophy 4:0:0:4

Addresses the fundamental questions of philosophy—What is real? What is good? How do we know?—by considering the answers given by philosophers from India, China and Japan. Philosophy in Asia has not been viewed as an abstract academic subject with little or no relevance to daily life. Rather, it has been seen as one of life's most basic and most important enterprises. It is seen as essential to overcoming suffering and improving the quality of human life. There are no rigid distinctions between philosophy and religion in Asian thought. Class examines the Asian philosophical tradition in an attempt to understand both its historical importance and its relevance to society today. *Prerequisite: none.*

PL 2084 Science and Society 4:0:0:4

Investigates the relation between science and society. This course is offered in two forms: (1) Thinking about the environment: a survey of contemporary environmental issues with emphasis on the development of the reasoning skills needed to make informed judgments. In the past, topics covered have included the history of environmentalism in the

United States., atmospheric ozone, global warming, acid rain, air pollution, global population growth, pesticides, radon, nuclear power, biodiversity and species extinction and genetically modified crops. (2) Science and pseudoscience: a survey of popular “pseudoscientific” claims with emphasis on such issues in the philosophy of science as demarcation, evidential warrant, scientific progress, science and public policy and fallacies of reasoning. In the past, topics covered have included UFO sightings and alien abductions, the Nemesis theory of dinosaur extinctions, astrology, creationism, psychic phenomena, theories of intelligence, alternative medicines, global warming and cold fusion. Student input in determining topics to cover is heavily emphasized. Students are required to make a 20-minute presentation on a topic of their choice and submit a follow-up five-page written report. *Prerequisite: none.*

PL 2094 Space and Space-time 4:0:0:4

What is the nature of space? Is it an independently existing substance, or does it merely consist in the relations between physical objects? Can motion be described simply in terms of the relational properties of objects, or must people always define motion with respect to an absolute motionless substratum? Does the existence of left-handed gloves entail the existence of absolute space? This course considers these and other questions about the nature of space and time as they appear in the writings of the following philosophers and scientists: Plato, Aristotle, Descartes, Newton, Leibniz, Berkeley, Kant, Poincaré and Einstein. *Prerequisite: none.*

PL 2104 Magic, Medicine and Science 4:0:0:4

An introduction to basic issues in metaphysics (What does reality consist of?) and epistemology (What is knowledge and how is it obtained?). Investigation takes the form of a philosophically oriented survey of the history of western science from the Greeks to the Newtonian synthesis. Course looks at the metaphysical and epistemological origins of three grand systems of thought, organic, magical and mechanical, and indicates the extent to which modern science can be seen as arising out of their synthesis. Course views the key figures in this his-

tory as they saw themselves first and foremost as natural philosophers. Topics to be covered include pre-Socratic cosmology, Plato, Aristotle, Plotinus, the Hermetic Corpus, Ficino’s naturalistic magic, Pico’s supernatural magic, Paracelsus and the ontic theory of disease, Copernicus, Galileo, Kepler, Descartes, Hobbes, the Cambridge Platonists and Newton. *Prerequisite: none.*

PL 2114 Philosophy of Relativity 4:0:0:4

The first part of this course develops the physics underlying special relativity and considers such conceptual questions as: Does Special Relativity prohibit faster-than-light travel? Does it allow a traveling astronaut to age less and return home in the distant future? What is the significance of Einstein’s famous equation $E=mc^2$? The second part of the course develops the physics underlying general relativity and considers conceptual issues surrounding such current applications as time machines, wormholes and “warp-drive” space-times. *Prerequisite: none.*

PL 2124 Philosophy of Quantum Mechanics 4:0:0:4

Quantum mechanics is the best-confirmed theory of particle dynamics in existence today. Not only is it the basis for all digital technologies, it also serves as the theoretical foundation for our best-confirmed theories of matter (quantum field theories). On the other hand, since its inception, it has been beset with conceptual problems. In particular, there is no current consensus on just how to interpret it: What would the world be like, if it were true? This course first develops the theory from a historical perspective, and then canvasses a number of proposals that have been offered as to how it should be interpreted. Other topics include conceptual issues surrounding such current applications as quantum teleportation, quantum computing and quantum cryptography. *Prerequisite: none.*

PL 2164 Modern Philosophy 4:0:0:4

This course examines the central figures and issues of the modern era: 17th and 18th century European enlightenment. The course focuses on issues that were important not only in this modern period but remain important today, including the

state of nature and society, epistemology, metaphysics and the role of God in philosophical thinking. Topics covered include the Renaissance and science, Descartes and rationalism, Hume and empiricism and Kant’s Copernican revolution. *Prerequisite: none.*

**Advanced Level
PL 3014 Metalogic 4:0:0:4**

Metalogic is sometimes referred to as the logic of logic. This course demonstrates the soundness and completeness of first-order logic, the Gödel incompleteness theorem for formal arithmetic, and reviews Turing machines and the notions of computability and undecidability. *Prerequisite: PL 2104 or a strong mathematical background (third- or fourth-year mathematics majors).*

PL 3034 Critical Theory 4:0:0:4

The course covers the interactions between the explanatory, the normative, and the ideological dimensions of social and political thought. Starting with the founder of critical theory, Karl Marx, the course examines the Western Marxist tradition in philosophy. Among the issues discussed are the problems of domination and exploitation, the relationship between capitalism and democracy, the formation of personal and social identities, the threat of fascism, the role of the media and the impact of technology on social development. *Prerequisite: one 2000-level PL course.*

PL 3044 Political Philosophy 4:0:0:4

Political philosophy is concerned with evaluating the ways people should live together in communities and with finding the appropriate and legitimate governing institutions that promote the ideals of freedom, justice, equality and happiness. The questions are why these institutions have a legitimate authority over their members and what is their role in determining how the benefits and burdens of a society are distributed among citizens. The class starts from two essential historical sources, Locke and Kant, before considering contemporary social-political philosophy, including contractarianism, libertarianism, utilitarianism, communitarianism and democratic socialism. Discussion includes the connections among such issues as democracy, freedom, justice, rights, private property, eco-

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conomic equality, global justice and community. *Prerequisite: one 2000-level course.*

PL 3054 Philosophy of Art 4:0:0:4

The course is concerned with the perception, interpretation, expression and creation of works of art and beauty. It asks: What does it mean to describe anything as aesthetic? What is a work of art? What do artists do? How can people understand a work of art? Does art have more to do with emotion than reason? Course examines the nature of aesthetic experience as well as works of art, including painting, photography, film, architecture, sculpture, music, literature, theater, dance and popular arts-like television and video programs. *Prerequisite: one 2000-level course.*

PL 3064 Philosophy of Technology 4:0:0:4

The course is a critical, reflective examination of the impact, effects, and outcomes of technologies upon human activities. Above all, it is the study of the nature of the technologically textured ecosystem or "technosystem." The course focuses on the ways in which technologies change human life, individually, socially and culturally. It also considers the effects of human-technology relations on science, culture, democracy and human values. Its aim is to understand the structures of change and transformation, and to help students to develop critical forms of thought so as to be able to understand, evaluate, appreciate and criticize technological development. *Prerequisite: one 2000-level course.*

PL 3074 Philosophy of Mathematics 4:0:0:4

Are the objects of mathematics real? What does it mean to say that a mathematical claim is true? What is the nature of mathematical knowledge? What is the relation between mathematics and the physical world? This course looks at how contemporary philosophers have attempted to answer these and related questions. *Prerequisite: one 2000-level course or instructor's permission.*

PL 3094 Philosophy of Science 4:0:0:4

An advanced introduction to topics in the philosophy of science. the course covers

the notions of natural laws, scientific explanation and confirmation, the nature of scientific theories, the realism/anti-realism debate, logical positivism and its successors (logical empiricism, historicism, social constructivism, etc.) as well as survey work in one or more of the following (time permitting): philosophy of physics, philosophy of biology, philosophy of psychology, philosophy of social sciences, philosophy of medicine. The objectives are to be introduced to the major fields of study in contemporary philosophy of science and, above all, to gain a firm understanding of the relation between philosophy and science and the important reciprocally enhancing role each has for the other. *Prerequisite: one 2000-level course.*

PL 3104 Metaphysics and Epistemology 4:0:0:4

Metaphysics seeks to answer general questions concerning the nature of reality: What does reality consist of? What are the presuppositions that underlie inquiry into nature? Epistemology seeks to answer the questions: What is knowledge and how is it obtained? This course surveys answers to these and related questions in the works of five important philosophers in the western tradition: Aristotle, St. Aquinas, Leibniz, Kant and Whitehead. *Prerequisite: one 2000-level course.*

PL 3114 Special Topic in Philosophy 4:0:0:X

Topic to be determined by the instructor; variable credit. *Prerequisites: one 2000-level course and instructor's permission.*

PL 3404 Independent Study in Philosophy 4:0:0:4

Focus on a special topic in Philosophy completed under the guidance of faculty member. May be repeated for credit on a different topic. *Prerequisite: instructor's permission.*

PL 4052 Business Ethics 4:0:0:2

This course considers issues of corporate responsibility and the ethical challenges of economic systems. It presents the principles and criteria for making ethical decisions in relation to law, corporate relations, social responsibility, privacy and other contexts. It investigates the

influence of technology on the ethics of corporate decision-making. A case study approach is used. *Prerequisite: required for students in the Business and Technology Management Program. Does not satisfy general education requirements in Humanities and Social Sciences.* Note: This course meets four hours a week for seven weeks or two hours a week for 14 weeks. All class sessions combine lecture and discussion and focus on actual case studies.

PL 4062 Computer Ethics 4:0:0:2

This course considers issues of corporate responsibility and the ethical challenges of economic systems. It presents the principles and criteria for making ethical decisions in relation to law, corporate relations, social responsibility, privacy and other contexts. It investigates the influence of technology on the ethics of corporate decision-making. A case study approach is used. *Prerequisite: required for students in the Business and Technology Management Program. Does not satisfy general education requirements in Humanities and Social Sciences.* Note: This course meets four hours a week for seven weeks or two hours a week for 14 weeks. All class sessions combine lecture and discussion and focus on actual case studies.

PL 4504 Senior Project in Philosophy 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project advisor. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: Liberal Studies seniors only and departmental permission.*

POLITICAL SCIENCE

PO 2614 Introduction to Political Science 4:0:0:4

The course introduces the basic topics of political science. The main focus of the course is to give an overview of human polity and its impact and affect as a civil society. It covers different political systems, concepts, political ideology, political process, origins and functions of different types of rights, justice, and equal

treatment, duties and responsibilities of states and citizens, libertarianism, policy-making as a process and international systems. *Prerequisite: none.*

PO 3614 Comparative Politics 4:0:0:4

The course focuses on nations and national states and their political relations to each other. The main feature includes the inter-relations and confrontations among the bloc nations, such as first, second, third and fourth worlds. In doing so, major emphasis will be given to advanced as well as underdeveloped nations such as France and Great Britain, the mid-developed nations such as Germany and Japan, late-developed nations, such as Soviet Union and Russia, experimental developed nations such as India and South Africa, and underdeveloped nations such as Afghanistan and Bangladesh. *Prerequisite: PO 2614.*

PO 3704 Special Topics in Politics

4:0:0:4

Focus on a special topic in anthropology completed under the guidance of faculty member. May be repeated for credit on a different topic. *Prerequisite: instructor's permission.*

PO 3804 Independent Study in Politics

4:0:0:4

Independent or small group work, under supervision of instructor, by special arrangement. *Prerequisites: Liberal Studies and Digital Media majors only; instructor's permission.*

PO 4504 Senior Project

4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project advisor. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: Liberal Studies seniors only and departmental permission.*

PSYCHOLOGY

The fourth credit hour for psychology courses is used for experimental investigations, laboratory work, fieldwork or trips to museums and/or zoos to provide an opportunity to make descriptive obser-

vations of subjects. The psychology electives are divided into two levels: introductory (2000-level) and advanced (3000-4000 levels). PS 2104 is a prerequisite for all advanced PS electives for a two or more course sequence.

Prerequisite Psychology Course

PS 2104 Introduction to Psychology

Advanced Electives

PS 3114 Physiological Psychology
 PS 3124 Comparative Psychology
 PS 3214 Learning and Cognition
 PS 3314 Social Psychology
 PS 3324 Environmental Psychology
 PS 3414 Developmental Psychology
 PS 3424 Abnormal Psychology
 PS 3434 Personality Psychology
 PS 3444 Animal Behavior
 PS 3704 Humans and Their Environment
 PS 3714 It's About Time
 MA 2212 Data Analysis I*
 MA 2222 Data Analysis II*
 LA 2014 Technology and the Human Condition

**Two math courses in statistics (MA 2212 and MA 2222) are required*

Advanced Studies

PS 4114 Senior Research Thesis

One- or two-semester research project to be completed under the guidance of a faculty member. Agreement of instructor required before registration.

Advanced Topics

PS 4124 Guided Readings

Selected problems in psychology. Individual or group studies/ projects under faculty supervision involving guided reading and or research, topics to be arranged. For mature students wishing to undertake specialized independent study under tutorial guidance. *Prerequisite: junior standing or departmental permission. Agreement of instructor required before registration.*

E. Special Topics In Psychology

PS 3444 Special Topics

Focus on a special topic in Psychology completed under the guidance of faculty member. May be repeated for credit on a different topic. Agreement of instructor required before registration.

Undergraduate Courses

PS 2104 Introduction to Psychology

4:0:0:4

The scientific study of behavior and the mind. Topics include experimental design and basic statistics, learning and memory and biopsychology. Also included: the nature of sensation and perception, cognitive, abnormal, developmental, social and environmental psychology. Course consists of lectures, class discussion, films and videos and a number of projects, both in class and on computers.

PS 3114 Physiological Psychology

4:0:0:4

The study of the relationship between the body, especially the brain, and behavior and the mind. Topics include the physiological and biochemical bases for learning, memory, sensation and perception, motor control, hunger, sex, sleep and mental disorders. Lateralization in the brain and its implications, as well as techniques and technologies in neuroscience. Course consists of lectures, class discussion, films and videos and a number of projects, both in class and on computers.

PS 3124 Comparative Psychology

4:0:0:4

Examines behavior and neuroanatomical mechanisms across species providing an investigation of comparative developmental stages, causal mechanisms, evolutionary history and function of animals' behavior. Topics include learning and cognition, neuroanatomical and neurochemical controls of behavior, thought and language, sensory and perceptual capacities and the biological bases of social behavior. In addition to course text readings and lectures, students participate in labs (interactive computer programs), in-class demonstrations, field trips and videos that provide hands-on experience and supplementary exposure to examples of concepts and ideas within the area of comparative psychology. *Prerequisite: PS 2104 (PS 3214 is optional).*

PS 3214 Learning and Cognition

4:0:0:4

This course concerns the experimental analysis of cognition and behavior in animals. Most of the discussions focus on laboratory findings with animals, but as

viewed from an evolutionary framework concerned with the natural histories of the species. In addition to discussions of established results about cognition and intelligence in animals, an important emphasis is also placed on critiquing the methods of these studies, specifically the logic, evidence and technology used to test and interpret conclusions. *Prerequisite: PS 2104.*

PS 3314 Social Psychology 3:1:0:4

Explores issues of human behavior as it is affected by social interaction and situations. Addresses the nature of social psychological inquiry, with particular emphasis on research methods. Course topics include aggression, altruism, attitudes, attraction, conformity, group dynamics, perception of self and others, prejudice, social roles, the biological basis of social behavior and interpersonal bargaining. Cultural differences in interpreting social behavior and context are also considered. Students are asked to collect data on social psychological phenomenon for each major topic covered, as the major part of the laboratory requirement. A final term paper is required that contains a review and critical analysis of the research on a topic in social psychology. *Prerequisite: PS 2104.*

PS 3324 Environmental Psychology 3:1:0:4

Course deals with the interactions people have with built and natural environments: how settings affect behavior; how people change environments to fit their needs; how people can become an active part of the environmental design process. It is concerned with the way people use space and the way environmental design meets (or fails to meet) human needs. These concerns are valid for very small scale design problems (as in human factors engineering); mid-size spaces (architecture and interior design); and for large scale spaces (communities, urban areas). The goals of the course are to introduce the student to this subject matter, provide familiarity with research methods associated to studying people and behavior in real world settings and issues in environment and human relations.

PS 3414 Developmental Psychology 4:0:0:4

The development of humans across the life-span. The main focus is on the effects of aging on the social and cognitive development of the person. Issue in parenting, child care, education, elder care, death and dying are also discussed. Lab and field examples are used to illustrate main themes in this course. *Prerequisite: PS 2104.*

PS 3424 Abnormal Psychology 4:0:0:4

Covers a variety of different psychological disorders. Common examples are depression, anxiety, schizophrenia and personality disorders. Major theories such as psychoanalytical, behavioral, cognitive, and biological are discussed in terms of why people develop such disorders and how to treat them. *Prerequisite: PS 2104.*

PS 3434 Personality Development 4:0:0:4

The study of psychological theories related to personality theory. Its goal is to ask the question why we think and act the way we do. Exploration of topic through many of the major theories of psychodynamic, behavioral, cognitive, humanistic, trait and biological perspectives. *Prerequisite: PS 2104.*

PS 3444 Animal Behavior 4:0:0:4

This course provides an understanding of the psychological, biological and evolutionary principles guiding animal behavior through an in-depth analysis of concepts and topics such as learning, response to environmental changes in the short and long-term, reproductive behavior, care for offspring, foraging behavior and optimality, navigation and cognition, aggression, affiliative behaviors and sociality. Students learn to use scientific methods as applied in the study of animal behavior via ethological observational or experimental methods. In small, individual research projects, each student practices data collection and appropriate scientific writing style. *Prerequisite: PS 2104.*

PS 3444 Special Topics

Focus on a special topic in psychology completed under the guidance of faculty

member. May be repeated for credit on a different topic. Agreement of instructor required before registration.

PS 3704 Humans and their Environment 4:0:0:4

This course addresses ecological understanding of interactions of human with non-human environments through relevant topics: ecosystems, human interaction with ecosystems, human societies as self-regulating systems, attitudes toward nature, case studies in ecological history, present environmental crises and attempts at resolutions.

PS 3714 It's About Time 4:0:0:4

This course is concerned with all aspects of time, including its measurement, time scales in nature, psychological issues and the nature of time itself. Topics include origin and evolution of calendars and clocks, psychological and physiological basis of time and timing, time in the arts and, finally, the nature of time itself in philosophy and modern physics, from Einstein's relativity to modern cosmology.

PS 4114 Senior Research Thesis

One- or two-semester research project to be completed under the guidance of a faculty member. Agreement of instructor required before registration.

PS 4124 Guided Readings

Selected problems in psychology. Individual or group studies/projects under faculty supervision involving guided reading and or research, topics to be arranged. For mature students wishing to undertake specialized independent study under tutorial guidance. *Prerequisite: junior standing or departmental permission. Agreement of instructor required before registration.*

Graduate Courses

PS 905 Psychology: Applied 2½:0:0:3

This course shows how various problems, particularly in work, can be solved through the judicious use of psychological principles. Phenomena addressed include human-machine interaction and other engineering-behavior interactions, smoking, study habits, memory, creative thinking, group interaction, raising chil-

dren, influencing people, self-control and specific problems brought up in class by students. Students learn to employ the method of behavioral analysis in gaining an understanding of various problems. They select a problem, do a behavioral analysis and, finally, modify it as a class project. *Prerequisite: PS 2104.*

PS 906 Human Cognition and Information Processing 2½:0:0:3

Human cognitive capabilities including natural language and information processing. Memory, internal representation of knowledge, concept information, symbol manipulation, language acquisition, reasoning and problem solving. Artificial intelligence approaches to natural language learning and acquisition of cognitive skills. *Prerequisite: PS 2104.*

PS 907 Human-Computer Interaction 2½:3:0:3

This course introduces students to human behavioral issues in the design and use of interfaces for information systems. Basic issues of behavioral research and evaluation methods are discussed. Sensory systems and memory and learning theory relevant to human factors systems are reviewed and related to specific interface issues, such as interaction devices, dialogue design and reference material. The focus is on understanding the issues involved in creating systems amenable to human use. *Prerequisite: PS 2104 or equivalent.*

PS 908 Experimental Psychology I 2½:3:0:3

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 perform a series of experiments with human and animal subjects. *Prerequisite: PS 2104.*

PS 909 Experimental Psychology II 2½:3:0:3

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. *Prerequisite: PS 2104.*

PS 910 Theories of Learning 2½:0:0:3

Programmed learning, behavior therapy, attitude function and social interaction. All students are required to perform one experiment on learning under guidance of instructor. Available to undergraduate majors in social science. *Prerequisite: PS 2104 or equivalent.*

PS 911 Psychology of Language and Communication 2½:0:0:3

Methodological problems in analysis of language, verbal behavior in animals, anatomical and physiological aspects of speech apparatus, operant and respondent conditioning of verbal behavior, semantics, statistical approaches and mathematical models, contextual factors and pathology of speech. All students are required to perform one experiment under guidance of instructor. Available to undergraduate majors in social science. *Prerequisite: PS 2104 or equivalent.*

PS 912 Sensation and Perception 2½:0:0:3

Review of different sensory systems: vision, audition, taste, smell, touch, temperature sensitivity, vestibular and kinesthetic senses and their relations to non-sensory controlling stimuli such as states of the organism, learning and social psychological variables. Techniques for obtaining psychophysical data on each sensory system and relations of these techniques to theories of discrimination. Available to undergraduate majors in social science. *Prerequisite: PS 2104 or equivalent or instructor's permission.*

PS 913 Physiological Psychology 2½:0:0:3

Physiological and anatomical bases of behavior. Memory, motivation, emotion, sleep reward mechanisms, psychosurgery and higher cortical functions. *Prerequisite: PS 2104.*

PS 915 Behavioral and Societal Aspects of Transportation 2½:0:0:3

Behavioral analyses of transportation decision-making and travel characteristics. User needs in design of transportation systems: crowding, social isolation, crime, comfort and convenience. Social impacts of transport systems on communities. *Prerequisite: undergraduate introductory psychology course or equivalent.*

PS 920 Proseminar in Psychology 2½:0:0:3

Major areas of psychology required of all master's candidates. History and systems, sensation and perception, learning, developmental and abnormal.

PS 925 Social Impact Assessment 2½:0:0:3

How physical changes in urban or rural settings affect social systems and group and individual behavior. Measuring quality of life and social responses to technology; uses of alternative futures paradigms. Students do an analysis of a problem in social impact and report finding to class.

PS 926 Environmental Psychology 2½:0:0:3

Critical issues in person-environment relations, including privacy, crowding and environmental design. Work includes a term paper and a major research project, emphasizing applications of psychological research methods to practical design problems or specific environmental issues.

PS 928 Advanced Topics in Environmental Psychology 2½:0:0:3

This course varies from year to year depending on the needs and interests of students and instructors. Potential subjects include social impacts of transportation systems; stress and the environment; aversive environmental factors; laboratory assessment of environmental effects on animal learning; effects of pollution; human factors of software design; assessing the built environment including the office; and applied behavioral analysis.

LIBERAL STUDIES PROGRAM

PS 997 Thesis for Degree of Master of Science *each 3 units*

Independent research project demonstrating scientific competence performed under guidance of advisors.

SOCIOLOGY

SO 2014 Technology and Social Change *4:0:0:4*

Given that (at least on a mythic level) technology is the most important force shaping society and culture today, we will concentrate on the dialectical, interactive shaping of societies and technologies. Many approaches, from technological determinism to neo-marxism and post-modernism, are used in examining various social issues having to do with social change. The objective of this course is to provide a survey of the development of sociological theories of societal development and change. In addition, this course surveys the current information and research on the specific impact of modern technology on contemporary society. Issues of social identity, communication, work, inequality, deviance, power and social control are examined in the context of society, technology and social change.

SO 2024 Sociology of Organizations *4:0:0:4*

Modern societies are organizational societies. Indeed, nearly all modern work and much play occurs in organizations. As a result, organizations and organizational

management have important personal and social effects: organizational experiences can bring pain or pleasure to their members, and managerial decisions can send an organization's profits soaring or plummeting. The course examines the nature and place of organizations and managerial systems in modern societies. The central questions of the course include: Do organizations pursue goals or do managers use organizations to pursue narrow interests? How do managers control workers and how much control is necessary and optimal? To what extent are managers rational decision makers? Is there a "best way" to structure and manage an organization?

SO 3014 Environmental Sociology *4:0:0:4*

Environmental sociology is the study of the reciprocal interactions between the physical environment, social organization and social behavior. Within this approach, environment encompasses all physical and material bases of life in a scale ranging from the most micro level to the biosphere. Two major themes form the focus of this course: (1) Sociology is often described as the study of human communities. Ecology is often described as the study of natural communities. Environmental Sociology is the study of both together. People, other animals, land, water, air are all closely interconnected. Together they form a solidarity that has been called ecology. As in any community, there are also conflicts in the

midst of interconnections. Environmental sociology studies the largest of communities with an eye to understanding the origins of, and proposing solutions to, these social and bio-physical conflicts. (2) Environmental problems are problems for problems that threaten our existing patterns of social organization—and of society problems that challenge people to change those patterns of social organization. One of sociology's most basic contributions to the study of environmental problems is to point out the pivotal role of social inequality. Social inequality cannot be understood apart from the communities in which it takes place. Inequality shapes social experience and social experiences shape all experiences. *Prerequisite: instructor's permission*

ORGANIZATIONAL BEHAVIOR

This program is offered at Brooklyn MetroTech campus only and is limited to 15 incoming students per semester.

Students who meet all of the course and GPA requirements are formally admitted to the MS in Organizational Behavior in the Department of Management at the end of their junior year.

Requirements for the MS in Organizational Behavior

Core Courses:	9 units
Area of Concentration:	18 units
Free Electives:	6 units
Research Project:	3 units
Total:	36 units

MANAGEMENT PROGRAM

Academic Director: Barry S. Blecherman

The Department of Management at Polytechnic University is the New York City/Tri-state region's academic hub for technology and innovation management. Because most of the department's students are working professionals, class schedules are geared to their needs and are typically offered after regular office hours. Classes are structured to enable participants to receive individual attention and to work closely with faculty. The course of study is designed for those who work in technology-intensive industries and in companies that depend on technology for products and services.

The Master of Science in Management (MSM) is recognized, along with the Master of Business Administration (MBA), by the Graduate Management Admission Council as a graduate professional management degree. Polytechnic's modern MSM curriculum is designed to prepare working professionals for increasing responsibility in management positions in technology-intensive settings. This updated program is aimed at developing competencies in modern decision making and in the selection, allocation and direction of human, financial, physical, technological and organizational resources in a period of rapid technology-led change.

These management skills can be applied in a broad range of professional settings in both the private and public sectors, in production and service-oriented activities and in traditional as well as high-technology environments.

Polytechnic's graduate program in management takes a pragmatic, modern results-oriented approach that emphasizes integrating technology and people for the creation of value in the marketplace and in modern organizations. Even subjects such as accounting, finance and marketing are taught not as special areas of expertise, but as basic tools for managerial decision making in a technology-intensive and knowledge-based environment. Courses are increasingly supported by a modern technological, web-based infrastructure. The program con-

tinually introduces state-of-the-art material in paper and digital format.

After completing the core courses, degree candidates build further managerial skills in their choice of eight concentrations all designed for success in the global economy.

- Entrepreneurship
- Electronic Business
- Technology Management
- Information Management
- Telecommunications Management
- Human Resource Management
- Construction Management
- Operations Management

The program concludes with a capstone project course, MG 970 Project in Strategy and Innovation, which takes a high-level perspective in learning how to set goals, establish policies and implement strategies for ongoing competitive success, especially in environments where technology and innovation are critical.

Students may elect, with their adviser's approval, to conclude their studies with a thesis instead of this project course.

Some fundamental knowledge of probability and statistics is required for this program. Students without such a background are required to take a managerial probability and statistics course such as MA 2054 or its equivalent. Students with this knowledge may apply for a waiver of this requirement.

Visit the program's website at www.msm.poly.edu for the most current information.

GOALS AND OBJECTIVES

The goal of the Master of Science in Management is to provide the highest quality learning, centering on innovation, technology and information management, and e-Business in the New York City Tri-State Region and beyond.

ADMISSION AND DEGREE REQUIREMENTS

Criteria for admission include a bachelor's degree with at least a B average from an accredited college or university and demonstrated evidence of motivation, maturity, the ability to benefit from and contribute to professional graduate studies and a strong desire to make a difference that in some fashion is associated with innovation, technology and modern change. 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 such as the Graduate Record Examination (GRE) may be requested as support for admission.

The MSM requires completion of 12 courses, or 36 units, with a B average or better. A maximum of 9 units of transfer credits may be granted for graduate courses taken elsewhere, as evaluated by an adviser.

UNDERGRADUATES IN GRADUATE MSM CLASSES

With three exceptions, undergraduates may not enroll in graduate MSM classes. The three exceptions are: (1) undergraduate students enrolled in a joint BS-MS program associated with the Department of Management may, with the approval of the department adviser, register for graduate management courses; (2) undergraduate seniors with a 3.0 GPA or better may, with the signature of the MSM program director, register for MSM core courses: MG 601, MG 607, MG 608, MG 609 and MG 650; and (3) undergraduate seniors majoring in BTM with a 3.0 GPA or better may, with the signature of the MSM program director, register for any MSM course.

No other undergraduate may register for any MSM course. No undergraduates are permitted in any other MSM class.

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 toward the master's degree are able, upon admission, to apply all courses taken toward a certificate toward fulfillment of a degree program. Additional information may be obtained from the department.

Management certificates are offered in the following fields:

- Electronic Business
- Entrepreneurship
- Construction Management
- Human Resource Management
- Information Management
- Operations Management
- Technology Management
- Telecommunications Management

THE MS MANAGEMENT CURRICULUM

Core Courses. The core courses provide a foundation upon which students can pursue cutting-edge specializations within the degree program. These courses provide intensive exposure to the disciplines required of a professional manager. Students who have taken these courses elsewhere or previously at Polytechnic, or who have had equivalent experience, may apply to substitute elective courses for such core courses; however, all students are required to complete 36 units (12 courses).

- MG 601 Organizational Behavior
- MG 607 Marketing
- MG 608 Managerial Economics & the Economic Environment
- MG 609 Managerial Accounting & Finance
- MG 650 Management of Information & Information Technology

Core courses should be taken as early in the program as possible.

Areas of Concentration. Students must choose an area of concentration. This 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 concentrations are shown below.

Free Electives. Two appropriate graduate courses may be chosen from any program at Polytechnic with adviser's approval.

Project in Strategy and Innovation (MG 970). This required integrating course is recommended for students' final semester. 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 free electives. Substitutions may be made with adviser's approval in any concentration area.

Electronic Business

The Electronic Business Concentration focuses on the new arena of electronic business and the Internet. The key aspects for managing a firm that operates increasingly in digital space and the process of digital-intensive market creation are studied. The relevant methods and concepts for effective electronic-business decision making are explored and applied.

Required:

- MG 717 Enterprise Data Systems
- MG 750 Management of Electronic Business
- MG 867 Technology Strategy

Select one:

- MG 615 Leadership & Team Development
- MG 631 Organization Theory & Design
- MG 646 Introduction to Retailing & Supply Chain Management
- MG 652 Telecommunication Regulation, Policy & Law
- MG 654 Economics & Strategy for Information Sectors
- MG 655 Introduction to Management of Data Communications & Networks
- MG 660 Management of New & Emerging Technologies
- MG 770 Entrepreneurship & Venture Creation
- MG 820 Project Assessment & Management
- MG 860 Financial Planning, Internal Reporting & Operation Control
- MG 863 Market Research
- MG 864 New Product Development

Entrepreneurship

The Entrepreneurship Concentration is offered for the manager, professional or specialist who is interested in enterpre-

neurial management, either as entrepreneur starting a new business, as an "entrepreneur" in a large, established firm or as a professional (e.g., venture capitalist) interested in playing a role in new enterprises. Modern entrepreneurial concepts and cases are studied and applied.

Required:

- MG 770 Entrepreneurship & Venture Creation
- MG 865 Managing Technological Change & Innovation
- MG 867 Technology Strategy

Select one:

- MG 615 Leadership & Team Development
- MG 631 Organization Theory & Design
- MG 646 Introduction to Retailing & Modern Supply Chain Management
- MG 654 Economics & Strategy for Information Sectors
- MG 660 Management of New & Emerging Technologies
- MG 750 Management of Electronic Business
- MG 820 Project Assessment & Management
- MG 860 Financial Planning, Internal Reporting & Operation Control
- MG 863 Market Research
- MG 864 New Product Development

Construction Management

The Concentration in Construction Management provides engineers and other professionals in the construction industry with the knowledge necessary to understand relevant managerial and physical infrastructural technological developments and to be able to integrate construction and management to be effective and innovative.

Select four:

- MG 624 Organization Development
or
- MG 631 Organization Theory & Design
- MG 630 Operations Management
or
- MG 635 Managing for Quality
- MG 820 Project Assessment & Management
- MG 825 Construction Administration
- MG 826 Construction Estimates & Costs
- MG 827 Specifications & Contracts

Selected courses in the Exec 21 Program offered by the Department of Civil Engineering can be counted as concentration electives in construction management with the approval of the Department of Management and the Exec 21 Program.

Human Resource Management

The Concentration in Human Resource Management prepares professionals for today's technology-intensive environment. It provides the knowledge and techniques to deal with human resource issues and to achieve high quality innova-

tion and productivity in often turbulent organizational settings. The changing nature of work and shifting professional expectations are explored.

Required:

- MG 612 Human Resource Management
- MG 633 Research Methods
- MG 865 Managing Technological Change & Innovation

Select one:

- MG 611 Career Management
- MG 613 Labor Relations
- MG 614 Conflict Management
- MG 616 Job and Workplace Design
- MG 617 Performance Measurement & Reward Systems
- MG 620 Consulting in Organizations
- MG 621 Outsourcing: A Human Capital Strategy
- MG 622 Staffing Organizations
- MG 623 Training in Organizations
- MG 624 Organizational Development
- MG 625 Seminar in Organization & Career Change
- MG 626 Human Resource Information Systems
- MG 628 Internet Applications in Human Resource Management
- MG 631 Organization Theory & Design
- MG 635 Managing for Quality

Information Management

The Concentration in Information Management provides Information Technology (IT) professionals, programmers, systems experts and others with IT-related career goals and experience with the knowledge to understand how IT enhances the effectiveness of modern firms and with the ability to manage creative and professional people.

Required:

- MG 654 Economics & Strategy for Information Sectors
- MG 717 Enterprise Data Systems
- MG 867 Technology Strategy

Select one:

- MG 626 Human Resource Information Systems
- MG 631 Organization Theory & Design
- MG 652 Telecommunication Regulation, Policy & Law
- MG 660 Management of New & Emerging Technologies
- MG 655 Introduction to Management of Data Communications & Networks
- MG 750 Management of Electronic Business
- MG 820 Project Assessment & Management

Operations Management

The Concentration in Operations Management is designed for managers involved in modern operations. It is designed to give operations managers the knowledge necessary, within the context of modern operations management and expertise, to be effective in service as well as manufacturing industries.

Required:

- MG 630 Operations Management
- MG 635 Managing for Quality
- MG 820 Project Assessment & Management

Select one:

- MG 610 Quantitative Analysis for Managerial Decisions
- MG 615 Leadership & Team Development
- MG 616 Job & Workplace Design
- MG 646 Introduction to Retailing & Supply Chain Management
- MG 770 Entrepreneurship & Venture Creation
- MG 864 New Product Development
- MG 865 Managing Technological Change & Innovation
- MG 867 Technology Strategy

Technology Management

The Technology Management Concentration is designed for managers, engineers and other professionals in technology-intensive environments or involved with technology-intensive products, processes or services. It provides the modern methods and concepts necessary for making technology investment decisions; for understanding technology and innovation strategy, product life cycles, and competitive factors; and for developing the special skills necessary for managing creative people and professionals.

Required:

- MG 820 Project Assessment & Management
- MG 864 New Product Development
- MG 865 Managing Technological Change & Innovation

Select one:

- MG 615 Leadership & Team Development
- MG 646 Introduction to Retailing & Supply Chain Management
- MG 652 Telecommunication Regulation, Policy & Law
- MG 654 Economics & Strategy for Information Sectors
- MG 655 Introduction to Management of Data Communications & Networks
- MG 660 Management of New & Emerging Technologies
- MG 664 Management & the Legal System
- MG 750 Management of Electronic Business
- MG 770 Entrepreneurship & Venture Creation
- MG 860 Financial Planning, Internal Reporting & Operation Control
- MG 867 Technology Strategy

Telecommunications Management

The Concentration in Telecommunications Management provides managers in the telecommunications and information industries with modern methods and concepts relevant in telecommunications and information management and for integrating telecommunications and information technology into a firm's overall decision making.

Required:

- MG 655 Introduction to Management of Data Communications & Networks
- MG 656 Advanced Management of Data Communication & Networks

Select two:

- MG 615 Leadership & Team Development
- MG 652 Telecommunication Regulation, Policy & Law
- MG 654 Economics & Strategy for Information Sectors
- MG 660 Management of New & Emerging Technologies
- MG 717 Enterprise Data Systems
- MG 750 Management of Electronic Business
- MG 770 Entrepreneurship & Venture Creation
- MG 820 Project Assessment & Management
- MG 867 Technology Strategy

GRADUATE COURSES

MG 601 Organizational Behavior

2½:0:0:3

Integration of behavioral science theories, concepts, research and techniques for understanding of human behavior in organizations. Topics include motivation and job satisfaction; decision-making; group dynamics; work teams; leadership; communication; power politics and conflict; organization culture, structure and design; impact of technology; work stress; organizational change and development. Analysis of organizational behavior problems by case studies and simulated situations.

MG 607 Marketing

2½:0:0:3

Marketing concepts, processes and institutions: positioning, segmentation and 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, governmental and international markets.

MG 608 Managerial Economics

2½:0:0:3

The fundamentals of microeconomics needed by managers. Demand theory (theory of the consumer) including models of demand, demand elasticities and demand forecasting. Supply theory (theory of the firm) including diminishing returns, profit maximizing production levels, labor/capital tradeoffs and long-run vs. short-run issues. Market structures

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and how they affect optimal production and profit levels. Positive and negative externalities and government intervention including regulation, tariffs and subsidies. Selected applied topics. All topics are presented with emphasis on managerial application.

MG 609 Managerial Accounting and Finance *2½:0:0:3*

Elements of accounting and finance of importance to managers. 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 611 Career Management *2½:0:0:3*

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.

MG 612 Human Resource Management *2½:0:0:3*

A survey course in which human resource functions are examined from the perspectives of individual managers as well as organizational strategy. Topics include work force characteristics, recruitment and staffing, training and development, performance evaluation and rewards, compensation and benefits, effects of legislation, the changing labor force and the future of the HR function within the organization.

MG 612A Human Resource Management *3:0:0:3.6* (ePoly online course)

This course is equivalent to MG 612. It has the same requirements, with additional topics and required online discussions.

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 labor-relations problems, particularly those of collective bargaining, emphasizing interrelationships with social, economic and legal trends.

MG 614 Conflict Management *2½:0:0:3*

Investigation of the nature and meaning of conflict in professional and technical organizations as well as in society. Analysis of the design of conflict avoidance and mitigation programs. Alternative dispute resolution modalities are presented and demonstrated. Skill building around collaborative conflict resolution.

MG 615 Leadership and Team Development *2½:0:0:3*

Focuses on the essential role of multifaceted leadership in diverse organizational settings. Explores the nature of leadership and its relationship to team development and organizational effectiveness. Includes a broad survey of theory and research on leadership and teams in organizations. Includes a hands-on approach involving experiential learning and case analyses, which will be conducted in teams, requiring students to be active participants.

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, sociotechnical design approaches and the emerging role of artificial intelligence.

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 evaluations. The role of compensa-

tion benefits and other rewards in attracting, retaining and motivating employees is addressed comprehensively.

MG 617A Performance Measurement and Reward Systems *3:0:0:3.6* (ePoly online course)

This course is equivalent to MG 617. It has the same requirements, with additional topics and required online discussions.

MG 620 Consulting in Organizations *2½:0:0:3*

Provides a practical orientation to consulting in organizations within an academic framework. Prepares students from a variety of disciplines for roles as internal as well as external consultants by building knowledge and skills to successfully take a client and project from entry through termination and evaluation. Each student is required to take a project from conception to presentation, thereby providing an in-depth understanding of the details and issues that need to be addressed in the consulting role.

MG 621 Outsourcing: A Human Capital Strategy *2½:0:0:3*

A comprehensive course that prepares students from a variety of disciplines with the knowledge and skills necessary to make the “build” or “buy” decision when considering outsourcing as an appropriate alternative. Topics covered include strategic implications, financial aspects, project management, internal consulting, metrics, legal considerations, development of an effective template RFP (request for proposal), internal communication details and management of the vendor/provider relationship.

MG 622 Staffing Organizations *2½:0:0:3*

This course examines the design and management of successful staffing processes used to form matches between people and jobs in order to achieve organizational effectiveness and individual job satisfaction. Emphasis will be on the psychological theories, measurement concepts and practical techniques of personnel recruitment and selection, including such topics as human resource planning, job analysis, the reliability and validity of employee assessment methods and legal issues in the employment relationship.

MG 623 Training in Organizations 2½:0:0:3

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.

MG 624 Organization Development 2½:0:0:3

Applied theory and research related to the 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.

MG 625 Seminar in Organization and Career Change 2½:0:0:3

Examination of organizational restructuring, including downsizing, reengineering, delayering, mergers and acquisitions, focusing on the impact of such change on professional and managerial careers. Emphasis on current organizational and individual management practices in coping with rapid structural and cultural change in the work environment. Experts from the private and public sectors as well as consulting firms address these management practices.

MG 626 Human Resource Information Systems 2½:0:0:3

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. Focus on design and use of HRIS to facilitate objectives of human resource functions as well as to support entire organizations.

MG 6264 Human Resource Information Systems 3:0:0:3.6
(ePoly online course)

This course is equivalent to MG 626. It has the same requirements and topics, with the addition of required online discussions and critical reflections on a specific topic.

MG 628 Internet Applications in Human Resource Management 2½:0:0:3

A survey of the effective use and application of current Internet technologies for human resource (HR) functions. Topics or issues to be examined include information acquisition by specific HR functions, “Best Practices” of HR functions utilizing Internet and Intranet technologies, creating websites to realize business goals and to benchmark comparable websites for improvement, developing policy manuals to address proper use of the Internet, determining what HR information to include on an organization website, assessing the impact of Internet technologies on organization design, evaluating privacy and security issues, developing a vision for HR on the Internet and building an HR Internet plan.

MG 6284 Internet Applications in Human Resource Management 3:0:0:3.6
(ePoly online course)

This course is equivalent to MG 628. It has the same requirements and topics, with the addition of required online discussions and critical reflections on a specific topic.

MG 630 Operations Management 2½:0:0:3

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 2½:0:0:3

Analysis of theories of large-scale organizations focusing on their structure and design. Includes characteristics of bureaucracy, adhocracy, suboptimization, human dynamics and informal systems, influence and control systems, and planned change. Examination of both formal and informal organizations through research and case studies.

MG 633 Research Methods 2½:0:0:3

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 or instructor’s permission.*

MG 635 Managing for Quality 2½:0:0:3

Focusing on quality and overall customer satisfaction as a primary objective of manufacturing and service operations is a proven competitive weapon. This course examines the concepts and methods for building quality into the management process. Total quality management (TQM) and similar approaches are covered through readings, cases and examples.

MG 646 Introduction to Retailing and Supply Chain Management 2½:0:0:3

This course provides an introduction to retailing and supply chain management. Both qualitative and quantitative aspects of retailing and supply chain management will be covered by this course. The underlying objective is to: (1) introduce students to the standard business concepts (and associated terminology) involved in the retailing and supply chain management arena; (2) develop student skills in understanding and analyzing retailing, marketing, logistics, operations, channel management and allied issues, and the interactions between them; and (3) examine and discuss the important role played by technology and integration at various points in the supply chain.

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MG 650 Management of Information and Information Technology 2½:0:0:3

This course is designed for managers who need to understand the role and potential contribution of information technologies in organizations. The focus of the course is on different information technologies and their applications in managing business critical data, information and knowledge. The course concentrates on the current state of IT in organizations, challenges and strategic use of IT, IT infrastructure and architecture, building, implementing and managing IT applications, and emerging issues such as intelligent systems, business process re-engineering, knowledge management and group support systems.

MG 652 Telecommunications Regulation, Policy and Law 2½:0:0:3

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 impact the telecommunications industry and commerce and society generally. The options and opportunities afforded by recent regulatory and policy issues.

MG 654 Economics and Strategy for Information Sectors 2½:0:0:3

This course in applied competitive strategy draws upon recent experiences in the impact of information technology upon diverse industries. Students completing this course will have mastered a basic understanding of the economic and competitive implications of information technology. This competence in analysis is arrived at through understanding how availability of information (through technology or otherwise) affects the basic strategic options available and how firms and industries are likely to be affected. In addition, students will be introduced to the often poorly structured process of evaluating the economics of potential systems innovations. They will then be able to participate in strategic systems planning from a managerial point of view.

MG 655 Introduction to Management of Data Communications and Network 2½:0:0:3

Introduction of the fundamentals of modern telecommunications and networking to the current and future managers. Covers basic concepts such as components of data-communication, data transmission, Open System Interconnection (OSI), TCP/IP and other models, data link and network layers, and local area networks (LANs). The emphasis is to expand technical knowledge and discuss related managerial issues.

MG 656 Advanced Management of Data and Communications Networks 2½:0:0:3

Explores advanced issues and trends in modern enterprise networking. Examines the implications of such developments in the business environment and the infrastructural needs of organizations and clusters of organizations. Reviews ramifications of the TCP/IP revolution leading to commercialization of the Internet/World Wide Web. Discusses the network infrastructure required to implement Intranets/Extranets, electronic commerce and interorganizational business communication and collaboration generally. Evaluates emerging technologies (such as electronic payment systems, corporate digital libraries, push technology, multicasting, firewalls and digital signatures). Deals with the implications of internetworking, such as digital cities, smart buildings, distance learning, telecommuting and teleconferencing. *Prerequisite: MG 655.*

MG 660 Management of New and Emerging Technologies 2½:0:0:3

A survey of the exciting new and emerging technologies that are becoming available to the new business world domain of the global information marketplace. Architectures and issues for implementation for these new media are presented. The "Information Highway" is presented, and its opportunities, applications and challenges are discussed. This course is for the manager who is interested in staying current with and learning about new technologies for use in business. No specific engineering background is required.

MG 664 Management and the Legal System 2½:0:0:3

Impact of the legal system on corporate strategy, managerial decisions and planning processes. Issues covered include protection of intellectual and technological properties; consumer, contract and commercial laws; employer liability; negligence and risk-management from legal and corporate viewpoints; and constitutional and regulatory aspects of conducting business.

MG 717 Enterprise Data Systems 2½:0:0:3

Addresses modern issues of large-scale information and knowledge management through design, development and implementation of different kinds of database technologies. Introduces and elaborates data modeling through entity relationship method, relational model, SQL applications, database architecture, different types of database management systems, data integrity and administration, etc. Also introduces emerging database technologies such as distributed Internet-based databases, distributed client/server databases, multidimensional databases, groupwares, data warehousing and data mining for decision support, etc.

MG 750 Management of Electronic Business 2½:0:0:3

Investigates the management implications of electronic business. Topics include: (1) accelerated new product development; (2) impact of technology on the value chain: the changing role of intermediaries; (3) electronic commerce: business models and strategies for survival general lifestyle; (4) implications of "being wired"; and (5) business applications involving collaborative communication, computation and teamwork. Course material is designed to be dynamic and Internet-based, reflecting the nature of change in electronic commerce and the IT industry, and the potential implications of electronic business for managers. Students work on a project that requires: following developments in the business and IT press, interviewing managers and product developers and simultaneously testing and discussing current developments in the e-commerce marketplace. Classes are conducted using the case method, and a high level of class participation is expected.

MG 770 Entrepreneurship and New Venture Creation 2½:0:0:3

Focuses on entrepreneurship and venture creation as key engines for wealth creation and successful business strategy in the modern innovation-intensive, high-tech economy. Deals with such key issues as: (1) assessing attractiveness of opportunities; (2) launching a new venture; (3) nurturing and growing and entrepreneurial venture; (4) obtaining the necessary financial, human and technology resources; (5) managing the transition from a small entrepreneurial firm to a large, sustainable professionally managed but still entrepreneurial corporation; and (6) being an entrepreneur and promoting entrepreneurship in a large corporation.

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 and 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, constructors and 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 New Product Development 2½:0:0:3

The dynamics of technology and the pressures of competition are driving enterprises to make their product development and production processes strategically more effective, and economically more efficient in time and cost. Course deals with the state-of-the-art in new product activities for service and manufacturing firms, examining in depth the marketing technology and manufacturing technology linkages.

MG 865 Managing Innovation 2½:0:0:3

Focuses on the effective management of technological change and innovation, which is accomplished by employing a dual perspective. One perspective is based on individual, group and organizational theory, research and practice. This body of literature, viewpoints and experience provides essential guides for successfully managing the introduction of new technologies. Realizing the full potential of new technologies requires effectively managing change to assure the commitment of all stakeholders. The second perspective is based on innovation theory, research and practice. This body of literature, viewpoints and experience provides key insights for effectively managing the process of innovation and the impact of innovation on all parts of an enterprise. Specifically, there is explicit consideration of the need within a firm to manage and inspire people so that they can effectively communicate and innovate.

MG 866 Technology Policy 2½:0:0:3

This course focuses on the macro-environment influencing and relevant to technology decision making, strategy and innovation in firms, government agencies, non-for-profit institutions and other organizations. Primary concerns include introducing effective approaches for analyzing and evaluating societal-wide factors that influence innovation; assessing various attempts and policies for stimulating innovation in a city, region, nation or on a global basis; exploring the role of technology and innovation in diverse managerial, economic and social contexts (e.g., advanced economies, rapidly emerging economies and Third World economies); the relationship between business-government and NGOs in promoting and sustaining innovation; the impact of global rivalry and global cooperation in the technology and innovation arena; and the place of technology and innovation in the post-Cold War era and in the early 21st century. Also listed under SS 866.

MG 867 Technology Strategy 2½:0:0:3

Examines in depth the strategic technological decisions that a general manager faces. From entrepreneurial start-ups to established companies, in dynamic as well as mature environments, there must be a conscious process of formulating and implementing a technology strategy to serve the business interests of the firm. Such a strategy would guide investments in research and development, selection among and timing of alternate technologies, organization and communications, formation of alliances and funding of ventures.

MG 934 Research Project in Organizational Behavior 2½:0:0:3

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 instructor's permission.*

MANAGEMENT PROGRAM

MG 968 Seminar in Management of Technology 2½:0:0:3

Complements the MOT elective curriculum by providing in-depth treatment of specific current topics in this rapidly changing field or by providing a structured forum for dealing with relevant issues in current practice. Depending on the theme that is chosen for each semester that the course is given, the format may be either readings and research or a series of discussions of contemporary issues led by expert practitioners.

MG 970 Project in Strategy and Innovation 2½:0:0:3

An integrative course that brings together the concepts and theories from a number of individual courses. Considers the corporation from the viewpoint of senior corporate and divisional management. Uses case studies and projects to focus on interrelationships between strategy, technology, innovation, corporate culture, organization structure and human factors in domestic and global corporations. *Prerequisite: advanced standing.*

MG 975 Selected Topics in Management 2½:0:0:3

Current topics in various fields are analyzed and discussed. *Prerequisites: advanced standing and instructor's permission.*

MG 976/977 Readings in Management 3 units each

Directed individual study of supervised readings in advanced areas of management. *Prerequisite: department head's permission.*

MG 985 Selected Topics in Organizational Behavior 2½:0:0:3

Discussion and analysis of current topics in organizational behavior. *Prerequisites: Advanced standing and instructor's permission.*

MG 986/987 Readings in Organizational Behavior 3 units each

Directed individual study or supervised readings in advanced areas of organizational behavior. *Prerequisite: department head's permission.*

MG 997 Thesis for Degree of Master of Science 3 units

Original investigation in a topic chosen by the student. Conferences and progress reports required during work, and final written report required at completion. Oral examination may be requested by the department. *Prerequisites: degree status and approval of supervising professor, adviser and department director.*

INFREQUENTLY OFFERED COURSES

MG 505 Probability and Managerial Statistics 2½:0:0:3

Starts with the basic concepts of random phenomena and goes on to advanced applications of statistics relevant to managers. Topics include: probability theory, discrete and continuous probability distributions, sampling, measures of central value and dispersion, hypothesis testing, statistical inference, quality control, analysis of variance, regression, correlation and nonparametrics. Emphasis is placed on application of concepts. No unit will be allowed towards any graduate degree program administered by the Department of Management.

MG 610 Quantitative Analysis for Managerial Decisions 2½:0:0:3

Teaches the student to build mathematical models of managerial problems. Types of models discussed include linear and non-linear programming, queuing, decision analysis and decision trees, and others. The class covers the assumptions made by each model, the model's formulation and solution, and issues that go beyond the scope of the models. This course focuses on methodologies and their applications, not on derivation of algorithms.

MG 619 Employee Scheduling

MG 830 Formulation and Analysis of Public Works Projects

Also listed under CE 781.

MG 850 Cost Systems

Prerequisite: MG 609.

MG 860 Financial Planning, Internal Reporting and Operation Control

Prerequisite: MG 609.

MG 863 Market Research

Prerequisite: MG 607.

MG 871 Manufacturing Strategies

Also listed under MN 622.

MANAGEMENT OF TECHNOLOGY EXECUTIVE PROGRAM

Academic Program Co-Directors: Mel Horwitch and Nina D. Ziv

For forward-thinking managers, the Management of Technology (MOT) Program is the path to leadership in today's knowledge economy.

One of the first accredited universities to offer an advanced degree in MOT, Polytechnic University is a recognized leader in the field. Rather than grafting a few courses onto a traditional MBA program, Polytechnic's MOT Program possesses a thoroughly innovative integrated curriculum.

Key characteristics of the MOT Program:

- Provides knowledge needed to manage technology-intensive corporations
- Focuses on strategic implications of technology and innovation
- Encompasses innovation management in all modern technology arenas such as media/entertainment, bio-medical/pharma/chemical, new materials, telecoms, financial and professional services
- Deals with the impact of technology and innovation throughout an enterprise
- Addresses physical, digital (including Internet-based) and mobile innovation
- Enables key transition from technologists to high-level, effective technology managers
- Assumes a global perspective
- Explores and develops new business models based upon technology-enabled innovation

In the MOT curriculum, even traditional subjects such as finance, operations management and marketing are taught with technology-enabled-innovation issues in mind. Subjects, concepts and issues directly related to technology management and accessing innovative capability that form the MOT Program core include:

- Customers, suppliers and other partners as sources and co-creators of innovation
- New product and services development
- The global search for innovation and

technology and choosing among increasingly global technology sources and markets, including Europe, the Pacific Rim, Israel, India and others

- Entrepreneurship
- Integrating technology and management
- Venture capital and venture creation
- The Internet and the Web-innovation as new platforms for innovation
- Innovation-friendly cultures and organizations
- The IT-innovation connection
- Revitalized R&D
- High-technology products and services
- Strategic technology planning and innovation-intensive new product business models
- Knowledge management
- Technology choice and acquisition
- Multiple and diverse levers for technology-enabled innovation

The program is well-suited for engineers and scientists with increasing managerial responsibility, as well as professionals, functional and business managers in finance, banking, telecommunications, design, retailing, media/entertainment and other increasingly technological environments.

MOT is an executive program. As such, it has the following general features:

- Close interaction and teamwork
- A professional, modern and informal learning environment
- Participants viewed as real partners in the learning process (in class and in the joint generation of intellectual capital as presentations, reports or cases—in paper and digital formats)
- A curriculum that is continually updated
- Close collaboration with respected partners in industry and the relevant scholarly community
- Full courses and half-semester courses to make the most of the limited time available
- Carefully selected elective courses to maintain flexibility in meeting diverse professional needs
- A blend of live class experience with

the use of modern, Web-based technology

- Effective remote-collaboration learning and teamwork that are also enabled by technology
- Learning materials that are often in digital Web-based format to take advantage of Internet-based technologies and methods
- The incorporation of technology with ease of use and access as key watchwords

There are also more focused tracks in MOT: Bio-Pharma, Management of Technology and Innovation in Financial Services (MOTIFS), Management of Technology and Innovation in Retailing (MOTIR) and an e-Business track.

MOT classes are held every other week on Thursday evening and all day Saturday at 55 Broad Street, in the heart of lower Manhattan.

An all-inclusive fee covers tuition and fees, textbooks and other educational material, special tutorials and lectures, and meals on class days. Visit the program's Web site at www.mot-tim.poly.edu for the most current information.

ADMISSIONS REQUIREMENTS

Admission to the MOT Program is based on an in-depth evaluation of a candidate's academic record, work experience and overall intellectual and professional qualifications and potential.

Applicants must demonstrate strong commitment, an ability to benefit professionally from rigorous 16-month executive programs and significant promise of future career advancement. Because of the heavy demands of these programs, it is important that employers also explicitly support such professional education.

In general, GRE and GMAT tests are not required for applying to the MOT or MOT Programs. But the MOT Executive Master's Management Degree Programs office may ask an applicant to submit scores later in the admissions process.

The Executive Master's Degree Program uses an admission process called the Self-Managed Application (SMA). Applicants must gather the mate-

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rials required by the program and forward them in a single envelope to:

Administrative Director
MOT-TIM Executive Master's Degree Programs
Polytechnic University
55 Broad Street, Suite 13B
New York, NY 10004

What the single envelope should contain:
1. Completed application, professional résumé and application fee.

2. Transcripts for previous college and university work. In order for transcripts to remain official, they must be sealed in the original envelope. Opened transcripts are not considered official.

3. Two letters of recommendation, which are generally from a supervisor or high-level colleague who is familiar with student's professional work.

The final step for admission is a personal interview with one of the academic co-Directors to discuss career objectives and to make sure students' aims fit the goals of the program.

For more information, contact the MOT program administrative director:
Tel: 718-260-4014
Fax: 212-547-7029
E-mail: mot-tim@poly.edu
Web: www.mot-tim.poly.edu

DEGREE REQUIREMENTS AND CURRICULUM

The 36-unit program consists of the following (the order in which courses are given may vary):

First Semester

MG 603 Organizational Behavior & Management Processes in Innovative Corporations
MG 609 Managerial Accounting & Finance
MG 865 Managing Innovation

Second Semester

MG 608 Managerial Economics and the Economic Environment
MG 670 Operations Management for Knowledge-Based Enterprises
MG 693 Information Technologies, Systems & Management in Organizations

Third Semester

MG 607 Marketing
MG 820 Project Management & Assessment for Technology Managers
MG 774 Advanced Trends in Technology Management & Innovation

Fourth Semester

MG 795 Global Innovation
MG 950 MOT Capstone Project Course
MG Elective Course I** (select one from the list below)
MG Elective Course II** (select one from the list below)

Elective Course Portfolio

MG 781 Selected Topics in Networking & Information Technologies**
MG 784 Negotiation in Technology-Intensive Sectors**
MG 785 High-Technology Leadership**
MG 786 High-Technology Entrepreneurship
MG 787 Intellectual Property for Technology & Information Managers**
MG 788 Modern Supply Chain Management: Integration Through Technology**
MG 789 Special Elective Topics for MOT & TIM**
MG 797 Financing for Value Creation**

* variable credit (1½/3 unit) course

** half-semester courses offered in third or fourth semesters

SPECIAL MOT TRACK:

Bio-Pharma Track

The Bio-Pharma MOT Track deals with the effective management of technology and innovation in the bio-pharma sectors. Jointly sponsored by the Department of Management and Othmer Department of Chemical and Biological Sciences and Engineering, this track covers the diverse array of firms that comprise the modern bio-pharma arena. The track also provides a broad and business-oriented overview of emerging technologies that are changing the nature of competition in bio-pharma. Finally, the Bio-Pharma Track introduces participants to the key managerial and competitive implications of developments that are significantly affecting the structure and future of bio-pharma value creation.

The Bio-Pharma curriculum is as follows:

First Semester

MG 865 Managing Innovation
MG 609 Managerial Accounting & Finance
MG 603 Organizational Behavior & Management in Innovative Corporations

Second Semester

MG 963 Information Technologies, Systems & Management in Organizations
MG 607 Marketing
CBE 771/MG 771 Bio-Pharma Sectors: Structure, Organization & Management

Third Semester

MG 820 Project Management & Assessment for Technology Managers
MG 608 Managerial Economics
CBE 768/MG 772 Managing Technological Innovation & Emerging Technologies in the Bio-Pharma Sectors

Fourth Semester

MG 950 MOT Project Course Capstone
CBE 769/MG 773 Emerging Trends in Innovation & Technology in the Bio-Pharma Sectors
MG Elective Course I** (select one from the list below)
MG Elective Course II** (select one from the list below)

Elective Course Portfolio

MG 781 Selected Topics in Networking & Information Technologies**
MG 784 Negotiation in Technology-Intensive Sectors**
MG 785 High-Technology Leadership**
MG 786 High-Technology Entrepreneurship
MG 787 Intellectual Property for Technology & Information Managers**
MG 788 Modern Supply Chain Management: Integration Through Technology**
MG 789 Special Elective Topics for MOT and TIM**
MG 797 Financing for Value Creation**

* variable credit (1½/3 unit) course

** half-semester courses offered in third or fourth semesters

SPECIAL MOT TRACK:

The e-Business Track

e-Business constitutes for many professionals in the MOT environment an important arena for value creation. It can enhance market performance and can make organizations more efficient and effective. Those MOT participants wishing to be formally recognized as knowledgeable in e-Business focus may choose to enter the MOT e-Business Track. Choosing this track requires the completion of a final project dealing specifically with an important topic in the e-Business world as part of the Capstone Course in the final semester. The e-Business track is open to all MOT participants.

SPECIAL MOT TRACK:

Management of Technology and Innovation in Financial Services [MOTIFS]

Management of Technology and Innovation in Financial Services [MOTIFS] is a special Track within the overall MOT Program. The degree that is awarded is the same degree awarded for the overall MOT Program.

MOTIFS is designed for professionals in the financial services industry who aim for and require greater understanding of innovation, technology and information management in financial services. MOTIFS provides an MOT curriculum with an emphasis on technological and competitive challenges facing securities, insurance, banking and other financial services segments.

The MOTIFS curriculum is as follows:

First Semester

- MG 603 Organizational Behavior & Management Processes in Innovative Corporations
- MG 609 Managerial Accounting & Finance
- MG 865 Managing Innovation

Second Semester

- MG 608 Managerial Economics
- MG 693 Information, Technology, Systems & Management in Organizations
- MG 796 Modern Financial Institutions

Third Semester

- FE 603 Money, Banking & Financial Markets
- MG 607 Marketing
- MG 820 Project Management & Assessment for Technology Managers

Fourth Semester

- MG 798 Managing Technological Innovation and Emerging Technologies in Financial Services or
- MG 799 Modern Financial Products
- MG 950 MOT Capstone Project Course
- MG Elective Course I**
(select one from the list below)

Elective Course Portfolio

- MG 781 Selected Topics in Networking & Information Technologies**
- MG 784 Negotiation in Technology-Intensive Sectors**
- MG 785 High-Technology Leadership**
- MG 786 High Technology Entrepreneurship*
- MG 787 Intellectual Property for Technology & Information Managers**
- MG 788 Modern Supply Chain Management: Integration Through Technology**
- MG 789 Special Elective Topics for MOT and TIM**
- MG 797 Financing for Value Creation**
- MG 820 Project Management & Assessment for Technology Managers*

* variable credit (1/3 unit) course

** half-semester courses offered in third or fourth semesters

SPECIAL MOT TRACK:

Management of Technology in Innovation and Retailing [MOTIR]

The MOTIR Track in the MOT Program integrates the proven curriculum for modern technology management education with selected courses specifically tailored to the key technology and managerial challenges faced by today's retailing industry. This track serves all executives involved in some part of the overall retailing value chain, from supplier, distributor, to the ultimate consumer.

The MOTIR curriculum is as follows:

First Semester

- MG 603 Organizational Behavior & Management Processes in Innovative Corporations
- MG 609 Managerial Accounting & Finance
- MG 865 Managing Innovation

Second Semester

- MG 670 Operations Management for Knowledge Based Enterprise
- MG 693 Information, Technology, Systems & Management in Organizations
- MG 765 The Retailing Industry: Structure, Organization & Management

Third Semester

- MG 607 Marketing
- MG 608 Managerial Economics
- MG 766 Managing Technological Innovation & Emerging Technology in the Retailing Industry

Fourth Semester

- MG 950 MOT Capstone Project Course
- MG 767 Global Retailing & Supply Chain Management*
- MG 788 Modern Supply Chain Management: Integration Through Technology**
- MG Elective Course I**
(select one from the list below)
- MG Elective Course II**
(select one from the list below)

Elective Course Portfolio

- MG 781 Selected Topics in Networking & Information Technologies**
- MG 784 Negotiation in Technology-Intensive Sectors**
- MG 785 High-Technology Leadership**
- MG 786 High Technology Entrepreneurship*
- MG 787 Intellectual Property for Technology & Information Managers**
- MG 789 Special Elective Topics for MOT and TIM**
- MG 797 Financing for Value Creation**

* variable credit (1/3 unit) course

** half-semester courses offered in third or fourth semesters

*** existing financial engineering course; see Financial Engineering Program catalog course section

SPECIAL MOT TRACK:

The e-Business Track

e-Business constitutes for many professionals in the MOTIFS environment an important arena for value creation. It can enhance market performance and can make organizations more efficient and effective. Those MOTIFS participants wishing to be formally recognized as knowledgeable in e-Business focus may choose to enter the MOTIFS e-Business Track. Choosing this track requires the completion of a final project dealing specifically with an important topic in the e-Business world as part of the Capstone Course in the final semester. The e-Business track is open to all MOTIFS students.

COURSES

The following MOT courses are unique to this executive management program. For other course descriptions, refer to the Management Program section of this catalog.

MG 603 Organizational Behavior and Management Processes in Innovative Corporations 2½:0:0:3

Introduction to issues and concepts in organizational and administrative behavior, with emphasis on designing and maintaining organizations that can innovate and adapt. Management processes for flexible and innovative organizations. The evolution of technology intensive business organizations. The role of technology in the growth of the modern firm. Human resource management and organization development in technology-intensive firms.

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. Global marketing and marketing on the Internet.

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MG 608 Managerial Economics

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 and currency systems. The economics of innovation and entrepreneurial activity. The role of technology in economic growth and in international competition.

MG 609 Managerial Accounting and Finance

2½:0:0:3

Principles and practices of the modern finance function including accounting and corporate finance, and their relevance for all information business managers. Strategic perspectives—balancing long-term development and short-term returns. Financing of ventures and innovative activities. Project selection, capital budgeting and risk analysis. Special emphasis is placed on financial decision making in the information business sectors and the financial assessment of increasingly important knowledge-intensive assets.

MG 610 Quantitative Analysis for Managerial Decisions

2½:0:0:3

Applications 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 670 Operations Management for Knowledge-Based Enterprises

3:0:0:3

Services and product development and process change. Managing the learning curve. Conflicts between innovation and productivity. Operations management as an element of overall strategy. Flexible operations systems and automation and information systems, CAD/CAM and computer-integrated operations. Quality control in this course. Students develop an understanding of the strategies, tools, processes and techniques for improving the profitability and competitiveness of

modern businesses from an operations perspective. Among other areas that receive emphasis: developing an operations strategy; managing operations as technology and economics change; measuring and improving “productivity” in the modern manufacturing and service sectors using activity-based costing in operations management; and theory of constraints and understanding “quality.”

MG 774 Advanced Trends in Technology Management and Innovation

2½:0:0:3

This course explores several trends that have emerged in the technology management and innovation arena in the past decade. These include the advent of digital-based innovation in the late 1990s, which has had a profound effect on how many firms conduct business; the effect of the crash of the NASDAQ in March 2000 and 9/11, which had a major effect on corporations who now had to operate within major economic and creative constraints; the development of the concept of networks as it relates to the organization and strategy of the firm; the development of the wireless technology platform and its effect on technology innovation; and the development of a new innovation paradigm that suggests a relationship between information technology, creativity and business practices. The course emphasizes classroom discussions as well as team-based and individual projects.

MG 693 Information Technologies, Systems and Management in Organizations

2½:0:0:3

Designed for managers who need to understand the role and potential contribution of information technology (IT) within organizations. The focus is on information technology and its business applications. Course concentrates on the current state of IT in organizations, challenges and strategic use of IT, IT infrastructure and architecture, the technical foundation of IT, building and implementing organization information systems, emerging issues in IT such as intelligent systems, business process re-engineering, knowledge management and group support systems. Course format is interactive with concept presentation followed by open discussion on real-world applications of IT and business cases.

MG 765 The Retailing Industry: Structure, Organization, and Management

3 units

Provides introduction to the emerging structure of the modern retailing industry and to effective retailing management. Also investigates how key firms in the modern retailing sector are managed and how pacesetter firms are organized and structured at both the strategic and operational levels. Covers both physical and internet based retailing. *Prerequisite: MOTIR Track only.*

MG 766 Managing Technological Innovation and Emerging Technologies in the Retailing Industry

3 units

Provides an introduction to technological innovation and emerging technologies retailing. The focal point of this course is the effective management of technological innovation in modern retailing. The role of technology platforms and applications, technology development and use, and the relationships between technologies and business processes are also discussed. *Prerequisite: MOTIR Track only.*

MG 767 Global Retailing and Supply Chain Management

1¼:0:0:1½

Deals with current theory and practice in global retailing and supply chain management and the link between globalization and supply chain management. The course also examines the flow and transformation of goods from the raw material stage through to the end user. The globalization of retailing has triggered a range of innovations in the supply chain which will also be the focal point of this course. *Prerequisite: MOTIR Track only.*

MG 771 The Bio-Pharma Sectors: Structure, Organization and Management

2½:0:0:3

Introduction to effective management in the modern bio-pharma sectors. Investigates how key bio-pharma firms are organized and managed at both the strategic and operational levels. Particular attention is paid to various forms of technology and innovation management occurring in the bio-pharma arena. Also listed under CBE 771.

MG 772 Managing Technological Innovation and Emerging Technologies in the Bio-Pharma Sectors 2½:0:0:3

Introduction to technological innovation and emerging technologies that are changing the nature of competition in the bio-pharma sectors. Concentrates on modern approaches for research and discovery of new molecules and on development of processes to manufacture them in large quantities. Explores the two major routes for this discovery activity and manufacturing processes: the “chemical” route and the “biological” route. Provides a blend of conceptual overviews, essential technical and scientific basics, competitive, regulatory and management implications of the developments studied and specific cases studied and industry examples. Also listed under CBE 768.

MG 773 Emerging Trends in Innovation and Technology in the Bio-Pharma Sectors 2½:0:0:3

Deals with selected important trends and issues that are having a major influence on the management of innovation and technology in the bio-pharma sectors. Covers a range of topics and comprises written papers, team presentations, readings and invited speakers. Intended to be integrative, and demands application of the knowledge gained in the Management of Technology Program as a whole. Actual topics explored may vary from year to year. Also listed under CBE 769.

MG 781 Selected Topics in Networking and Information Technologies (half-semester course) 1½:0:0:1½

Comprises an in-depth exploration of selected modern networking and information technologies. The specific topics studied vary from year to year. Examples are mobile communications, IP telephony, enterprise data systems. The course builds on previous TIM courses. Course provides a solid technology grounding in a learning context which also emphasizes how these selected technologies affect markets, industries, providers, integrators and users. Course’s technical content is supplemented with actual case examples and guest speakers.

MG 784 Negotiation in Technology-Intensive Sectors (half-semester course) 1½:0:0:1½

Negotiation is the art and science of creating good agreements. This course covers the science of negotiation by discussing and applying theories of negotiation. The art of negotiation is learned through practice; students in this class develop the art of negotiation by negotiating with each other in realistic cases. A wide variety of negotiation applications is covered in this class, including one-time and repeated negotiation, single and multi-issue negotiations, and two-party and multi-party bargaining. Special emphasis is placed on negotiations in technology-intensive environments. This class is taught using the case method. Many of the examples used in this course will be cases that the students actually negotiate with each other. Students’ grades will be based on their performance in these negotiations and on their class participation.

MG 785 High-Technology Leadership (half-semester course) 1½:0:0:1½

Focuses on the essential role of multifaceted leadership in diverse high-technology management settings. Discusses different forms of modern high-technology leadership; e.g., the general management leader, the project leader, the technology leader, the visionary leader and the operational team leader. Case studies and actual examples of high-technology leadership are emphasized.

MG 786 High-Technology Entrepreneurship (variable 1½/3units)

Focuses on entrepreneurship as a critical engine for wealth creation in the high-technology, innovation-intensive economy. Deals with such key issues as: (1) assessing attractiveness of opportunities; (2) launching a new venture; (3) obtaining the necessary financial, human and technology resources; (4) managing the transition from a small entrepreneurial firm to a large, sustainable professionally managed but still entrepreneurial corporation; and (5) being an entrepreneur and promoting entrepreneurship in a large corporation.

MG 787 Intellectual Property for Technology and Information Managers (half-semester course) 1½:0:0:1½

Focuses on the role of intellectual property (e.g., patents, trade secrets, copyrights, trademarks, etc.) as a major element in modern technology and information strategy. Relevant concepts and case studies are used, with examples representing both classical and digital innovations.

MG 788 Modern Supply Chain Management: Integration Through Technology (half-semester course) 1½:0:0:1½

Introduction to the role of information technology in supply chain management. Both qualitative and quantitative aspects of supply chain management are covered. Articles pertaining to leading-edge research and management thought are discussed and analyzed by students. The underlying objective is to prepare participants to develop skills that are useful in analyzing technology, marketing, logistics, operations and broader channel-management issues. Classes are conducted using the case method, and a high level of class interaction is expected. Required in MOTIR Track; elective for MOT Program.

MG 789 Special Elective Topics for MOT and TIM (half-semester course) 1½:0:0:1½

Covers selected key emerging trends and issues in the MOT and TIM domains. Discussion with industry leaders and specialists from business, government and academia. Topical treatment of technologies, markets, business practices, government regulations and the relationships among them.

MG 795 Global Innovation (variable 1½/3units)

Focuses on global technology-enabled innovation. Topics covered include: accessing global sources of innovation, coordination and organization of activities around the world, new product development on a global basis, the role of revitalized global R&D, growing prominence of IT and e-Business in global innovation, and the role of alliances and linkages with customers, suppliers and other third parties. Introduces the latest and most relevant thinking, research and practices.

MG 796 Modern Financial Institutions and Their Competitive Environment
2½:0:0:3

Unique course intersects technological innovation and management with regard to the financial services industry. Course focuses on the management of modern financial enterprises, innovation and technology management in these organizations, and the risk-return tradeoff from a financial-institution perspective. Deals with both the theory and practice of financial institutions by analyzing the regulatory, technological and competitive factors that define the dynamics of this rapidly changing industry. Knowledge in this course is developed primarily through a mixture of textbook reading assignments and discussions of concepts in real business contexts through case studies. Course objective is to provide technology managers with a firm knowledge of the normative consequences on financial management decision-making to create shareholder value. *Prerequisite: MOTIFS Track only.*

MG 797 Financing for Value Creation
1½:0:0:1½

Organized around the key-creating strategies and financial skills required by managers of entrepreneurial and innovative firms at various stages of evolution: from new, stand-alone entrepreneurial ventures to innovative, technology-driven projects of established corporations.

MG 798 Managing Technological Innovation and Emerging Technologies in Financial Services
2½:0:0:3

Introduces emerging information technologies and their applications in financial services industries to current and future managers. Covers three major financial services industries: banking, investment and insurance. Students develop deeper understanding of concepts and analyze real-business context through case studies. Course provides adequate technical knowledge and discusses in depth related managerial issues.

MG 799 Modern Financial Products
2½:0:0:3

Examines critical management issues of the technology domain that characterizes modern financial products used for investment, hedging or trading purposes. The description and use of these instruments were introduced in MG 796 and MG 693, which provide the necessary background discussion of information technologies and systems. Course's principal focus is on managing the technological challenges in the valuation and risk management of these data-intensive modern financial products. *Prerequisites: MG 796 and MG 693. MOTIFS Track only.*

MG 820 Project Management and Assessment for Technology Managers
variable 1½/3units

Managing technology-based projects ranging from individual research and development to large-scale and complex technological systems. Feasibility and risk analysis. Project selection and portfolio optimization. Alternative financing methods. Functional and administrative structures, coordination and scheduling of activities, personnel planning, negotiations, contracts and computer-based techniques. Cost estimation, capital budgeting, cost controls and effective matrix management. Actual case studies are used as are relevant project management software applications.

MG 865 Managing Innovation
2½:0:0:3

Examines key managerial features of modern innovation. Identifies diverse ways firms can access innovative capabilities. The managerial interplay between technology and management leading to innovation in the marketplace is a major focus of discussion and work. Important substantive themes include: (1) the variety of innovation processes existing in the modern economy, such as radical vs. incremental, product vs. process vs. service vs. system and physical vs. digital; (2) the diversity of corporate settings in which modern innovation takes place, e.g., large corporation vs. small firm or start-up vs. networked organizations; and (3) the sources of modern innovation, e.g., developers, users, suppliers, universities and other third parties.

MG 950 MOT Capstone Project Course
2½:0:0:3

Provides a capstone, integrative and state-of-the art intellectual experience for participants at the conclusion of the program. The class focuses on a selected major subject that is of broad and compelling managerial concern and that is related in important ways to the innovation, technology-intensive and/or information business arenas. Students are initially divided into small groups to tackle various aspects of the overall subject; individual participants are expected to submit their own analysis of a specific issue or firm associated with the general subject. Participants are encouraged to employ concepts and insights they have acquired during the course of the entire program

FE 603 Money, Banking and Financial Markets
3 units

The perspectives of this course extend beyond a managerial focus within individual enterprises to the financial services industry as a whole. The course analyzes key environmental variables that have a significant impact on how financial services companies are managed such as: monetary policy, which determines interest rates; and regulatory policies, which prescribe the constraints within which financial services companies must operate. The course also focuses on the important role of information technology in the banking environment.

MANUFACTURING ENGINEERING PROGRAM

Program Director: William R. McShane

The Department of Mechanical, Aerospace and Manufacturing Engineering offers a graduate program leading to a Master of Science in Manufacturing Engineering. Some courses are offered at the undergraduate level as technical electives for various engineering programs.

In recent years, much has been written about how to improve the productivity, profitability and competitiveness of U.S. manufacturers. Many new approaches have been introduced. The first wave of these centered on improving competitiveness through improving quality and reducing inventory and cycle time by focusing on design, the introduction of product realization processes and the introduction of specific new methods such as TQM, JIT/TQC, new production control systems and activity based costing. The program at Polytechnic emphasizes these methods and supports them through courses in robust design and the design of experiments techniques. As for production, there are courses in 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 the program addresses specifically how to overcome cultural barriers through courses in managing the human side of technological change and developing high-performance teams. Currently in U.S. industry, attention is being focused on reducing variability in production, thereby improving asset utilization and hence profitability and customer satisfaction. Polytechnic offers new courses in production science that specifically address these issues.

The department's comprehensive program in manufacturing engineering concerns this array of new methods, which are generally applicable and thus portable. Students may acquire specific knowledge in any of the professional disciplines offered at Polytechnic through a concentration consisting of up to four courses. The program is interdisciplinary and designed for working professionals who

have responsibilities in manufacturing and for those who plan to enter manufacturing after completing the master's program.

Because hands-on experience is so important, the program often makes arrangements for full-time students and those part-time students who do not work full-time to do internships in nearby manufacturing industry. Students enrolled full time can complete the MS program, including the internship, in one year.

GOALS AND OBJECTIVES

The objectives of the MS program in Manufacturing Engineering are for its students to acquire the skills necessary to:

- Develop expertise in methods used in a wide variety of industries to increase profitability and competitiveness by improving quality, cycle time, design and production in factories and supply chains
- Develop expertise in computer-based programs used throughout industry to analyze problems and improve performance, including simulation, linear programming, project management, facility planning and production planning and control
- Cultivate a broad knowledge base through the choice of concentration of courses in manufacturing engineering and related fields to suit career needs
- Obtain hands-on experience through internships in local industry, which also provides material for a master's report

GRADUATE PROGRAM

The Master of Science in Manufacturing Engineering can be taken full time or part time.

Students are drawn from a wide variety of manufacturing firms, large and small. Students have come from such firms as Symbol Technologies, Standard Motor Products, IBM, Loral, Medical Labs Automation, Guild Moulders, Photocircuits Corporation, Pitney Bowes, Kraft-General Foods and Kepco.

This program is designed to:

- Empower the graduate to identify, evaluate and implement production improvement by applying new methods
- Provide experience in design and production through internships and 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 the leadership that such programs require. They will be well positioned to advance their own careers.

UNDERGRADUATE PARTICIPATION IN MANUFACTURING

Polytechnic offers undergraduate courses in manufacturing engineering, which allow students in different engineering disciplines to use manufacturing courses as electives in their undergraduate programs.

DESIRABLE BACKGROUNDS FOR GRADUATE STUDENTS

Admission to this graduate program is open to those holding an accredited engineering degree (BS or BE), to graduates in physics, chemistry, materials science and the biological sciences and to those holding an MBA.

International students with equivalent backgrounds are eligible to participate in the program.

REQUIREMENTS FOR THE MASTER OF SCIENCE

The degree program requires 36 units, typically made up of 11 courses and a 3-unit master's report, or 10 courses and a 6-unit master's report. Units may be granted for up to three relevant graduate level courses (9 units) completed elsewhere with a grade of B or better. Issues relating to the transfer of courses are addressed in the Mechanical Engineering Program section of this catalog.

Prerequisite Courses (or equivalent knowledge)

Students must be computer literate and have knowledge of engineering economy and probability and statistics. If the prospective student lacks the relevant knowledge, the requirement may be satisfied by the following courses:

- Probability and Statistics (MA 651 or equivalent)
- Computer Literacy (ME 2114 or equivalent)

Up to 6 credits of graduate courses in this category of prerequisite knowledge can be counted for degree credit as electives.

Required Core Courses 18 units

- MN 611 Quality Control & Improvement
- MN 618 Managing the Human Side of Technological Change
- MN 785 Computer Integrated Manufacturing Systems
- MN 788 Manufacturing Systems Engineering
- MN 789 Production Science
- MN 792 Design for Manufacturability (DFM)

Other Courses 18 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.

MASTER’S REPORT

MN 996 MS Report is normally 3 units. It may be expanded to 6 units by use of MN 997 as an elective. The master’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. Full-time students may also work on theoretical or experimental research projects at Polytechnic. In all cases, a faculty adviser is assigned. Written project proposals are required at the start of the work. A written summary and report are required upon completion of the project.

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 are later admitted to study for a master’s degree are usually able to apply all certificate course units toward the master’s degree.

If students have taken the equivalent of any required courses as an undergraduate, they must work with their adviser to select substitute courses. Additional information is available from the department. The certificate programs are shown below:

Certificate in Manufacturing Excellence by Design: Holistic Approach

Required Courses:

- MN 612 Robust Design
- MN 651 Design Strategies
- MN 792 Design for Manufacturability

Elective Courses (choose 2):

- MN 771 Product Realization Process
- MN 788 Manufacturing Systems Engineering
- MN 796 Electronic Systems Manufacturing

Certificate in Manufacturing Engineering and Production Science

Required Courses:

- MN 788 Manufacturing Systems Engineering
- MN 789 Production Science
- IE 619 Production Planning & Control

Elective courses (choose 2):

- MN 611 Quality Control & Improvement
- MN 618 Managing the Human Side of Technology
- MN 632 Building High Performance Teams
- MN 776 Manufacturing Resources Planning
- MN 785 Computer Integrated Manufacturing
- MN 796 Electronics Systems Manufacturing
- IE 682 Factory Simulation

Certificate in Achieving World Class Quality

Required Courses:

- MN 611 Quality Control & Improvement
- MN 612 Robust Design
- MN 632 Building High Performance Teams

Elective Courses (choose 2):

- MN 651 Design Strategies
- MN 771 Product Realization Process
- MN 788 Manufacturing Systems Engineering

GRADUATE COURSES

The courses with MN designations below are followed by a set of courses from other programs that are commonly taken by manufacturing engineering students.

MN 611 Quality Control and Improvement 2½:0:0:3

The goal of this course is to provide the student with a solid foundation in the cost of quality, quality assurance and quality management. Emphasis is placed on the basic tools of quality control such as control charts and their use, the concept of “out of control,” acceptance sampling, variables and attributes charts, and producer’s and consumer’s risk. A unique aspect of this course is the demonstration of the power of teams of people with different expertise to improve quality. A course project is required. *Prerequisite:* MA 651 or familiarity with the concepts of probability and statistics. Also listed under IE 611.

MN 612 Quality Engineering Using Robust Design 2½:0:0:3

The goal of this course is to provide a broad review of the procedures involved in improving the quality of manufacturing. By employing both Taguchi techniques, such as the use of signal-to-noise ratio representations, and other techniques less sensitive to parameter interactions, a full spectrum of robust design methods are presented. Applications of these procedures are reviewed, including online troubleshooting methods to assure quality in manufacturing. *Prerequisite:* IE 611. Also listed under IE 612.

MN 618 Managing the Human Side of Technological Change 2½:0:0:3

The introduction of new technology brings with it the need to sensitize and educate engineers and managers to the impact these changes have on the technical as well as the general work force. This course concentrates on the manner in which new technologies and the associated new work structures can be introduced to a technology-sensitive organization. Issues of learning, communication, motivation, the appropriate management of change and the leadership responsibility in “making it happen” are extensively discussed.

MN 632 Building High Performance Teams 2½:0:0:3

Successful manufacturing programs require the teaming of a number of professionals having a variety of types of expertise, such as product design, manufacturing process design, production engineering, quality control, testing, packaging. In the past, these individual experts were involved only in a serial fashion in the overall product realization process, with not very effective results. Considerable evidence suggests that uniting these experts in a consistent team produces substantial benefits. This course provides students with the skills and knowledge to build work unit effectiveness. Topics include diagnosing team functioning, understanding group dynamics, creating a productive team culture, surfacing and resolving critical issues and implementing strategies for organizational support.

MN 651 Design Strategies 2½:0:0:3

Product design is a major determinate of product cost, quality and customer satisfaction. The design process is explored including establishing customer requirements, developing product specifications, conceptual design, detailed design, design for manufacturability, competitive analysis and design for the environment. Computer-aided applications and case studies are reviewed.

MN 771 Product Realization Process (PRP) 2½:0:0:3

Getting new products developed and to market is a major factor in determining global competitiveness. Case studies will be used to illustrate the product realization process and the successful application of R&D, concurrent engineering, cross-functional teams, continuous improvement, computer applications, target costing and new product development management.

MN 776 Manufacturing Resources Planning (MRP II) 2½:0:0:3

Computerized systems to effectively run a manufacturing business are discussed as well as the process of software specification, evaluation, selection and implementation. Topics include MRP logic, enterprise resource planning, manufacturing execution systems, inventory manage-

ment and bill of materials. Several different software systems and their features are highlighted. Also listed under 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 under 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 under IE 788.

MN 789 Production Science 2½:0:0:3

Just-in-time and synchronous manufacturing methods are reviewed. The basic dynamics of factories are analyzed to understand the importance of congestion and bottleneck rates on cycle time and inventories. Analytical models are developed to study variability and randomness introduced by breakdown, setups and batching. Simulation studies are used to provide data on performance of transfer lines.

MN 792 Design for Manufacturability (DFM) 2½:0:0:3

Concepts and techniques for economical, functionally sound and high-quality product design for manufacture are introduced. Emphasis is placed on designing for easy assembly, both robotics and manual, and on the effective use of plastics for manufacturing cost reduction. Managerial and organizational approaches and case studies of successful designs are reviewed. Also listed under IE 792.

MN 796 Electronics Systems Manufacturing 2½:0:0:3

The physical design and manufacturability of modern electronics systems is a result of tradeoffs involving partitioning, electrical performance, cooling and mechanical stresses. Design parameters are derived to study the tradeoffs, along with specific examples from reverse engineering studies. The current status and future directions of low-cost, high-volume manufacturing technologies are examined.

MN 799 Supply Chain Engineering 2½:0:0:3

An understanding of how companies plan, source, make and deliver their products with a global competitive advantage. Course stresses the engineering components in developing an integrated supply chain that covers the entire manufacturing enterprise. It looks at the supply chain infrastructure and the velocities of different models. Focuses on understanding and detecting the constraints of the infrastructure and the lowest common denominator of the information system used. An understanding of logistical networks and the optimizing of the various traffic and location alternatives. Synchronization of supply and demand is examined in detail, looking at variability in both processes with the objective of maximizing throughput and capacity, emphasizing partnering, e-commerce and the bullwhip effect. Finally, course established global performance measurements that compare various companies in different industries.

MN 911/912 Selected Topics in Manufacturing Engineering I/II each 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 each 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 regular-

MANUFACTURING ENGINEERING PROGRAM

ly offered courses. The topic must be agreed upon by the student and adviser prior to registration. A written report on the topic is required. Prerequisites: approval of adviser, instructor and department head.

MN 996 MS Report I 3 units

Independent project demonstrating professional maturity and graduate-level knowledge completed under guidance of departmental adviser. Experimental work, software development and extensive analysis are commonly expected. Report must include results in one or more of these areas, critical analysis and interpretation of pertinent literature and should represent worthwhile contribution to the field. Written report (unbound) is required. *Prerequisite: adviser's approval.*

MN 997 MS Report II 3 units

With the approval of the graduate adviser, some students may undertake a 6 unit MS report. This should be planned in advance, during the registration for MN 996. In such cases, MN 997 is used for the second half of the registration. A grade of S or U is awarded in MN 996 in these cases, and the letter grade given in MN 997 applies to all 6 units. *Prerequisite: adviser's approval.*

THE FOLLOWING GRADUATE COURSES ARE OFFERED IRREGULARLY IN RESPONSE TO INDUSTRY DEMAND

MN 794	Physical Design of Products
MN 802	Thermal Design of Electronics System for Performance & Reliability
MN 804	Thermal Issues in Manufacturing Processes

MANUFACTURING ENGINEERING UNDERGRADUATE COURSE ELECTIVES

These courses are under the administrative control of the Department of Mechanical, Aerospace and Manufacturing Engineering, and are available as undergraduate electives in mechanical engineering and other programs. MN 3714 to MN 4714 form the "University Sequence" and can be used by all undergraduates to satisfy the degree requirement for such a sequence bridging the junior and senior years.

MN 3714 Manufacturing I 4:0:0:4

A product must meet both a customer need and goals of performance, cost, quality, reliability, safety and the environment to be successful in the marketplace. The course addresses the issues that are critical to the design of a product for manufacture and the methods that have been found to be successful in addressing these issues. The design process is studied and illustrated by means of class exercises and a term project. Selected manufacturing processes are studied to establish the relationship between product design and manufacturing process complexity. *Prerequisite: junior status.*

MN 3734 Applied Manufacturing 4:0:0:4

Effective manufacturing education should be applicable to actual work situations. This course provides grounding in the basics of manufacturing in the classroom through study of manufacturing systems, design, quality, manufacturing planning, lead time and the supply chain. Grounding in an actual manufacturing environment is achieved through students spending about half the course working on a project in a neighboring manufacturing company. The project consists of observing and then applying manufacturing engineering principles to resolve an actual problem at the site.

MN 4714 Manufacturing II 4:0:0:4

World Class manufacturing has been the focus of many multi-disciplinary fields as global competition has reduced traditional core competencies. Contemporary productive enterprises have been further refined in a systematic approach in which quality is infused through the organization process. These processes may be human or capital and are all becoming variable Lean Corporate Enterprise. A technique called 6 Sigma Control has been shown to be efficacious in implementation of goals on increasing corporate value. This course will examine the contemporary productive enterprise in light of current quality organizational and lean manufacturing techniques. *Prerequisite: MN 3714.*

MATERIALS SCIENCE PROGRAM

Program Director: Sung Whang

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 today's 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.

Furthermore, materials scientists may work in research and development, plant operations or consulting. They 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 a few.

MATERIALS SCIENCE

It is estimated that nearly 40 percent of all engineering research is in the area of materials science, which is defined as the study of the interrelations among atomic structure, crystal structure, microstructure and properties of materials. The fundamental principles, involving basic physics and chemistry, are universally applied to metals, ceramics, polymers, semiconductors, nanomaterials, intermetallic compounds and composites. With this understanding it is possible to tailor materials with specific properties for particular applications.

DEGREES OFFERED

The program prepares students for a Master of Science in Materials Science and a Doctor of Philosophy in Mechanical Engineering, with a concentration in Materials Science available.

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.

GOALS AND OBJECTIVES

The objectives of the MS program in Materials Science are for its students to acquire the skills necessary to:

- Develop expertise and hands-on experience in modern materials analysis techniques
- Have a broad knowledge base on the relationship between microstructure and properties of metallic and ceramic materials
- Provide solid foundation on the role of crystal structure and defects in controlling mechanical and fracture behavior of crystalline materials
- Familiarize themselves with current materials-processing techniques and fundamentals

ADMISSIONS REQUIREMENTS

To be admitted to the master's program, applicants must have the equivalent of a bachelor's degree in metallurgy or materials science. Applicants with a bachelor's degree in a science or engineering field 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 academic performance and training.

DEGREE REQUIREMENTS

Full-time graduate students enrolled in the master's program are generally

required to complete a master's thesis. Part-time students are 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 MS degree.

Required Courses for the MS in Materials Science:

Enrollment in the program is open to students with undergraduate degrees in engineering or the physical sciences.

Course No.	Course Title	Units
MT 600	Structure-Property Relationships	3
MT 640	Reactions in Solids	3
MT 660	Ceramic Technology	3
ME 600	Applied Computational Methods	3

Project or Thesis*

MT 996	Report Project for MS	3-6
or		
MT 997	Thesis for MS	9-12

Elective Course Work:

With adviser's approval, elective courses may be chosen from the catalog in areas related to materials science—e.g., physics, chemistry and polymers. 12-21

Total 36

**Part-time students must take the project course.*

UNDERGRADUATE COURSES

INTERDEPARTMENTAL COURSE

MT 3814 Materials Science and Engineering 3:3:0:4

Atomic Structure and Bonding, Atomic Arrangement in Crystals, Crystal Imperfections, Mechanical Behavior and Failure of Materials, Phase Diagrams, Materials Selection. The Laboratory Part Involves Tensile, Hardness, Impact and Fatigue Testing, as well as Optical and Scanning Electron Microscopy of Materials.

GRADUATE COURSES

MT 600 Structure-Property Relationships in Materials 2½:0:0:3

Dependence of physical properties on the structure and symmetry of crystalline materials: a unified approach to thermal, electrical and mechanical properties. Symmetry elements and point groups, tensors and matrices, electrical properties, stress, strain, elasticity, thermal expansion, piezoelectricity, Pyroelectricity, thermodynamics of equilibrium properties, transport properties (thermal and electrical conductivity).

MT 601/602 Special Topics in Structure-Property Relationships I/II each 2½:0:0:3

Advanced or specialized topics in structure-property relationships in materials presented at irregular intervals. *Prerequisite: MT 600.*

MT 603 Introduction to Electron Microscopy I 2½:0:0:3

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 2:2:0:3

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 2½:0:0:3

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.

MT 611/612 Special Topics in Thermodynamics and Statistical Mechanics of Metals I/II each 2½:0:0:3

Advanced or specialized topics in thermodynamics and statistical mechanics of metals. *Prerequisite: MT 610.*

MT 620 Plastic Deformation and Fracture 2½:0:0:3

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.

MT 621/622 Special Topics in Deformation and Fracture I/II each 2½:0:0:3

Advanced or specialized topics in deformation and fracture. *Prerequisite: MT 620.*

MT 630 Theory of Metals 2½:0:0:3

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.

MT 631/632 Special Topics in Theory of Metals I/II each 2½:0:0:3

Advanced or specialized topics in electronic properties of materials. *Prerequisite: MT 630.*

MT 640 Reaction in Solids 2½:0:0:3

Bases of kinetic theory; diffusion controlled transformation; nucleation and growth in liquids and solids; surfaces and interfaces in solids; diffusionless phase transformation.

MT 641/642 Special Topics in Reactions in Solids I/II each 1½:2:0:3

Advanced or specialized topics in reactions in solids. *Prerequisite: MT 640 or instructor's permission.*

MT 650 Advanced Engineering Metallurgy 2½:0:0:3

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, alloy designs and designs of alloys for challenging environments.

MT 651/652 Special Topics in Advanced Engineering Metallurgy I/II each 2½:0:0:3

Advanced or specialized topics in advanced engineering metallurgy presented at regular intervals.

MT 660 Ceramic Technology 2½:0:0:3

Bonding and structure of ceramic solids; structure of crystalline compounds; structure of glasses; defects in stoichiometric and non-stoichiometric ceramics; surfaces and interfaces; diffusion in crystalline oxides and glasses; grain growth, sintering and vitrification; special microstructures; optical ceramics; electrical and dielectric ceramics; brittle fracture, thermal stresses, and strengthening mechanisms in ceramic compounds.

MT 706 Magnetism and Magnetic Materials 2½:0:0:3

Origin of magnetism in atoms and solids. Diamagnetic vs. paramagnetic behavior. Ferromagnetic domain theory. Antiferromagnetism and ferromagnetism. Structure and properties of magnetic materials.

MT 707 Thin Film Technology 2½:0:0:3

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 permission.*

MT 708 Semiconductor Materials and Devices 3:0:0:3

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 3:0:0:3

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 is printed out. Also listed under EL 646.

MT 714 Electrochemical Processes 2½:0:0:3

A presentation of the fundamentals of electrochemical reactions, focusing 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; electrosolution and deposition.

MT 720 Advanced Materials Analyses Mechanisms in Metals 2½:0:0:3

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 763/764 Seminar in Metallurgy and Materials Science each 0:0:0:2½

Preparation and presentation by students of seminars on topics of physical metallurgy, metallurgical engineering or materials science. Students critically review technical papers selected 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 and approved, the student is required to defend his thesis during an oral examination.

THE FOLLOWING GRADUATE COURSES ARE OFFERED AS NECESSARY

- 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

MATHEMATICS PROGRAM

The Department of Mathematics administers the mathematics degree program. More information can be obtained from the department Web site, <http://www.math.poly.edu>, by calling 718/260-3850 or by sending an e-mail to chair@math.poly.edu.

Mathematics comprises abstraction, logic, and quantitative reasoning. It is an indispensable tool for science and engineering. Today, mathematicians are employed by a wide range of companies, including Wall Street investment banks and government agencies, especially the National Security Agency. Polytechnic offers a complete spectrum of mathematics courses leading to bachelor's, master's and doctoral degrees. The degree programs provide not only a solid foundation in mathematics, but also extensive exposure to how mathematics is used in other fields of science and engineering. The department prides itself on providing each mathematics major, undergraduate or graduate, with extensive individual attention and a program tailored to individual needs.

UNDERGRADUATE PROGRAMS

The undergraduate program in mathematics provides both a background for advanced study or subsequent research in mathematics and training for those students who expect to terminate their formal education with a bachelor's degree.

For science and engineering majors, mathematics provides the theory and methods essential to understanding the mathematical aspects of their respective fields.

With these objectives, the Department of Mathematics offers courses in mathematics and, for the mathematics major, specific programs leading to the Bachelor of Science degree.

Students wishing to pursue a bachelor's degree in mathematics may elect to follow either of two courses of study. Students wishing to focus their studies within mathematics or applying mathe-

matics to other fields may elect the program leading to a BS in Mathematics. Students wishing to incorporate extensive physics into their mathematical training may elect the program leading to a BS in Mathematics and Physics. These two programs provide basic grounding in mathematical knowledge.

REQUIREMENTS FOR THE BACHELOR OF SCIENCE

	Credits
MA 1012, 1022, 1112, 1122, 2012, 2112, 2122, 2132, 2312, 2322, 3012, 3112, 3914, 4113, 4413, 4423, 4613, 4623, 4924	47
CS 1114	4
PH 1004, 2004	8
EN 1014, 1204	8
HI 2104	4
CM 1004	4
Minor Specialties*	18
Humanities/Social Science electives	12
Elective Sequence	8
Free electives, with adviser approval	15
	128

**Minor specialty: at least 9 credits beyond the required courses in a single area of study other than mathematics. The sequence must be well integrated and consistent, thereby enabling the student to gain knowledge in an area other than mathematics. Students should consult the faculty adviser of the department of interest when selecting electives. This requirement may be satisfied by either two minor specialties or one 18-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:

- Chemical Engineering
- Chemistry
- Computer Engineering
- Computer Science
- Economics
- Electrical Engineering
- Management
- Mechanical Engineering
- Physics
- Psychology
- Statistics
- Technical Writing

- Transportation

Advanced placement credits may be given toward 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 6 credits to be applied toward the 128-credit requirement for bachelor's degrees in mathematics.

DUAL MAJOR IN MATHEMATICS AND PHYSICS

Polytechnic offers undergraduates a dual major in mathematics and physics, according to the general rules described in the section "Degree Requirements." Specific course requirements for this 128-credit degree must be approved by advisers from both the mathematics and physics programs.

The dual major gives students the 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 go on to graduate studies in either of the two subjects.

MINOR IN MATHEMATICS

Students may obtain a minor in mathematics by taking 15 credits of mathematics courses, 8 credits of which are in addition to the major department's requirement in mathematics. At least 6 of these 8 credits must be taken by students while enrolled at Polytechnic.

GRADUATE PROGRAMS

The Department of Mathematics offers graduate level mathematics courses in analysis, geometry, topology, algebra, 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 and doctoral degrees in mathematics. Departmental requirements for these degrees are supplemented by 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

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 one-year course in advanced calculus. In case of acceptance without these credits, students are asked to take the sequence MA 621/622 at Polytechnic in addition to other requirements listed below for the master's degree.

Thirty-six units are required. Six units may be devoted to a thesis.

Course No.	Course Title	Units
MA 601/602	Applied Matrix Theory I/II	6
MA 621/622	Elements of Real Analysis I/II	6
MA 630	Elements of Complex Analysis	3
MA 640	Elem. of Geometry and Topology	3
	Elective courses	12
	Additional electives	<u>6</u>
Total		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

Requirements for the doctoral degree 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. The minor fields are encouraged to be chosen outside the Department of Mathematics, selected from such fields as applied mechanics, financial engineering, control theory, computer science, traffic engineering and electrical engineering.

Forty-eight units of courses and at least 24 thesis credits are required. Only courses with grades of B or better can be used to satisfy the PhD requirements. A PhD candidate must maintain at least a 3.0 average. Students are required to pass a Part 0 written examination covering fundamental topics; a Part 1 written examination covering real and complex analysis and linear and abstract algebra; and a Part 2 oral examination on topics chosen by the student and the dissertation adviser. After passing the Part 2 examination, the student writes a dissertation under the supervision of a faculty adviser. The final requirement for the PhD is an oral exam on the student's dissertation.

Students must demonstrate the ability to read mathematical text written in French, German or Russian.

Contact the Department of Mathematics for more information.

UNDERGRADUATE COURSES

MA 0902 Introduction to Precalculus 4:0:0:2

Foundations of Algebra: exponents, multiplication of algebraic expressions, factoring algebraic expressions, working with algebraic fractions. Proportionality, rates of change, equation of a line, completing squares, the quadratic formula, solving equations, system of linear equations, inequalities, domain and range of functions. Note: credit for this course may not be used to satisfy the minimum credit requirement for graduation.

MA 0912 Precalculus A 4:0:0:2

Exponential and logarithmic functions, transformations of functions; trigonometric identities. *Prerequisite: diagnostic exam.* Note: credit for this course may not be used to satisfy the minimum credit requirement for graduation.

MA 0922 Precalculus B 4:0:0:2

Continuation of Precalculus: trigono-

metric functions, compositions, inverses and combinations of functions, polynomial and rational functions. *Prerequisite: MA 0912.* Note: credit for this course may not be used to satisfy the minimum credit requirement for graduation.

MA 1012 Calculus IA 4:0:0:2

Introduction to Calculus I: limits, derivatives of functions defined by graphs, tables and formulas, differentiation of power, polynomial, exponential, trigonometric, logarithmic, inverse trigonometric functions and implicit differentiation. *Prerequisite: diagnostic exam, MA 0922 or equivalent.*

MA 1022 Calculus IB 4:0:0:2

Continuation of Calculus I: the Integral. First and second order linear constant coefficient homogeneous differential equations. Parametrized families of curves. Optimization. *Prerequisite: MA 1012.*

MA 1112 Calculus IIA 4:0:0:2

Introduction to Calculus II: techniques of integration. Improper integrals. Elementary numerical analysis. Solving non-linear equations. Numerical methods of integration. *Prerequisite: diagnostic exam, MA 1022 or equivalent.*

MA 1122 Calculus IIB 4:0:0:2

Continuation of Calculus II: applications of integration. First and second order linear constant coefficient inhomogeneous differential equations. Approximation of functions by means of Taylor polynomials. Sequences, Series, Taylor series, Power series. Fourier series. *Prerequisite: MA 1112.*

MA 1132 Numerical Methods for Calculus 4:0:0:2

Parametrized family of curves. Elementary Numerical Analysis. Introduction to differential equations. Solution of first and second order linear differential equations with constant coefficients. Use of mathematical software to solve differential equations. Fourier series. *Prerequisite: AP credit or transfer credit for Calculus I and II.*

MATHEMATICS PROGRAM

MA 1144 Mathematics for Liberal Studies 4:0:0:4

Management Science - Euler Circuits, Hamiltonian Circuits, Traveling Salesman Problem, Scheduling Tasks; Coding Information - Zip Codes, Bar Codes, Binary Codes, Cryptography; Social Choice and Decision Making - Elections with only two alternatives, three or more alternatives, weighted voting systems; Fair Division - The Adjusted Winner Divorce Procedure, Cake-Division Schemes; Consumer Finance Models - Models for savings, arithmetic and geometric growth, compound interest, the number e .

MA 2012 Elements of Linear Algebra I 4:0:0:2

Introduction to vector concept. Linear transformations. Matrices and Determinants. Characteristic roots and eigenfunctions. *Prerequisite: MA 1022 or equivalent.*

MA 2054 Applied Business Data Analysis I 4:0:0:4

Applications of theories of random phenomena to problems in business management. Topics include probability theory, discrete and continuous probability distributions, sampling, measures of central value and dispersion, sampling distributions, statistical estimation and introduction to hypothesis testing. Use of statistical software is integrated with the previous topics; examples are drawn from problems in business decision-making. Applications to advanced statistical applications in business management. Topics include hypothesis testing, statistical inference, analysis of variance, regression, correlation, quality control and nonparametrics. Emphasis placed on application of concepts. Use of statistical software integrated with the previous topics. *Prerequisite: MA 1022.*

MA 2112 Multivariable Calculus A 4:0:0:2

Introduction to Multivariable Calculus. Analysis of functions of several variables, vector valued functions, partial derivatives, and multiple integrals. *Prerequisite: MA 2012 and MA 1122.*

MA 2122 Multivariable Calculus B 4:0:0:2

Continuation of Multivariable Calculus. Optimization techniques, parametric equations, line integrals, surface integrals and major theorems concerning their applications. *Prerequisite: MA 2112.*

MA 2132 Ordinary Differential Equations 4:0:0:2

First order differential equations: modeling and solving. Stability of autonomous equations. Higher order linear ordinary differential equations: Solution bases, Wronskian, and initial value problems. Linear system of first order differential equations with constant coefficients: Elimination and eigenvalue method of solution. Elementary concepts of numerical analysis. Numerical solution of initial value problems for ordinary differential equations. *Prerequisites: MA 1122 and MA 2012.*

MA 2212 Data Analysis I 4:0:0:2

Basic theory of probability. Random variables. Distributions. Expectation. Functions of a random variable. Descriptive statistics. Data description. Sampling distributions. Use of statistical software is integrated with previous topics. *Prerequisite: MA 1122 or equivalent.*

MA 2222 Data Analysis II 4:0:0:2

Point and interval estimation. Hypothesis testing. Linear regression. One-way analysis of variance. Use of statistical software is integrated with the previous topics. *Prerequisite: MA 2212.*

MA 2312 Discrete Mathematics I 4:0:0:2

Logic and induction. Sets and functions. Recursive definitions. Counting techniques. Inclusion-exclusion principle. *Prerequisite: MA 1022 or equivalent.*

MA 2322 Discrete Mathematics II 4:0:0:2

Recurrence relations and generating functions. Equivalence relations and partial orderings. Graphs and connectivity of graphs. Trees and sorting. Boolean algebra, languages, and finite state machines. *Prerequisite: MA 2312.*

MA 3012 Introduction to Probability I 4:0:0:2

Probability of events. Random variables. Discrete and continuous distributions. Joint distributions. Expectation. Functions of a random variable. Central limit theorem. *Prerequisite: MA 2112 or equivalent.*

MA 3112 Complex Variables I 4:0:0:2

Functions of a complex variable. Derivatives and Cauchy-Riemann equations. Integrals and Cauchy integral theorem. Power and Laurent Series. Residue theory. *Prerequisite: MA 2122 or equivalent.*

MA 3914 Reading Seminar in Mathematics I 4:0:0:4

Reading, study and investigation of selected topics in mathematics. Problem discussions and presentations by participating students. *Prerequisite: approval of departmental adviser.*

MA 4013 Introduction to Number Theory 3:0:0:3

Properties of integers and prime numbers. Congruences. Theorems of Fermat, Euler and Wilson. Quadratic residues. Diophantine equations. *Prerequisite: MA 1112.*

MA 4023 Elements of Abstract Algebra 3:0:0:3

Basic properties of groups, rings, fields, Euclidean rings and modules. Field extensions and Galois theory. Finite fields. *Prerequisite: MA 2012.*

MA 4113† Introduction to Mathematical Statistics 3:0:0:3

Standard first course in mathematical statistics, recommended for those planning to take advanced courses in statistics. Sampling distributions, tests of hypotheses, significance tests, point and interval estimation, regression and analysis of variance. *Prerequisite: MA 3012.*

MA 4123† Statistical Methods 3:0:0:3

Analysis of variance with simple experimental designs. Sampling procedures, including sequential analysis. Nonparametric statistical methods. Statistical decisions. *Prerequisite: MA 4113.*

MA 4413† Vector Analysis and Partial Differential Equations 3:0:0:3

Vector algebra and vector calculus. Surface, line and volume integrals. Theorems of Gauss, Green and Stokes. Curvilinear coordinates. Fourier series, Legendre polynomials and Bessel functions. Dirichlet and Neumann problems. Heat flow, wave motion, vibration problems. *Prerequisite: MA 2122 and MA 2132.*

MA 4423† 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 2132 and some experience in computer programming.*

MA 4433 Complex Variables 3:0:0:3

Functions of a complex variable. Derivatives and Cauchy-Riemann equations. Integrals and Cauchy integral theory. Power and Laurent series. Residue theory. Conformal mappings. Schwarz-Christoffel transformations. *Prerequisite: MA 2122 and MA 2132.*

MA 4613/4623 Analysis I/II 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 and Gamma functions. *MA 4613 prerequisite: MA 2122 and MA 2132. MA 4623 prerequisite: MA 4613.*

MA 4924 Reading Seminar in Mathematics II 4:0:0:4

Reading, study and investigation of selected topics in mathematics. Problem discussions and presentations by participating students. *Prerequisite: departmental adviser's approval.*

GRADUATE COURSES

MA 531/532 Applied Mathematics in Engineering and Science I/II each 2½:0:0:3

Vector algebra and vector analysis. Determinants and matrices. Jordan normal forms. Eigen values 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 2122 and MA 2132 or equivalent. MA 532 prerequisite: MA 531.*

MA 5414 Stringology: Mathematics of String Comparisons in Computational Biology 3:3:0:4

Basic combinatorial problems of string manipulation – string matching, string editing, string distance computations arising from areas of text processing, computational biology and genomics. Classical, modern and entirely new approaches to these problems will be presented with all necessary mathematical and computer science backgrounds including coding theory and symbolic manipulation.

MA 600 Elements of Discrete Mathematics 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. *Prerequisite: adviser's approval.*

MA 601/602 Applied Matrix Theory I/II each 2½:0:0:3

Systems of linear equations. Matrices and determinants. Vector spaces and linear transformations. In-depth introduction to theory and application of linear operators and matrices in finite-dimensional vector spaces. Eigen values, eigenvectors, diagonalization and symmetric matrices. Invariant subspaces, elementary divisors and canonical forms. Minimax theorems for eigen values of Hermitian pencils. Introduction to numerical methods of linear algebra. *MA 601 prerequisites: MA 2012 and MA 2122 or equivalent. Also listed under EL 525. MA 602 prerequisite: MA 601.*

† Course may be accepted for graduate credit in department other than Mathematics.

MATHEMATICS PROGRAM

MA 610 Graph Theory 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 and networks. *Prerequisite: MA 600 or adviser's approval.*

MA 612 Queueing Theory 2½:0:0:3

Steady-state solutions for single and multiple channels. Various arrival and service distributions and queuing disciplines. Transient solutions. Emphasis on theory, with solution techniques given for specific classes of queues. *Prerequisite: MA 600 or adviser's approval.*

MA 614 Optimization: Linear and Non-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. Quadratic programming, Kuhn-Tucker conditions. Wolfe's method. Applications, problem formulation and computer solutions. *Prerequisite: MA 600 or adviser's approval.*

MA 618 Topics in Algebra 2½:2:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 4023, MA 601 and MA 602.*

MA 621/622 Elements of Real Analysis I/II each 2½:0:0:3

Functions, sequences, bounds, limits. Properties of continuous functions. Mean-value theorems, infinite series, power series and Taylor series. Partial differentiation. Extreme value problems with constraints. Implicit functions. Transformations. Uniform continuity. Theory of the Riemann and Stieltjes integral. Uniform convergence. Improper integrals. *MA 621 prerequisite: MA 2122 and MA 2132 or equivalent. MA 622 prerequisite: MA 621.*

MA 623 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 621 and MA 622.*

MA 624 Theory of Partial Differential Equations 2½:0:0:3

Partial differential equations. Cauchy-Kowalewski theorem. First-order differential equations, systems of differential equations in two variables, characteristics and classification, hyperbolic, parabolic and elliptic systems. Well-posedness. *Prerequisites: MA 621 and MA 622.*

MA 630 Elements of Complex Analysis 2½:0:0:3

Analytic functions of a complex variable. Complex numbers, differentiation and integration. Cauchy theorems. Power and Laurent series. Evaluation of integrals by residues. Conformal mappings and Schwarz-Christoffel transformations. *Prerequisites: MA 2122 and MA 2132 or equivalent (not open to students who have taken MA 3112 or MA 4433).*

MA 631 Applications of Complex Analysis 2½:0:0:3

A brief review of important characteristics of analytic functions. The use of conjugate functions in the solution of two-dimensional potential problems. The study of conformal mappings with emphasis on Schwarz-Christoffel transformations and their applications. *Prerequisite: MA 630.*

MA 639 Topics in Analysis 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 621 and MA 630.*

MA 640 Elements of Geometry and Topology 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 2122 and MA 2132 or equivalent.*

MA 649 Topics in Geometry and Topology 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisite: MA 640.*

MA 651 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. *Prerequisite: MA 1122 or equivalent.*

MA 652 Regression—Analysis of Variance—Time Series Analysis 2½:0:0:3

Discussion of models and computational schemes associated with correlation, regression coefficients, analysis of variance and time series models. *Prerequisite: MA 4113 or MA 651.*

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, brachistochrones.
Prerequisite: MA 4623 or MA 622.

MA 665 Numerical Analysis 2½:0:0:3

Interpolation. Approximation of functions by polynomials. Fast Fourier transform. Numerical integration. Solution of nonlinear equations. Iterative improvement of solutions of linear equations. Eigen values of matrices. Numerical solution of ordinary differential equations. *Prerequisites: MA 2122, MA 2132 and some experience in computer programming.*

MA 666 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 601, MA 665 and some experience in computer programming.*

MA 668 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. Applications. *Prerequisite: MA 4623 or equivalent.*

MA 679 Topics in Applied Mathematics 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 601 and MA 630.*

MA 681 Elements of Probability 2½:0:0:3

Probability of events, distribution of random variables, joint distribution, transformations. *Prerequisites: MA 2122, MA 2132 and MA 3012 or equivalent.*

MA 682 Stochastic Processes 2½:0:0:3

Normal and stationary processes, Wiener processes, Poisson and renewal processes, Markov processes. *Prerequisite: MA 681 or equivalent.*

MA 683/684 Statistical Inference I/II each 2½:0:0:3

Point and interval estimation of statistical parameters. Theory of statistical estimators. Fundamentals of statistical tests of hypotheses. Second semester: extended theory of hypothesis testing, including sequential tests. Nonparametric methods in statistics. *MA 683 prerequisite: MA 681 or equivalent. MA 684 prerequisite: MA 683.*

MA 685 Multivariate Analysis 2½:0:0:3

Multivariate normal distribution. Simple, partial and 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. *Prerequisite: MA 684.*

MA 686 Regression and Analysis of Variance 2½:0:0:3

Linear regression of one or more independent variables. Least square estimates of regression coefficients. Gauss-Markov theorem. Confidence regions for and tests of hypotheses about regression coefficients. Tests 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. *Prerequisite: MA 684.*

MA 687 Nonparametric Methods in Statistics 2½:0:0:3

Statistical methods not bound by assumption of known parametric form of the distribution of observations. Applications to engineering and scientific research in which observations are not ordered on a numerical scale. Order statistics, tolerance regions, permutation tests, goodness of fit tests, limiting distributions and large-sample properties of tests. *Prerequisite: MA 681.*

MA 691/692 Time Series Analysis I/II each 2½:0:0:3

Careful study of tractable models for statistical analysis of scalar time series. Models treated: (1) "error plus trend" models, (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 691 prerequisites: MA 681 and MA 684. MA 692 prerequisite: MA 691.*

MA 699 Topics in Probability and Statistics 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 681 and MA 683.*

MATHEMATICS PROGRAM

MA 701 Abstract Algebra 2½:0:0:3

Basic algebraic structures, groups, rings, fields, integral domains and modules. Field extensions and Galois theory. *Prerequisite: MA 601 or equivalent.*

MA 721 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. *Prerequisites: MA 621 and MA 622 or equivalent.*

MA 722 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 721.*

MA 731/732 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. Applications to classical analysis. *MA 731 prerequisites: MA 601 and MA 721. MA 732 prerequisite: MA 731.*

MA 740 Topology 2½:0:0:3

Topological spaces. Compactness, connectedness, continua, extension theorems and metrization theorems. Simplexes, simplicial topology and applications. Fixed-point theorems. Graphs and networks. Homology and cohomology theory. Introduction to Morse theory. *Prerequisites: MA 621 and MA 622 or equivalent.*

MA 750 Manifolds and Lie Groups 2½:0:0:3

Elementary theory of manifolds. Tangent space, mappings, submanifolds, fields, fiber bundles, Lie groups, homogeneous spaces. Elements of the theory of connections, Riemannian geometry. Imbedded manifolds. Calculus of variations. Harmonic forms, complex manifolds and Morse theory. *Prerequisites: MA 621 and MA 622.*

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 theorems and topological degree to study properties of solutions to ordinary and partial differential equations. No previous courses in topology are required. *Prerequisite: MA 4623 or MA 622.*

MA 781 Probability 2½:0:0:3

Measure-theoretic foundations of probability. Expectations, distribution functions, characteristic functions. Modes of convergence of random variables and distribution functions. Laws of large numbers. The multidimensional central-limit theorems and related asymptotic expansions. Infinitely divisible distributions. *Prerequisite: MA 721.*

MA 783/784 Stochastic Processes I/II each 2½:0:0:3

Foundations of stochastic processes. Kolmogorov's extension theorem. Properties of sample paths. Conditional expectation. Martingales. Classes of stochastic processes. Gaussian processes, Markov processes, and others. Second order properties. Stationary processes. Applications. *MA 783 prerequisite: MA 781. MA 784 prerequisite: MA 783.*

MA 808 Advanced Topics in Discrete Mathematics 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisite: MA 600.*

MA 818 Advanced Topics in Algebra 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisite: MA 701.*

MA 828 Advanced Topics in Real and Complex Analysis 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 721 and MA 722.*

MA 838 Advanced Topics in Differential Equations 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 623, MA 624, MA 721 and MA 722.*

MA 846 Fourier and Laplace Transforms 2½:0:0:3

Application of transform methods to partial differential equations of mathematical physics. Includes introduction to the Wiener-Hopf technique. *Prerequisite: MA 630.*

MA 848 Advanced Topics in Topology 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 740 and MA 750.*

MA 858 Advanced Topics in Differential Geometry 2½:0:0:3

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisites: MA 740 and MA 750.*

MA 868 Advanced Topics in Applied Mathematics *2½:0:0:3*

Asymptotic expansions of definite integrals and of solutions to differential equations. Perturbation theory. Variational methods. Nonlinear vibrations. Distributions and spectral representation of linear operators. Relaxation methods. Boundary value problems. *Prerequisites: MA 601 and MA 630.*

MA 888 Advanced Topics in Probability *2½:0:0:3*

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisite: MA 782.*

MA 898 Advanced Topics in Statistics *2½:0:0:3*

Course content varies. In spring of year prior to course offering, a detailed description is posted and mailed to all graduate mathematics students. *Prerequisite: MA 684.*

MA 941–946 Reading in Mathematics I–VI *each 2½:0:0:3*

Reading done under guidance of faculty members and devoted mainly to scholarly papers. *Prerequisite: department's permission.*

MA 958/959 Selected Topics in Advanced Mathematics I/II *each 2½:0:0:3*

Review of current mathematics research. Specific topics vary, depending on instructor. *Prerequisite: department's permission.*

MA 997 Thesis for Master of Science Degree *each 3 units*

Thesis to present results of independent investigation of suitable problem in 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. Re-registration fee, any part: 3-unit charge. *Prerequisite: degree status.*

MA 999 Dissertation for Doctor of Philosophy Degree *each 3 units*

Results of independent investigation of some problem in mathematics. The student must demonstrate ability to do creative work and include original research of the caliber deemed worthy of publication in recognized scientific journals. An oral examination on the dissertation subject and related topics is required. Re-registration fee, any part: 3-unit charge. *Prerequisites: degree status and qualifying examination.*

Typical Course of Study for the Bachelor of Science in Mathematics

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1012	Calculus IA1 (½ semester)	4	0	0	2
CM 1022	Calculus IB (½ semester)	4	0	0	2
CS 1114	Introduction to Programming and Problem Solving	3	3	0	4
EN 1014	Writing & Humanities I ²	4	0	0	4
SL 1010	Freshman Seminar	1	0	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1112	Calculus IIA (½ semester)	4	0	0	2
MA 1122	Calculus IIB (½ semester)	4	0	0	2
PH 1004	Introductory Physics I	4	1½	1	4
EN 1204	Writing & Humanities	4	0	0	4
Free Elective					4
					16

SOPHOMORE YEAR

Fall Semester

MA 2012	Linear Algebra I (½ semester)	4	0	0	2
MA 2132	Ordinary Diff. Equ (½ semester)	4	0	0	2
PH 2004	Introductory Physics II	4	1½	1	4
HI 2104	Modern World History	4	0	0	4
Minor Specialty					4
					16

Spring Semester

MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi. Calculus B (½ semester)	4	0	0	2
MA 2312	Discrete Math. I (½ semester)	4	0	0	2
MA 2322	Discrete Math. II (½ semester)	4	0	0	2
HU/SS Elective ³		4	0	0	4
Minor Specialty					4
					16

JUNIOR YEAR

Fall Semester

MA 3012	Intro. Probability I (½ semester)	4	0	0	2
MA 3112	Complex Variables I (½ semester)	4	0	0	2
HU/SS	Elective ³	4	0	0	4
Minor Specialty					4
Sequence Elective ⁴					4
					16

Spring Semester

MA 3914	Reading Seminar in Math. I	4	0	0	4
HU/SS Elective ³		4	0	0	4
Minor Specialty					4
Sequence Elective II ⁴		3			4
					16

SENIOR YEAR

Fall Semester

MA 4113	Intro. Math. Statistics	3	0	0	3
MA 4413	Vector Analysis and P.D.E.	3	0	0	3
MA 4613	Analysis I	3	0	0	3
Minor Specialty					2
Free Elective ⁵					5
					16

Spring Semester

MA 4423	Intro. Numerical Analysis	3	0	0	3
MA 4623	Analysis II	3	0	0	3
MA 4924	Reading Seminar in Math. II	4	0	0	4
Free Elective ⁴					6
					16

Total credits required for graduation:

128

1. Students who are placed by examination or by an adviser into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1012.

2. Students who are placed by examination or by an adviser into EN 1080 must subsequently register for EN 1034, rather than EN 1014.

3. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II Elective courses in different disciplines and one from Level III Advanced Elective courses.

4. A list of approved Sequence Electives is available from the department.

5. The Free Elective can be a course offered by any department, provided it does not duplicate material studied in other courses.

MECHANICAL ENGINEERING PROGRAM

Program Director: Said Nourbakhsh

The BS in Mechanical Engineering can be completed both in a full-time or part-time schedule. Students choosing the Co-Op Program are accommodated. There is no evening program, and as a result, part-time students have to take the same classes as full-time students. Transfer students are welcome and are required to meet the minimum residence requirements set by the University. There are pre-planned programs or articulation agreements with several colleges to ease the transfer. The Office of Admissions should be consulted for details. Polytechnic offers graduate degrees Master of Science and Doctor of Philosophy in Mechanical Engineering. For each level, the student must choose one of three specialty areas: (1) thermal and fluid sciences, (2) mechanical analysis and design or (3) controls and robotics. At the PhD level, two more options exist, in aerospace and materials science. All mechanical engineering graduate degrees are offered to both full-time and part-time students at the Brooklyn campus.

MECHANICAL ENGINEERING PROFESSION

Mechanical engineering is a dynamic and continually evolving profession and the most diverse among all engineering disciplines. 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. Mechanical engineering also has a long tradition of leadership in helping to develop the natural environment by breaking new ground in such areas as resource conservation, improved efficiency of energy-consuming devices, development of codes for a safer technological environment, new energy sources and the like. Undergraduate and graduate programs in mechanical engineering are designed primarily to develop talents in such

areas as design of components, fluid and thermal systems, controls and robotic systems and computer-integrated mechanical and electromechanical systems. However, many graduating students eventually apply their training to the additional diversified fields of computer engineering, nanotechnology, software development, financial engineering, bioengineering, manufacturing, astronautics, systems engineering and corporate management and law. As students mature and realize their abilities, their professional lives may center on engineering research, government, business or education.

AEROSPACE ENGINEERING PROFESSION

Aerospace engineering is the art and science associated with the design and performance of aircrafts, missiles and spacecrafts. 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.

Vehicles currently being designed or projected for the future stagger the imagination when seen from the standpoint of complexity, scope of engineering and scientific problems and audacity of the mission. Until recently, long-range missiles, moon vehicles, deep space probes and space habitats had been confined to the realm of science fiction. To meet these design challenges, aerospace engineers must understand the scientific principles that give them the greatest possible potential and flexibility. Conflicting requirements imposed by such considerations as safety, reliability, cost, maintenance, production and handling often demand compromises to attain optimum design. Aerospace engineers are responsible to resolve such issues.

UNDERGRADUATE PROGRAM

The mechanical engineering curriculum achieves balance between principle and practice. Computer and laboratory experiences are an integral part of the curriculum, as is the emphasis on engineering design—both the systematic process of design, as well as the creative content. Three aspects of design addressed through the course content are (1) the concept of design and the corresponding concept of multiple solutions, (2) the process of design and (3) the tools and skills for design. The first includes both the creative element and project work, at least when the problem does not have a unique solution. The second includes introduction to the systematic process, as represented by concurrent engineering, quality management and the product realization process, as well as other concepts that set the framework for modern design. The third includes design tools, such as CAD and finite element analysis, as well as the underlying engineering theory for designing and analyzing components and systems.

The integrated design exposure and experience in the curriculum is described as follows: freshman year, students take EG 1004 Introduction to Engineering to learn how things are built and why, discuss ethics in engineering, be introduced to computer aided drafting tools and work in team projects. Sophomore year, students take ME 2213 Statics and ME 2211 Statics Laboratory to enhance the understanding of static equilibrium of rigid bodies, and MT 2813 Introduction to Materials Science and MT 2811 Materials Science Laboratory to examine the impact of material properties on design. Junior year, students take ME 3513 Measurement Systems to learn to design experiments; ME 3313 Fluid Mechanics to understand design of fluid and thermal systems; Machine Design to consider the design aspects of machines and systems; and ME 3223 Dynamics to consider the design of systems where motion is involved and ME 3413 Automated Control to understand

MECHANICAL ENGINEERING PROGRAM

the control of mechanical, aerospace, robotic, thermo-fluid and vibrating systems. Finally, the design experience culminates with the capstone ME 4111 and ME 41113 Senior Design I and II course, during which students work in teams of two or three or four and design, fabricate and test projects and systems. In addition to the systematic and creative processes of design, the capstone design experience includes engineering consideration of safety, ethics, economy, project planning and budgeting, quality and presentation.

The mechanical engineering electives available to seniors also contain significant design experience. ME 4363 HVAC Systems teaches design aspect of HVAC systems. ME 4353 Internal Combustion Engines addresses design issues for engines, while MN 3714 and MN 4714 Manufacturing Systems I and II offer the methodology of design via concurrent engineering and other modern concepts.

PLACEMENT

The industries in which most alumni are employed are primarily:

- National defense
- Utilities
- Telecommunications
- Larger consulting firms (infrastructure-related)
- A variety of small engineering firms

At the same time, there are emerging opportunities in biomedical systems, nanotechnology, mechatronics and pharmaceutical industries. Alumni have also used their basic ME education as a springboard to law, medicine, and senior corporate management.

GOALS AND OBJECTIVES

The objectives of the BS in Mechanical Engineering are for its students to acquire and develop the skills necessary to:

- Understand the fundamental principles of mechanical engineering, mathematics and the sciences that provide a foundation for and to inspire professional development
- Formulate, analyze and design thermal and mechanical components and systems
- Utilize modern engineering tools
- Work collectively in an effective manner in teams
- Compile information and communi-

cate it effectively

- Understand the context within which mechanical engineers practice their profession, particularly as it pertains to the interrelationship of technology and social and ethical issues

SPECIAL DEPARTMENTAL REQUIREMENTS

Students must meet the University requirement of a 2.0 GPA or better for graduation. For graduation, the students must also earn an average of 2.0 GPA or better in the ME required courses taken at the University. Seniors with GPAs of 3.5 or better may take certain graduate courses as electives with the departmental adviser's approval.

Students on academic probation are usually permitted to pre-register for the next semester, but are obliged to consult with their adviser after grades are posted and before classes begin. All students entering the BS in Mechanical Engineering in fall 2004 or later must take the FE exam prior to graduation, as a degree requirement. All others are strongly encouraged.

TRANSFER STUDENTS

All transfer students are required to meet the University's minimum residency requirement. In addition, transfer students in the Mechanical Engineering Program are required to take all junior and senior mechanical engineering courses and technical electives at Polytechnic.

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 BS in Mechanical Engineering in two additional years. Programs vary from college to college; students should meet with an undergraduate adviser for guidance. With some colleges, there are formal articulation agreements and typical programs of study. Students who have some course work 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 a good indicator for prospective students. However, the adviser must be consulted in all cases for a current deci-

sion; course content does change over the years at Polytechnic and other colleges, and it is a comparison of content that determines decisions in each case. Transfer students are strongly encouraged to meet with an undergraduate adviser separate and apart from the registration process so that a proper evaluation may be done. The Office of Admissions offers information on past decisions for a given college and can arrange a meeting with a departmental undergraduate adviser. Graduates of technology programs may be able to fulfill the requirements for a BS 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.

TYPICAL PROGRAM OF STUDY FOR THE BACHELOR OF SCIENCE

The program consists of four components: (1) engineering core, 61 credits, (2) science, 32 credits; (3) humanities and social sciences, 24 and (4) free and technical electives, 11 credits.

AEROSPACE ENGINEERING CONCENTRATION

The Department of Mechanical, Aerospace and Manufacturing Engineering offers a program leading to a Bachelor of Science in Mechanical Engineering with a concentration in aerospace engineering. During the first three years of study, students set the foundation for future professional subjects by following the course work of the mechanical engineering program. Senior year, aerospace concentration students take four courses particular to their concentration: (1) AE 4603 Compressible Flow, (2) AE 4613 Aerodynamics, (3) AE 4633 Aerospace Propulsion and (4) AE 4653 Aircraft Flight Mechanics. These courses provide students with the necessary foundation to pursue a career in the aerospace industry or pursue graduate studies in the field.

GRADUATE PROGRAM

Programs of study leading to degrees MS and PhD in Mechanical Engineering are available in each of five specialty areas:

- Aerospace (PhD only)
- Materials Science (PhD only)
- Mechanical Analysis and Design (MS and PhD)
- Systems, Controls and Robotics (MS and PhD)
- Thermal and Fluid Sciences (MS and PhD)

Within each of these specialties, students may choose to concentrate some of the electives from the other graduate programs in the department, namely, aerospace, industrial and manufacturing engineering.

A bachelor's degree and a good academic record in mechanical engineering from a suitable college or university are 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. 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 a graduate adviser designated by the department. All students are required to have a 3.0 GPA or better in each of the following: in the average of all graduate courses taken at Polytechnic (whether or not some of these courses are being used to satisfy specific degree requirements); in the average of all courses submitted for the graduate degree sought (MS or PhD); in each and every guided studies, readings, projects, thesis and dissertation courses or credits enrolled.

GOALS AND OBJECTIVES

The objectives of the MS in Mechanical Engineering are for its students to acquire the skills necessary to:

- Develop in-depth expertise in at least one of the sub-disciplines of mechanical engineering (e.g., thermo-fluids, structures and design or controls and robotics) to prepare for either a rewarding professional career or for studies toward a PhD or other degrees
- Diversify their knowledge base by

taking advanced courses in other disciplines

- Formulate, analyze and design components and systems through the use of modern advanced analytical and computational tools
- Further professional development through continuous learning across disciplines

The objectives of the PhD in Mechanical Engineering are for its students to master the skills necessary to:

- Obtain deep knowledge in one of the areas of mechanical engineering (e.g., materials, aerospace, thermo-fluids, structures and design and control and robotics) through advanced courses and research
- Identify problems, formulate research programs to address them, conduct research and produce results that advance the fundamental understanding of a certain sub-discipline by completing a dissertation in the chosen sub-discipline
- Communicate results of their research and other work effectively through conference presentations and refereed journal publications

REQUIREMENTS FOR THE MASTER OF SCIENCE

Course requirements for the MS 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.

Students must take at least 27 units in the MS at Polytechnic. No more than a total of 9 units may be attributed to transfer and readings courses. Validation credit is not allowed, but specific requirements may be waived (and appropriate substitutes designated) by the graduate adviser, based upon the student's prior studies or experience. Transfer credits are not granted for (1) undergraduate courses, (2) courses counted toward satisfying undergraduate degree requirements, (3) courses not related to the graduate program as stated in this catalog and (4) courses that received a grade lower than B.

Studies for the MS must be completed within a five-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:

Course No.	Course Title	Units
ME	600 Applied Computational Methods	3
ME	604 Transport Phenomena	3
ME	621 Stress Analysis	3
ME	660 Feedback Control	3
ME	Required for Specialty Area (see below)	6
	Electives, approved by graduate adviser	9
	Free Electives	9
Total		36

Departmental electives include courses from mechanical, industrial and manufacturing engineering programs, plus thesis or project credits. Students are encouraged to take at least one graduate course in mathematics as part of the non-mechanical engineering courses. All courses and program details are subject to adviser approval. If any transfer credits have been granted to the students, the number of non-departmental units permitted as electives is reduced from 9 by the number of transfer units granted. For example, if a student has been granted 6 units of transfer, the total number of electives that the student can take outside the department is 3 units.

Mechanical Analysis and Design

The required courses are at least two graduate courses with last digits in the range of 20 to 59. ME electives that have been offered the last few years include Stress Analysis II, Dynamics of Machines, Fracture Mechanics and Stress Analysis of Composite Materials.

Systems, Controls and Robotics

The required courses are at least two graduate courses with last digits in the range 60 to 79. ME electives that have been offered the last few years include Linear Systems, Adaptive Control and Neural Networks.

Thermal and Fluid Sciences

The required courses are at least two graduate courses with last digits in the range 01 to 19. ME electives that have been offered the last few years include HVAC, Experimental Methods in Thermal/Fluid Science, Thermal Issues in Manufacturing Processes, Turbulent Flow, Compressible Flow and Propulsion.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY

The PhD degree is a terminal degree beyond the MS and is focused on engineering research. Students are expected to advance the state of the art in their specialty by original and creative work.

An MS in Mechanical Engineering with a specialization in one of the three departmental areas (thermal/fluid sciences, mechanical analysis/design or systems/controls/robotics) or in aerospace engineering is required for admission to the PhD degree program. A 3.5 GPA or better in the MS work is generally required for admission. In cases where 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.

Unless specially exempted by the faculty, students have to take a written qualifying examination within the first two offerings of the exam after the date of joining the doctoral program. The general credit requirements for the PhD degree (beyond the BS degree and including MS degree credits) are:

	Units
Major work related to specialty	30-36
Approved courses in two minor areas	24-30
PhD Dissertation (ME 999)	24-30
Minimum total required	90

An MS degree, as defined by the requirements described in the preceding section, will count for 36 units of the above total. A minor is defined by a set of four minimum courses that are in a given area. For example, a student may choose heat transfer as a major specialty, with minors in mathematics and fluid mechanics.

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 3 units of ME 999 PhD Dissertation 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. A dissertation grade of U for two consecutive terms will affect whether a student will be permitted to continue doctoral work. Students are required to present the progress in their dissertation work to their guidance committees twice a year (typically at the beginning of each semester).

UNDERGRADUATE COURSES

AE 4603 Compressible Flow 3:0:0:3

Conservation equations for inviscid flows, one-dimensional flows, normal shock waves, one-dimensional flow with friction, one-dimensional flow with heat addition, oblique shock waves, Prandtl-Meyer expansion waves. *Prerequisites: ME 2313 and ME 3313.*

AE 4613 Aerodynamics 3:0:0:3

Incompressible inviscid flow, rotational and irrotational flow, elementary flows and their superposition, airfoil and wing geometry, aerodynamic forces and moments, thin airfoil theory, camber effects, incompressible laminar and turbulent boundary layer, vortex system, incompressible flow about wings, wing/body configurations, compressible flows past airfoils and wings, high-lift devices. *Prerequisite: AE 4603.*

AE 4633 Aerospace Propulsion 3:0:0:3

Operation, performance, and design methods for flight vehicle propulsion, air-breathing engines, ramjets, turbojets, turbofans and their components, elements of solid and liquid rocket propulsion system. *Prerequisite: AE 4603.*

AE 4653 Aircraft Flight Mechanics 3:0:0:3

Development of equations of motion. Characteristics of aircraft propulsion systems. Level flight performance of turbojet and propeller driven aircraft. Un-accelerated climbing flight and aircraft ceiling. Takeoff and landing performance. Longitudinal and lateral static stability. Linearized equations of motion. Longitudinal and lateral modes of motion. *Prerequisite: ME 3223.*

ME 1012 Introduction to Mechanical Engineering 2:0:0:2

This course introduces the range of mechanical engineering and emphasizes the basic principles and devices for storing and using energy, directing motion and satisfying needs. Case studies in design issues; related ethical and professional practice issues. Emphasis on a mindset of exploration: the special principles, value and applications of such devices as flywheels, counterweights and gyroscopes. Two design challenges to be worked on by teams, and presented. Engineering standards and standard parts. *Co-requisites: EG 1004 and ME 1112.*

ME 1112 Computer Aided Design 1:0:3:2

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. *Co-requisites: EG 1004 and ME 1012.*

ME 2211 Statics Laboratory ¹/₂:0:1¹/₂:1

Calculations of bending stress, bending moment, shear forces and deflections in beams, buckling of struts and equilibrium analysis of structures. *Co-requisite: ME 2213.*

ME 2213 Statics 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: PH 1004 and MA 1022. Co-requisite: ME 2211.*

ME 2313 Thermodynamics 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: PH 1004 and MA 1122. Co-requisite: MA 2132.*

ME 3211 Mechanics of Materials Laboratory 1/2:0:1/2:1

Measurement of elastic constants for isotropic and anisotropic materials, verification of stress and strain transformation equations, stress concentration concept, unsymmetric bending of beams and torsion of shafts. *Co-requisite: ME 3213.*

ME 3213 Mechanics of Materials 3:0:0:3

Concept of Stresses and strains in two and three dimensions, Stress-strain relationships, Stress transformation, Strain transformation, Axial members, Torsion of shafts, Bending of beams. *Prerequisites: ME 2213, ME 2211 and MA 2132. Co-requisite: ME 3211.*

ME 3223 Dynamics 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. *Prerequisites: MA 2132 and ME 2213.*

ME 3233 Machine Design 3:0:0:3

This course introduces students to the fundamentals of machine elements thus enabling them to employ the knowledge gained to design machines for various practical applications. The course begins with a brief review of stress, deformation and failure, followed by friction and wear. Subsequently, loaded columns, pressurized cylinders and shafts are presented. Bearings, gears, screws, springs, brakes, clutches and belts are discussed. The course ends with an introduction to MEMS, Micro-Electro-Mechanical Systems. *Prerequisite: ME 3213.*

ME 3311 Fluid Mechanics Laboratory 1/2:0:1/2:1

Fluid mechanics instrumentation and principles. This course consists of a set of laboratory experiments designed to reinforce the concepts presented in ME 3313 Fluid Mechanics. In addition this course involves team work, report writing and oral presentation. *Prerequisite: ME 3511. Co-requisite: ME 3313.*

ME 3313 Fluid Mechanics 3:0:0:3

Introduction to fluid, kinematics, hydrostatics, thermodynamics. Basic conservation laws in integral form for a control volume. Conservation of mass, momentum, angular momentum and energy for flow. Inviscid flow: Bernoulli's and Euler's equations. Viscous flow: flows in pipes and ducts, head loss and friction factor. *Prerequisites: PH 2004, MA 2132 and MA 2122.*

ME 3411 Automatic Control Laboratory 1/2:0:1/2:1

System ID, modeling, identification, and control of RC electrical network, and a DC servo motor, modeling and control of a maglev system, rotary inverted pendulum, and a coupled water tank system. *Prerequisite: ME 3511. Co-requisite: ME 3413.*

ME 3413 Automatic Control 3:0:0:3

Dynamic system modeling, analysis, and feedback control design with extensive, hands-on computer simulation. Modeling and analysis of dynamic systems. Description of interconnected systems via transfer functions and block/signal-flow diagrams. System response characterization as transient and steady-state responses and error considerations. Stability of dynamical systems: Routh-Hurwitz criterion and Nyquist criterion. Graphical methods for dynamical system analysis and design: root locus and Bode plot. Computer-aided feedback control design for mechanical, aerospace, robotic, thermo-fluid and vibratory systems. *Prerequisites: ME 3513 and ME 3223.*

ME 3484 Mechatronics 4:0:0:4

Mechatronics is a synergistic integration of mechanical engineering, control theory, computer science and electronics to manage complexity, uncertainty and communication in engineered systems. Mechatronics is an exciting "high-tech" and inherently multidisciplinary application, whose underlying concepts can be understood by practicing engineers of diverse academic backgrounds. The typical knowledgebase for the design and operation of mechatronics systems comprises of dynamic system modeling and analysis, decision and control theory, sensors and signal conditioning, actuators and power electronics, hardware interfacing, rapid control prototyping and embedded computing. This course provides a balanced introduction to the theory, simulation, hardware and software elements of mechatronics to students. The exposure to computer hardware/software for measurement and control introduces the students to modern tools such as data acquisition and control boards, micro-controllers, LabVIEW, MatLab, etc. Finally, planned project activities enable the students to integrate measurement, control, computer hardware and software components to develop proto-type mechatronics systems. *Prerequisites: MA 2132 and PH 2004.*

ME 3511 Measurement Systems Laboratory 1/2:0:1/2:1

Electric measurements, data acquisition, passive and active filters for signal conditioning, temperature, position, velocity and acceleration measurements. *Co-requisite: ME 3513.*

ME 3513 Measurement Systems 3:0:0:3

Electrical circuits and components, filtering, dynamic measurement system response characteristics, analog signal processing, digital representation, data acquisition, sensors. Study of measurement systems via computer simulation. *Prerequisite: MA 2132 and PH 2004.*

MECHANICAL ENGINEERING PROGRAM

ME 4111 Senior Design I 1:0:0:1

This section will emphasize manufacturing, product realization and customer satisfaction concern. Building effective teams/teamwork. Communication skills. Ethical issues. *Prerequisites: ME 3233, ME 3411, ME 3413 and ME 4311. Co-requisite: ME 4214.*

ME 4114 Senior Design II 4:0:0:4

This is the Capstone Engineering Design Course based on knowledge and skills acquired in earlier coursework. Product design, development, building and testing prototype hardware, with an emphasis on teamwork. The Product Realization Process emphasizing incorporation of engineering standards and realistic constraints. Emphasis on communication skills. Students project is a major component of the course. *Prerequisites: ME 4111, ME 4214, ME 4311 and ME 4313.*

ME 4213 Design and Fabrication of Composite Materials 3:0:0:3

Introduction to composite materials. Introduction to types of reinforcements and matrix materials. Various applications in mechanical engineering. Manufacturing of polymer, metal and ceramic matrix materials. Analysis of laminated composites for mechanical properties. *Prerequisites: MT 2813, MT 2811 and ME 3213.*

ME 4223 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. *Prerequisite: ME 3223.*

ME 4214 Finite Element Modeling, Design and Analysis 3:3:0:4

The analysis of complex static and dynamic problems involves, in essence, three steps: selection of a mathematical model; analysis of the model; interpretation of the predicted response. The course deals with deriving analytical solutions and comparing them with Finite Element Analysis results. *Prerequisites: ME 3213, ME 3313, MA 2122 and MA 2132.*

ME 4311 Heat Transfer Laboratory 1:0:1:1

Heat transfer instrumentation and principles. This course consists of a set of laboratory experiments designed to reinforce the concepts presented in ME 4313 Heat Transfer. In addition this course involves team work, report writing and oral presentation. *Prerequisite: ME 3311. Co-requisite: ME 4313.*

ME 4313 Heat Transfer 3:0:0:3

Introduction to the modes of conduction, convection and radiation heat transfer. Analysis of multi-dimensional geometries for the conduction mode. Unsteady conduction. Numerical methods of analysis. Introduction to convection. Internal and external convection. Natural convection and boiling and condensation. Principles of radiative heat transfer. *Prerequisites: ME 2313 and ME 3313.*

ME 4353 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 engines. Design for performance and efficiency. Pollutant formation and controls, emissions tests. *Prerequisites: ME 2313, ME 3313 and ME 4313.*

ME 4363 Heating, Ventilation and 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. *Prerequisites: ME 2313, ME 3313 and ME 4313.*

ME 4484 Smart Systems 4:0:0:4

Smart engineering products and decision aids (e.g., computational agents) abound in society. This course equips the students with essential tools frequently used to impart intelligence to a variety of systems. Specifically, after reviewing examples of smart systems found in consumer/industrial products and software agents, the course provides introduction to fundamentals of optimization theory, signal processing, system identification, estimation and control theory, condition monitoring, fault diagnostic, neuro-systems, decision systems (hierarchical, decentralized), distributed computing, etc. Applications of these tools in the design and development of smart systems are illustrated. The course gives a balanced introduction to the theory, simulation, hardware and software elements of smart systems. Students are expected to gain expertise in at least one aspect of smart systems. Simulation and hardware projects enable students to develop prototype smart products. *Prerequisites: MA 2132 and PH 2004.*

MN 3714 Manufacturing Systems I 4:0:0:4

A product must meet both a customer need and goals of performance, cost, quality, reliability, safety and the environment to be successful in the marketplace. The course addresses the issues that are critical to the design of a product for manufacture and the methods that have been found to be successful in addressing these issues. The design process is studied and illustrated by means of class exercises and a term project. Selected manufacturing processes are studied to establish the relationship between product design and manufacturing process complexity. *Prerequisites: MA 2122 and PH 1004.*

MN 4714 Manufacturing Systems II 4:0:0:4

This course is a continuation of MN 3714, one of the university sequences. The techniques addressed in this course in the context of manufacturing systems can be applied to business processes in a variety of industries. The building blocks from the first course were basic concepts in manufacturing operations, bottlenecks, simulation and engineering economics, including ROR and ROI. A project was

done using a spreadsheet simulation, to focus on basic principles. The work continues with extensive project work using ARENA, readings on the Theory of Constraints and on Throughput Accounting, discussions of manufacturing processes, quality assurance and at least one field visit. The course depends upon effective teamwork, centered on project work and presentations. *Prerequisite: MN 3714.*

MT 2811 Materials Science Laboratory 1/2:0:1 1/2:1

Students learn how to characterize the microstructure and crystal structure of a material by optical and scanning electron microscopy and X-ray diffraction. The mechanical characterization is accomplished by hardness, tensile and yield strength, impact and fatigue testing. *Prerequisites: PH 1004, CM 1004 and MT 2813.*

MT 2813 Introduction to Materials Science 3:0:0:3

Students in this course become familiar with atomic structure and bonding, atomic arrangement in crystals, crystal imperfections, mechanical behavior and failure of materials and binary phase diagrams. *Prerequisites: PH 1004 and CM 1004. Co-requisite: MT 2811.*

MT 4853 Manufacturing Engineering and Processes 3:0:0:3

This course introduces the students to the manufacturing processes involved in fabricating components used in mechanical systems; casting processes; bulk metal deformation and sheet-metal forming processes; materials-removal processes; Joining and fastening processes; manufacturing automation; and integrated manufacturing systems. *Prerequisites: MT 2811 and 2813.*

GRADUATE COURSES

ME 600 Applied Computational Methods 2 1/2:0:0:3

Computational methods used in formulation and solving problems that occur in engineering. Methods of interpolation, numerical differentiation and integration, solution of linear and nonlinear equations and eigenvalue problems. Finite difference methods. Particular attention to continuum techniques, e.g., Rayleigh-Ritz, Galerkin and collocation.

ME 700 Finite Elements 2 1/2:0:0:3

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.

THERMAL AND FLUID SCIENCES

ME 601 Thermodynamics I 2 1/2:0:0:3

Availability functions, general thermodynamic relations, equations of state, general thermodynamic equilibrium criteria. Also listed under CH 771.

ME 604 Transport Phenomena 2 1/2:0:0:3

Eulerian and Lagrangian approaches, conservation laws, momentum transfer (Navier-Stokes) equations and their derivations, energy transfer equations and derivations, mass transfer equations scaling analysis and simplifications for internal and external flows, introduction to turbulence.

ME 605 Heat Transfer 2 1/2:0:0:3

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.

ME 610 Fluid Dynamics 2 1/2:0:0:3

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. Also listed under CH 631.

ME 701 Advanced Thermodynamics 2 1/2:0:0:3

Continuation of ME 605. Applications of thermodynamic equilibrium criteria to various problems, including chemical reactions. *Prerequisite: ME 601.*

ME 706 Convective Heat Transfer 2 1/2:0:0:3

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 604, ME 605 or adviser's approval.*

ME 707 Conductive Heat Transfer 2 1/2:0:0:3

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 604, ME 605 or adviser's approval.*

ME 708 Radiative Heat Transfer 2 1/2:0:0:3

Fundamentals of radiative mechanisms of energy transfer. Definitions of basic qualities. Equations of transfer, radiative heat-flux vector and conservation equations. Properties of surfaces and participating media. Applications to engineering systems. *Prerequisite: ME 604, ME 605 or adviser's approval.*

ME 711 Viscous Flow and Boundary Layers 2½:0:0:3

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. *Prerequisite: ME 604 or ME 610.*

ME 712 Turbulent Flow 2½:0:0:3

General theories of turbulence, basic concepts, transition, homogeneous turbulence, analysis of turbulent shear flows, turbulent heat and mass transfer, experimental methods. *Prerequisites: ME 604 or ME 610 and ME 711.*

ME 713 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: ME 604 or ME 610.*

ME 715 Computational Methods in Thermal Fluid Sciences 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. *Prerequisites: ME 600 and ME 604 or ME 605 or ME 610.*

ME 716 Experimental Methods in Thermal-Fluid Sciences 2½:0:0:3

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 604, ME 605 or adviser's approval.*

ME 717 Thermal Design of Electronics Systems 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. *Prerequisite: ME 604, ME 605 or adviser's approval.* Also listed under MN 802.

ME 718 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. *Prerequisite: ME 604, ME 605 or adviser's approval.* Also listed under MN 804.

ME 803 Combustion 2½:0:0:3

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 604.*

ME 841 Vehicle Dynamics 2½:0:0:3

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: adviser's approval.*

ME 804 Theory of Propulsion 2½:0:0:3

Principles of modern high-speed propulsion based on chemical energy sources. Airbreathing engines, combustion thermodynamics, flows with chemical reactions, thermochemistry of solid and liquid rocket engines. Engineering parameters in engine design. *Prerequisite: ME 604 or ME 605.*

ME 809 Multiphase Heat Transfer 2½:0:0:3

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; dropwise and film condensation. Critical heat flux. *Prerequisite: 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.

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 2?: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: adviser's approval.*

ME 644 Mechanical Vibrations I 2½:0:0:3

Dynamics of one-, two- and multi-degree of freedom systems with and without damping. Application to balancing of multi-cylinder engines, crank mechanism dynamics and rotating machinery.

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.

ME 652 Advanced Dynamics I
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 651.*

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 621.*

ME 724 Stress Analysis of Composite Materials
2½:0:0:3

Composite materials (high strength filaments embedded in a matrix) have relatively a 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 or adviser's approval.*

ME 735 Fracture Mechanics
2½:0:0:3

Introduction to fracture mechanics. Linear elastic, elastic-plastic and fully plastic fracture mechanics modeling 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: ME 621 or adviser's approval.* 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 multi-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: 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.

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 EL 522.

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 625.

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. *Prerequisites: ME 660 and ME 671.*

ME 770 Optimal Robust Control
2½:0:0:3

Matrix theory and linear system fundamentals, H2 norm, performance specifications, linear quadratic regulation (LQR), Kalman filtering, and linear quadratic Gaussian (LQG) control, robustness properties of LQR, on lack of robustness of LQG controllers, small gain theorem, multi-objective robust control. *Prerequisite: ME 670.*

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 EL 823.

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: ME 661 and ME 671.* Also listed under EL 822.

ME 870 Frequency Domain Methods in Control 2½:0:0:3

Systems and operators, stabilizability, parameterization of stabilizing controllers, H00 weighted sensitivity minimization for rational plants, H2 and H00 controller design. *Prerequisite: ME 671.*

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.*

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.*

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 EL 825.

SELECTED TOPICS, PROJECTS, THESIS AND DISSERTATION

ME 786/787 Special Topics 2½:0:0:3

These numbers are reserved for special topics that are offered periodically by the Mechanical Engineering 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. *Prerequisite: tailored to the offering.*

ME 886/887 Advanced Topics 2½:0:0:3

These numbers are reserved for advanced topics that are offered periodically by the Mechanical Engineering 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 Topic" and the more complete title appears on the student's transcript. *Prerequisite: tailored to the offering.*

ME 901-904 Guided Readings I-IV each 3 units

Open to qualified graduate students interested in special advanced topics. Directed study, including analytical work and/or laboratory investigations. *Prerequisite: adviser's approval.*

ME 996 MS 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. *Prerequisite: degree status.*

ME 997 MS 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 12 units of ME 996/997 counted toward degree. *Prerequisite: ME 996.*

ME 999 PhD Dissertation each 3 units

Doctoral 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. *Prerequisite: degree status.*

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

- ME 602 Thermodynamics II
- 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 813 Viscous Compressible Flow
- ME 821 Continuum Mechanic
- ME 831 Stability of Structures
- ME 842 Trajectories and Orbits

Typical Course of Study for the Bachelor of Science in Mechanical Engineering

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
EG 1004	Intro Engineering & Design	1	3	2	4
MA 1012	Calculus IA1 (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
CM 1004	General Chemistry	3	2	1	4
EN 1014	Writing & Humanities I ¹	4	0	0	4
SL 1010	Freshman Seminar	1	1	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
MA 1112	Calculus IIA (½ semester)	4	0	0	2
MA 1122	Calculus IIB (½ semester)	4	0	0	2
PH 1004	Introductory Physics I	4	1½	1	4
ME 1012	Intro Mechanical Engineering	2	0	0	2
ME 1112	Computer Aided Design	1	0	3	2
EN 1204	Writing & Humanities II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
MA 2012	Linear Algebra I (½ semester)	4	0	0	2
MA 2132	Ordinary Diff. Equ. (½ semester)	4	0	0	2
PH 2004	Introductory Physics II	4	1½	1	4
MT 2811	Materials Science Lab	½	1½	0	1
MT 2813	Intro Materials Science	3	0	0	3
HI 2104	Modern World History	4	0	0	4
					16

Spring Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi Calculus B (½ semester)	4	0	0	2
MA 2212	Data Analysis I (½ semester)	4	0	0	2
ME 2211	Statics Lab	0	0	3	1
ME 2213	Statics	3	0	0	3
ME 2313	Thermodynamics	3	0	0	3
	HU/SS Elective ³	4	0	0	4
					17

JUNIOR YEAR

Fall Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 3211	Mechanics of Materials Lab	½	1½	0	1
ME 3213	Mechanics of Materials	3	0	0	3
ME 3511	Measurement Systems Lab	½	1½	0	1
ME 3513	Measurement Systems	3	0	0	3
ME 3223	Dynamics	3	0	0	3
	HU/SS Elective ³	4	0	0	4
					15

Spring Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 3233	Machine Design	3	0	0	3
ME 3311	Fluids Lab	½	1½	0	1
ME 3313	Fluids	3	0	0	3
ME 3411	Controls Lab	½	1½	0	1
ME 3413	Controls	3	0	0	3
	University Sequence ⁴	4	0	0	4
					15

SENIOR YEAR

Fall Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 4111	Senior Design I	1	0	0	1
ME 4214	Finite Element Design	3	3	0	4
ME 4311	Heat Transfer Lab	½	1½	0	1
ME 4313	Heat Transfer	3	0	0	3
	ME Elective ⁵	3	0	0	3
	University Sequence ⁴	4	0	0	4
					16

Spring Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 4113	Senior Design II	4	0	0	4
	ME Elective ⁵	3	0	0	3
	ME Elective ⁵	3	0	0	3
	Technical Elective ⁵	3	0	0	3
	HU/SS Elective ³	4	0	0	4
					17

Total credits required for graduation:

128

1. Students who are placed by examination or by an adviser into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1012.

2. Students who are placed by examination or by an adviser into EN 1080 or EN 1090 must subsequently register for EN 1034, rather than EN 1014.

3. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II.

Elective courses in different disciplines and one from Level III Advanced Elective courses.

4. A list of approved Sequence Electives is available from the department.

5. A total of 12 credits are required for ME and Technical electives. Mix of 3 and 4 credits are allowed. Out of the 12 credits, 8 or more must be in ME.

Typical Course of Study for the Bachelor of Science in Mechanical Engineering with Concentration in Aerospace

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
EG 1004	Intro to Eng & Design	1	3	2	4
MA 1012	Calculus IA1 (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
CM 1004	General Chemistry	3	2	1	4
EN 1014	Writing & Humanities I ¹	4	0	0	4
SL 1010	Freshman Seminar	1	1	0	0
					16

Spring Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
MA 1112	Calculus IIA (½ semester)	4	0	0	2
MA 1122	Calculus IIB (½ semester)	4	0	0	2
PH 1004	Introductory Physics I	4	1½	1	4
ME 1012	Intro Mechanical Engineering	2	0	0	2
ME 1112	Computer Aided Design	1	0	3	2
EN 1204	Writing & Humanities II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
MA 2012	Linear Algebra I (½ semester)	4	0	0	2
MA 2132	Ordinary Diff. Equ.(½ semester)	4	0	0	2
PH 2004	Introductory Physics II	4	1½	1	4
MT 2811	Materials Science Lab	½	1½	0	1
MT 2813	Intro Materials Science	3	0	0	3
HI 2104	Modern World History	4	0	0	4
					16

Spring Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi Calculus B (½ semester)	4	0	0	2
MA 2212	Data Analysis I (½ semester)	4	0	0	2
ME 2211	Statics Lab	0	0	3	1
ME 2213	Statics	3	0	0	3
ME 2313	Thermodynamics	3	0	0	3
	HU/SS Elective ³	4	0	0	4
					17

JUNIOR YEAR

Fall Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 3211	Mechanics of Materials Lab	½	1½	0	1
ME 3213	Mechanics of Materials	3	0	0	3
ME 3511	Measurement Systems Lab	½	1½	0	1
ME 3513	Measurement Systems	3	0	0	3
ME 3223	Dynamics	3	0	0	3
	HU/SS Elective ³	4	0	0	4
					15

Spring Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 3233	Machine Design	3	0	0	3
ME 3311	Fluids Lab	½	1½	0	1
ME 3313	Fluids	3	0	0	3
ME 3411	Controls Lab	½	1½	0	1
ME 3413	Controls	3	0	0	3
	University Sequence ⁴	4	0	0	4
					15

SENIOR YEAR

Fall Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 4111	Senior Design I	1	0	0	1
ME 4214	Finite Element Design	3	3	0	4
ME 4311	Heat Transfer Lab	½	1½	0	1
ME 4313	Heat Transfer	3	0	0	3
AE 4603	Compressible Flow	3	0	0	3
	University Sequence ⁴	4	0	0	4
					16

Spring Semester

Course No.	Course Title	Class	Lab	Rec.	Cr.
ME 4113	Senior Design II	4	0	0	4
AE 4613	Aerodynamics	3	0	0	3
AE 4633	Aerospace Propulsion	3	0	0	3
AE 4653	Aircraft Flight Mechanics	3	0	0	3
	HU/SS Elective ³	4	0	0	4
					17

Total credits required for graduation:

128

1. Students who are placed by examination or by an adviser into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1012.

2. Students who are placed by examination or by an adviser into EN 1080 or EN 1090 must subsequently register for EN 1034, rather than EN 1014.

3. Approved HU/SS electives are courses with the following prefixes: AH, AN, EC, EN, HI, MU, PL and PS. Two courses must be from Level II. Elective courses in different disciplines and one from Level III Advanced Elective courses.

4. A list of approved Sequence Electives is available from the department.

ORGANIZATIONAL BEHAVIOR PROGRAM

Academic Director: Harold G. Kaufman

GOALS AND OBJECTIVES

The objective of the Master of Science Program in Organizational Behavior is to provide professionals and managers with the latest knowledge and techniques for addressing critical human issues in rapidly changing organizations to achieve high quality, productivity and job satisfaction.

GRADUATE PROGRAM

The course of study is designed for students with a wide variety of experience and needs. These range from human resource practitioners who need to update and broaden their qualifications to those with diverse backgrounds who wish to acquire the expertise to enter a field related to one of the following concentrations:

- Human Resource Management
- Management of Change
- Training and Development
- Human Resource Information Systems

Some of the unique aspects of the program focus on topics that address rapidly changing organizational environments, such as:

- Managing the impact of changing technology on people and organizations.
- Motivating knowledge workers to stay up-to-date with developments in their field
- Conflict resolution in turbulent and uncertain environments
- Designing new organizational structures that are more responsive to rapid change
- Career management in restructuring companies
- Training and development innovations to cope with changing job requirements
- Utilizing job and workplace design to improve motivation and performance
- Addressing human resource issues in organizations affected by globalization
- Outsourcing as a human capital strategy
- Developing effective leadership and teamwork
- Enhancing organizational effectiveness through human resource information systems and web-based human resource technologies

Because most Polytechnic students are working professionals, many with managerial responsibilities, class schedules are offered in the evenings after normal office hours. Seminar-style classes, emphasizing participation and discussion, enable organizational behavior students to receive individual attention and to work closely with faculty as well as classmates, often in teams.

An active, award-winning student chapter of the Society for Human Resource Management (SHRM) provides extra curricular opportunities for professional seminars, workshops and networking to enhance individual career development. With the unique knowledge and skills acquired from the Organizational Behavior Program, graduates have been able to pursue successful careers in prestigious firms ranging from high-tech to financial institutions as well as in the public sector, or as private consultants.

ADMISSION AND DEGREE REQUIREMENTS

Criteria for admission include 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 in organizational behavior. Applicants who do not meet all the criteria may be admitted as nondegree students with the opportunity, subsequently, to become a degree candidate. Satisfactory scores on the Graduate Management Admission Test (GMAT) or an acceptable equivalent test such as the Graduate Record Examination (GRE) may be used as support for admission to degree studies.

Students who have not completed an undergraduate course in statistics must enroll in MG 505 Probability and Managerial Statistics or its equivalent. Students without an adequate background in computers may be required to enroll in one or more of the preparatory courses in computer science—e.g., CS 530 Introduction to Programming and Problem Solving—offered by the Department of Computer and

Information Science. These courses are in addition to the degree requirements of 12 courses or 36 units, which must be completed with an average of B or better. A maximum of 9 units of transfer credits may be granted for graduate courses taken elsewhere, as evaluated by the academic director.

For the most current information on the Master of Science program in Organizational Behavior, please visit www.msob.poly.edu, the program's Web site.

CERTIFICATE PROGRAMS AND ONLINE COURSES

The Organizational Behavior Program offers graduate certificate programs designed primarily for professionals and managers with work experience. Individualized programs make it highly appropriate for specialists as well as generalists to improve and update their knowledge and skills in critical areas ranging from the redesign of jobs and organizations to human resource information systems. In consultation with the academic director, students may design a custom-made certificate program with appropriate courses to meet their professional development needs.

A certificate focusing on human resource management may be completed with only online courses. These are fully accredited graduate courses. For further information, refer to ePoly online learning in the Academic Policies and Degree Requirements section in Part I of this catalog.

Applicants for certificate programs must hold a bachelor's degree. A certificate program requires five courses, which are selected according to individual needs. Upon completion of a sequence with an average grade of B or better, students are issued a certificate.

Those who choose to apply for a Master of Science in Organizational Behavior are able, upon admission, to apply all courses taken for a certificate toward fulfillment of the graduate degree requirements. Additional information may be obtained from the academic director of the Organizational Behavior Program.

THE CURRICULUM

1. CORE COURSES

An organizational behavior foundation consists of three core courses upon which the student can build a specialization within the degree program. Core courses provide an introduction to the theory, research and practice basic to the field of 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 academic director. Other courses must be substituted with permission of the academic director. The core courses should be taken as early in the program as possible.

Required Core Courses:

- MG 601 Organizational Behavior
- MG 631 Organization Theory & Design
- MG 633 Research Methods

2. AREAS OF CONCENTRATION

Students must choose an area of concentration consisting of six courses. This may be one of four concentrations listed below or, with the academic director's approval, may consist of a series of six courses designed to meet students' special needs.

Students who have previously completed a specific course in any of the areas of concentration may be excused from taking that course by presenting proof of competence and receiving a waiver from the academic director. Other courses must be substituted, with permission of the academic director.

Courses in each of the four areas of concentration are shown below:

Human Resource Management

The concentration in human resource management prepares professionals to deal with the critical human issues involved in staffing, evaluating and rewarding employees in an era of rapidly changing work environments.

Required:

- MG 612 Human Resource Management
- MG 617 Performance Measurement & Reward Systems
- MG 622 Staffing Organizations

Select three:

- MG 611 Career Management
- MG 613 Labor Relations
- MG 614 Conflict Management
- MG 621 Outsourcing: A Human Capital Strategy
- MG 625 Seminar in Organization & Career Change

- MG 626 Human Resource Information Systems
- MG 628 Internet Applications in Human Resource Management
- MG 865 Managing Technological Change & Innovation

Management of Change

The concentration in management of change provides human resource professionals with the latest tools and techniques necessary to guide organizations and their employees through periods of rapid, potentially disruptive change, especially transitions created by changing technologies.

Required:

- MG 616 Job & Workplace Design
- MG 624 Organization Development
- MG 625 Seminar in Organization & Career Change*
or
- MG 865 Managing Technological Change & Innovation*

Select three:

- MG 611 Career Management
- MG 612 Human Resource Management
- MG 614 Conflict Management
- MG 615 Leadership & Team Development
- MG 620 Consulting in Organizations.
- MG 621 Outsourcing: A Human Capital Strategy
- MG 623 Training in Organizations
- MG 635 Managing for Quality

**If both of these courses are completed, one of them is applied toward the minimum of three electives in this concentration.*

Training and Development

The concentration in training and development prepares human resource professionals to design, administer and evaluate complex training and development programs, particularly in organizations affected by the introduction of new technology.

Required:

- MG 611 Career Management
- MG 623 Training in Organizations
- MG 624 Organization Development

Select three:

- MG 612 Human Resource Management
- MG 614 Conflict Management
- MG 615 Leadership & Team Development
- MG 616 Job & Workplace Design
- MG 620 Consulting in Organizations.
- MG 625 Seminar in Organization & Career Change
- MG 635 Managing for Quality
- MG 865 Managing Technological Change & Innovation

Human Resource Information Systems

The concentration in human resource information systems integrates knowledge and skills in information systems

and Internet applications together with human resource management to achieve organizational effectiveness in the new economy.

Required:

- MG 612 Human Resource Management
- MG 626 Human Resource Information Systems
- MG 628 Internet Applications in Human Resource Management

Select three:

- MG 616 Job & Workplace Design
- MG 617 Performance Measurement & Reward Systems
- MG 622 Staffing Organizations
- MG 650 Management of Information & Information Technology
- MG 655 Introduction to Management of Data Communications & Networks
- MG 717 Enterprise Data Systems
- MG 865 Managing Technological Change & Innovation

3. FREE ELECTIVES

Two appropriate graduate courses may be chosen from any program at Polytechnic with the academic director's consent.

4. RESEARCH PROJECT

MG 934 Research Project in Organizational Behavior. All students must submit an independent research project. In special cases, MG 997 Thesis for Degree of Master of Science may be substituted for students who wish to produce a major research study in a specialty.

BS/MS ACCELERATED HONORS PROGRAM

The Department of Management and the Department of Humanities and Social Sciences offer an honors program for exceptional first year or advanced undergraduate students. Through this program, students can earn a Bachelor of Science in Liberal Studies (with a concentration in behavioral sciences) and a Master of Science in Organizational Behavior in four to five years. For further information please refer to the description in the catalog section of the Department of Humanities and Social Sciences.

GRADUATE AND UNDERGRADUATE COURSES

For course descriptions, please refer to the Master of Science in Management Program section of this catalog.

PHYSICS PROGRAM

Academic Adviser: Edward L. Wolf

Physics is the basic science for the natural world—the science of matter, energy, and motion. Worthy of study for its own beauty, physics is also the foundation of engineering and the sciences.

At Polytechnic, physics is an interdisciplinary undertaking, with engineers and scientists who have formal education in physics and/or research specialization in physics forming an Interdisciplinary Physics Group.

The group is responsible for three elements: (1) the BS in Physics, described in this section of the catalog, (2) graduate seminars in physics spanning the various disciplines and (3) opportunities for students to specialize in physics at the PhD level while pursuing one of several discipline-specific programs in science or engineering.

Advanced undergraduates are encouraged to work with faculty on individual research in an honors format, particularly in Polytechnic's Microparticle Photophysics Laboratory.

The introductory undergraduate core courses in physics are taught in the Department of Introductory Design and Science, in which several members of the Interdisciplinary Physics Group are involved. For introductory physics courses, please consult the Introductory Design and Science Core Program in this section.

To contact the Interdisciplinary Physics Group, please e-mail Professor Edward L. Wolf at ewolf@poly.edu.

GOALS AND OBJECTIVES

The mission of the Physics Program is to provide Polytechnic undergraduates with a strong foundation in physics, suited to the discipline, and to offer advanced opportunities for formal study in physics. An Interdisciplinary Physics Group fosters advanced opportunities for undergraduates, including a BS in Physics, and encourages and strengthens the interdisciplinary graduate research and related pedagogy at Polytechnic.

FACULTY

(Interdisciplinary Physics Group)

PROFESSORS

Stephen Arnold, Thomas Potts Professor of Physics and University Professor

David C. Chang, Professor of Electrical and Computer Engineering and University Chancellor

Bruce A. Garetz, Professor of Physical Chemistry

Hellmut J. Juretschke, Professor of Physics

Sunil Kumar, Professor of Mechanical Engineering

Kalle M. Levon, Professor of Chemistry
Said Nourbakhsh, Professor of Materials Science

Edward L. Wolf, Professor of Physics

ASSOCIATE PROFESSORS

Jonathan Bain, Associate Professor of Philosophy of Science

Lorcan M. Folan, Associate Professor of Physics

Iwao Teraoka, Associate Professor of Polymer Chemistry

FACULTY EMERITI

Raphael Aronson

Hilda Bass

Henry L. Bertoni

Patrick Cahill

D.C. Choudhury

John J. Dropkin

Walter Kiszewick

Terje Kjeldaas Jr.

Donald Scarl

UNDERGRADUATE PROGRAM

The aim of the four-year Bachelor of Science 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 or doctor's degree. For many others, it means professional work in industry, government or in high school teach-

ing. 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, thorough analytic training and the universal logic of science enables physics students to take these different paths.

An innovative Bachelor of Science program in Physics is offered by the faculty of the Interdisciplinary Physics Group. A typical program of study for this degree is at the end of this section. The great advantage of this program over more traditional approaches is its highly flexible and interdisciplinary nature. Students learn physics and at the same time become accustomed to working with engineers. The basic concepts of physics have a lasting value which makes graduates more able to alter their career as opportunities become available. At the same time, students can choose, with the help of their adviser, from the wide range of technical material available at the university, to make their own unique career preparation.

The 128-credit program consists of three components: The first includes the science, computer science, humanities and math core courses required of all engineering students, plus an added 4-credit course on programming or computation (64 credits).

The second component, in contrast, deals with advanced topics in physics (28 credits) which include, thermodynamics, covered in ME 3314; electromagnetic waves, covered in EE 3604; electrical circuits, covered in EE 2004; dynamics and vibrations, covered in ME 3414; and quantum mechanics of atoms and molecules, covered in CM 703. Concepts of modern solid-state physics and modern optics are covered by PH 2344 and PH 4474, respectively. A capstone experience in Interdisciplinary Physics is provided in IDP Seminar (2 credits) and Senior Project (6 credits), as a part of the requirement.

The third component of the curriculum (34 credits) differs from a traditional BS program in Physics in that students can choose courses according to their career interests. For instance, recommended for a pre-PhD track are CM 704 Statistical Mechanics and ME 2514 Measurement Instrumentation. However, these optional 8 credits, along with 12 credits of technical electives and the 8-credit sequence (for a total of 34 credits, including the Senior Project) can be tailored to meet the needs of students interested in entrepreneurship, teaching, biophysics, biomedical instrumentation, integrated circuit electronics (ic electronics), scanning probe metrology and computational science and engineering.

For strong students, this program offers opportunities for dual degrees, especially the combinations PH/EE, PH/CM, PH/CH and PH/ME, because EE, CM and ME courses are built into the IPD programs. Dual degrees may be awarded, with approval of both of the departmental advisers involved, for students with as few as one additional year of credits. In the past, strong students have achieved dual degrees in four years of study by taking extra courses and sometimes including a summer course.

MINOR IN PHYSICS

The undergraduate physics minor consists of a set of four or more physics courses, totaling at least 15 credits. The courses should be at intermediate or advanced level and have the introductory physics sequence, PH 1004 and PH 2004, as prerequisites. An overall GPA of 2.0 is required in these courses to earn the minor. For transfer students, at least 8 credits must be earned at Polytechnic, with a 2.0 GPA.

Suitable courses include:

PH 2344	Introduction to Modern & Solid State Physics
PH 2814	Astronomy & Astrophysics
PH 3244	Concepts of Nanotechnology
PH 4244	Techniques & Applications of Nanotechnology
PH 547	Modern Optics

UNDERGRADUATE COURSES

For introductory courses in physics, see the Department of Introductory Design and Science section in Part 2 of this catalog.

PH 2344 Introduction to Modern and Solid State Physics 4:0:0:4

Special theory of relativity, Michelson Morley experiment. Planck's quantum hypothesis, photoelectric effect, Compton effect, Rutherford scattering, Bohr's atom, deBroglie wavelength, electron diffraction, wave function, uncertainty principle, Schrodinger equation. Application to: square well potential, one electron atom. Atomic nucleus, fission and fusion. Energy bands in a periodic lattice, Kronig Penney model, valence, conduction bands, impurity states, electron mobility. Semiconductor properties. Introduction to superconductivity; electron pairs, energy gap, Josephson effect. *Prerequisite: PH 2004.*

PH 2814 Astronomy and Astrophysics 4:0:0:4

Historical development of observational astronomy. Traditional and modern observational techniques. Theories of formation and evolution of stars, planets and galaxies. Current developments in astronomy, cosmology and astrophysics. *Prerequisite: PH 2004.*

PH 3104 Analytical Mechanics 4:0:0:4

Statics by virtual work and potential energy methods. Stability of equilibrium. Particle dynamics, harmonic oscillator and planetary motion. Rigid body dynamics in two and three dimensions. Lagrangian mechanics. Dynamics of oscillating systems. *Prerequisites: MA 2122 and PH 2004.*

PH 3124 Thermodynamics and Statistical Physics 4:0:0:4

Fundamental laws of macroscopic thermodynamics, heat, internal energy, entropy. Introduction to statistical physics, including applications of Maxwell, Fermi-Dirac and Bose-Einstein distributions. *Prerequisites: MA 2122 and PH 2344.*

PH 3234 Electricity and Magnetism 4:0:0:4

Properties of the electrostatic, magnetostatic and electromagnetic field in vacuum and in material media. Maxwell's equations with applications to elementary problems. *Prerequisites: MA 2122 and PH 2004.*

PH 3244 Concepts of Nanotechnology 3:0:1:4

The first of an interdisciplinary, two-semester sequence on concepts, techniques and applications of nanotechnology. Introduction to nanotechnology, examples of nanoscale systems. Systematics in miniaturization from the mm to the nm scale. Limits to miniaturization. Quantum concepts and elementary Schrodinger theory. Quantum effects in the behavior of chemical matter. Examples of self-assembled nanosystems from nature and from contemporary industrial products. *Prerequisite: PH 2004.*

PH 3811-3848 Reading Courses in Inter-disciplinary Physics 1:0:0:1- 4:0:0:4

Special topics in interdisciplinary physics supervised by staff member. *Prerequisites: PH 2344, must be an interdisciplinary physics major.*

PH 4244 Techniques and Applications of Nanotechnology 3:0:1:4

The second of a two-course sequence on concepts and techniques of nanotechnology. Novel function and performance can occur with materials or devices of size scales of one to 100 nanometers, a range extending from molecular scale to that of typical linewidths in contemporary microelectronics. Nanosystems may provide entirely new functions, by virtue of access enabled by the small size. Photo- and x-ray lithographic patterning. Scanning probe microscopes for observation and for fabrication. Molecular machines as envisioned by Drexler. The role of an der Waals force. Questions of "machine" manufacturability on the nm scale. The IBM GMR hard-drive "read" head. Micro- and nano-electromechanical devices and systems. Single-electron electronics. Molecular electronics. *Prerequisite: PH 3244.*

PH 4364 Introduction to the Quantum Theory 4:0:0:4

Quantitative introduction to the quantum theory, which describes understanding light, electrons, atoms, nuclei and solid matter. Superposition principle, expectation values, momentum operator and wave function, duality, current vector, hermitian operators, angular momentum, solution of the radial equation, electron in a magnetic field, perturbation theory, WKB approximation, identical particles. Applications include alpha decay, electrons in a periodic lattice, hydrogen spectrum, helium atom, neutron-proton scattering, and quark model of baryons. *Prerequisites: MA 2122 and PH 2344.*

PH 4474 Modern Optics 4:0:0:4

The physics of optics using both classical and semi-classical 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 optics. Introduction to electro-optics and nonlinear optics. *Prerequisite: PH 3234 or equivalent.*

PH 4902 Introduction to Senior Project in Interdisciplinary Physics 0:4:0:2

A qualified senior physics student or several such students work with a faculty member (and perhaps graduate students as well) on an advanced problem in interdisciplinary physics. In this introductory phase the student(s) and adviser select a suitable theoretical or experimental problem in the subject area and cognizant of resources at hand, make plans for its solution.

PH 4904 Senior Project in Interdisciplinary Physics 0:8:0:4

Concluding phase of the project; senior physics students or several such students work with a faculty member (and perhaps graduate students as well) to solve an advanced problem in interdisciplinary physics. The conclusion of the project is a written report and an oral presentation made to the supervising faculty.

PH 4912 Senior Seminar in Interdisciplinary Physics 2:0:0:2

Senior physics students, in consultation with the instructor, study and prepare presentations, several current research topics in the general area of interdisciplinary physics. Students' performance in this course is based on the mastery of the material chosen and also on the quality of the presentation made to the instructor and the seminar members.

GRADUATE COURSES**PH 547 Modern Optics** 3:0:0:3

The physics of optics using both classical and semi-classical 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 optics. Introduction to electro-optics and nonlinear optics. *Prerequisites: MA 2122, PH 3234 equivalents.*

PH 548 Modern Optics Lab 0:3:0:1

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. *Co-/Prerequisite: PH 547 or equivalent.*

PH 651/652 Introduction to Solid-State Physics I/II each 2½:0:0:3

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 667/668 Quantum Mechanics I/II each 2½:0:0:3

Quantum mechanics with applications to atomic systems. The use of Schroedinger's equations. Angular momentum and spin. Problems and approximation methods. Semi-classical theory of field-matter interaction. Also listed under EL 655/656.

PH 801/802 Selected Topics in Advanced Physics I/II each 2½:0:0:3

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. Note: this course is not offered every semester.

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 MS or PhD degree, to be performed under the direction of a member of the department. The number of research credits registered for each semester should realistically reflect the time devoted to research. *Prerequisites: degree status and graduate adviser's and research director's consent.*

Typical Course of Study for the Bachelor of Science in Physics

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab.	Rec.	Cr.
MA 1024	Calculus I	4	0	0	4
CM 1004	General Chemistry	3	2	1	4
EG 1004	Intro. Engineer. Design	1	3	2	4
EN 1014	Writing & Humanities I	4	0	0	4
SL 1010	Freshman Seminar	1	1	0	0
					16

Spring Semester

Course No.	Course Title	Class	Hours/Week			
			Lab	Rec.	Cr.	
MA 1124	Calculus II		4	0	0	4
PH 1004	Intro. Physics I		4	1½	1	4
CS 1114	Intro. Prog. & Problem Solving		3	3	0	4
EN 1204	Writing & Humanities II		4	0	0	4
					16	

SOPHOMORE YEAR

Fall Semester

MA 2012	Linear Algebra	4	0	0	2
MA 2132	Ordinary Diff. Equ. (½ semester)	4	0	0	2
PH 2004	Intro. Physics II	4	2	1	4
CS 1124	Object. Orien. Prog.	4	0	0	4
	or				
ME 2114	Comp. ME Engineer. Design	4	0	0	4
HI 2104	Modern World History	4	0	0	4
					16

Spring Semester

MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi. Calculus B	4	0	0	2
EE 2004	Fund. El. Ckts	3½	1½	1	4
PH 2344	Int.Mod/SolStPh	4	0	0	4
	Technical Elective ³	4	0	0	4
	or				
CM 2614	Phys. Chemistry I ³	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

EE 3604	Electromag. Waves	4	2	1	4
ME 3314	Flow/Thermal Systems	4	0	0	4
	or				
CM 3614	Physical Chemistry II ³	2	6	0	4
ME 3414	Dynamics, Vibr.	3	0	0	4
	HU/SS Elective	4	0	0	4
					16

Spring Semester

ME 2514	Measurement/Instrum.	3½	1½	0	4
	Technical Elective	4	0	0	4
	HU/SS Elective ¹	4	0	0	4
	Sequence A	4	0	0	4
					16

SENIOR YEAR

Fall Semester

CM 703	Chemical Physics I	4	0	0	4½
PH 4902	Intro. Senior Project		4		2
PH 4912	Seminar Cont. IDP	2			2
PH 4474	Mod. Optics	4	0	0	4
	Sequence B	4			4
					16½

Spring Semester

CM 704	Chem. Physics II ²	3½	0	0	4½
	or				
CM 5714	Mol.Mod.Sim. ³	3	3	0	4
	Technical Elective	4	0	0	4
PH 4904	Senior Project		8		4
	HU/SS Elective	4	0	0	4
					16½

Total credits required for graduation:

128

1. For students on the Entrepreneurial Track, HI 3165 is recommended.
 2. For students on the Entrepreneurial Track, recommended substitution and elective choices include MG 1002, MG 2304, MG 3204 and others in the Technology and Information Management Program section.

3. For students on the Computational Science and Engineering Track, the recommendation for the Technical Elective in the sophomore spring semester is shifted to junior fall semester; and EE 3604 is shifted to the junior spring semester; and ME 2514 is deleted.

SYSTEMS ENGINEERING PROGRAM

Program Director: Dariusz Czarkowski

Systems engineering is based on the body of theoretical knowledge that underlies the engineering of modern complex systems. Systems engineering applies this body of knowledge to designing 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, systems engineers may receive assignments crossing traditional lines of engineering applications. Systems engineering is presently applied in such areas as communications, networking, transportation, urban services, bioengineering, resource management, power and energy and environmental and pollution control.

The Systems Engineering Program stresses computer use. It covers, in an interdisciplinary manner, the viewpoints, tools of analysis and mathematical techniques of signals and systems, feedback control, analysis of data, optimization and simulation, communication of information, instrumentation and measurement. The orientation and training that systems engineering students receive at Polytechnic enable them to analyze and solve today's complex technological and societal problems.

The Department of Electrical and Computer Engineering administers the program leading to the degree 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 PhD in the area of systems may do so in the Electrical Engineering Program.

GOALS AND OBJECTIVES

The Master of Science program in System Engineering has the following specific objectives to provide students with the following:

- Skills and advanced knowledge in the design and analysis of engineering systems, including methods of modeling and simulation, methods for the analysis of signals and systems, theories of communication and control and techniques of optimization and of decision-making
- Training in using modern computers to perform analysis and simulation and to solve real system problems
- Baseline skills and knowledge in system engineering project management
- A basis for continued, lifelong learning in the system engineering profession

REQUIREMENTS FOR THE MASTER OF SCIENCE

The entrance requirement for a 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 remedy these deficiencies.

To satisfy the requirements for an MS in Systems Engineering, students must complete a total of 36 units of courses, as described below, and retain a B grade in all graduate courses. In addition, a B average is required in specific groups of courses, as indicated below.

GROUP I: Core Courses

Three courses from among the following:

- EL 525 Applied Matrix Theory
- EL 611 Signals, Systems and Transforms
- EL 621 Feedback Control I
- EL 625 Linear Systems
- EL 630 Probability
- MA 683 Statistical Inference I

9 Units

GROUP 2: Two approved one-year sequences, which may include the above courses. At least one of these sequences must be in EL courses.

6-12 Units

GROUP 3: Approved electives

15-21 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 prefixed courses.

An overall B average is required in the combination of five to seven courses offered to satisfy groups 1 and 2 above.

Students should consult the Department of Electrical and Computer Engineering's Graduate Student Manual (www.ece.poly.edu) for more detailed rules and procedures, including student status, transfer credits, recommended electives and one-year sequences, current areas of research and disqualification for low grades.

Descriptions of graduate electrical engineering and mathematics courses used in the System Engineering Program are located, respectively, in the Electrical Engineering and Mathematics Program sections of this catalog.

GRADUATE COURSE

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 an adviser. Oral thesis defense and formal, bound thesis volume are required. Registration of 9 units is required (continuous thesis registration is required). *Prerequisite:* degree status.

TECHNICAL COMMUNICATION PROGRAM

Academic Adviser: Elisa Linsky

While the demands for technology are constantly in flux, there is one resource that is always in demand: people who are able to communicate clearly and effectively. Technical communicators create and design work that helps people solve problems and learn new things. Their skill lies in the ability to determine the best way to present information to a specific audience. Their job is to creatively construct new knowledge from existing information.

The Department of Humanities and Social Sciences at Polytechnic University has developed a Bachelor of Science in Technical Communication to address this need. Through course projects and internships, students build a solid portfolio that demonstrates a wide range of writing, editing and design skills as well as in-depth knowledge within an area of specialization.

The following programs of study are available to our students:

- Bachelor of Science in Technical Communication
- BS/MS Accelerated Degree
- Minor in Technical Communication
- Master of Science in Specialized Journalism
- Graduate Certificate in Technical Communication

The Technical Communication Program is designed to train students to translate technical information so that it can be easily understood. Students develop their writing, editing, research and design skills and their interpersonal, organizational and management abilities. Students should have strong communication skills as well as a keen interest in, or aptitude for, technology, science and business. The curriculum explores the theoretical foundations of contemporary communications and the advancement of new media, with a strong emphasis on the practice of effective communication.

BACHELOR OF SCIENCE

See requirements for BS in Liberal Studies in the Liberal Studies Program section of this catalog. Students earning the BS in Technical Communication complete a series of 36 credits in technical communications courses. Up to 20 credits of other professional courses may be substituted, with approval of the academic adviser, for liberal studies focus courses.

GOALS AND OBJECTIVES

The specific goals and objectives of the Technical Communication Program are to provide the following:

- The fundamental skills that allow technical communicators to creatively construct new knowledge from existing information
- A solid foundation in the technology required to advance communication beyond its traditional confines
- An advanced understanding of user-centered design and its implications in the creation of new media

BS/MS ACCELERATED HONORS PROGRAM

The Technical Communications Program offers a BS/MS honors program for exceptional first-year students and advanced undergraduates. Through this unique program, students can earn both a Bachelor of Science and a Master of Science in Technical Communication/Specialized Journalism in just four to five years. The accelerated program allows students to take up to 9 credits that fulfill both undergraduate and graduate degree requirements. In addition, credit may be granted for high school Advanced Placement courses where a student earns a 4 or 5 on the AP test.

Students accepted into the program may also earn up to 18 credits through one or more undergraduate and graduate internship opportunities.

To be eligible for this program, high school students must meet the following criteria:

- A minimum 3.33 (B+) GPA
- A minimum 600 verbal SAT score (1200+ overall score preferred)

Polytechnic freshmen, sophomores and juniors must meet the following requirements:

- A minimum 3.33 (B+) GPA
- Two letters of recommendation from Polytechnic faculty

All candidates for the program must pass an entrance examination administered by the department and be interviewed by the program adviser. Once enrolled in the program, students are expected to maintain a 3.0 GPA.

MINORS IN TECHNICAL COMMUNICATION

A minor in technical communication is awarded to students who complete 16 credits (four courses) in technical communications. Any combination of courses may be taken.

The following combinations are recommended:

Technical Communication for Computer Professionals

- TC 2314 Computer Documentation
- TC 2324 Human Factors for Technical Communicators
- TC 3324 Writing for New Media
- TC 3134 Interactive Design for the Web and CD-ROM

Print and Digital Design

- TC 2114 Introduction to Visual Communication Design
- TC 2124 Digital Graphics
- TC 3124 Advanced Visual Communication Design
- TC 3134 Interactive Design for the Web and CD-ROM

Integrated Business Communication

- TC 2514 Marketing and Public Relations Writing
- TC 2114 Introduction to Visual Communication Design
- TC 2514 Technical Presentations
- TC 2524 Copyediting for Technical, Scientific and Business Publications

MASTER OF SCIENCE

GOALS AND OBJECTIVES

The specific goals of the MS in Specialized Journalism are to do the following:

- Provide the advanced communication skills necessary to create new knowledge from existing information in order to help others solve problems and learn new things
- Allow students to expand beyond a solid foundation in the essentials of technical communication and explore a specific area within the discipline: specialized journalism, writing for business, documentation and user-centered design, or writing for new media
- Train students to translate technical information so that it can be easily understood by others

REQUIREMENTS

The Master of Science in Specialized Journalism is awarded to students who complete a minimum of 36 units. Students enrolled in the program are required to complete the following core courses:

Course No.	Course Title	Units
JW 600	Introduction to Technical Communication*	3
JW 601	Style for the Professional Writer	3
JW 602	Copyediting for Technical, Scientific & Business Publications	3
JW 704	Master's Project	3

**Upon adviser approval, students with prior experience in technical communication may waive JW 600 and replace it with an elective course.*

At least 12 of the remaining units required for graduation should be in courses within the student's chosen specialization. Students may also take a limited number of related courses in other departments, such as CS 637 Programming Language or MG 601 Organizational Behavior with their adviser's approval.

The student will be encouraged to take 9 units of work in related fields outside the program. To qualify for a degree, students may elect to write either a comprehensive examination or a thesis embodying appropriate and substantive research. If students choose the former, examinations may be taken in the term in which courses are completed. A student choosing the thesis may apply up to 12 units of

thesis course work toward requirements for the degree. Acceptance of a thesis involves an oral presentation and defense.

AREAS OF SPECIALIZATION

To address the diversity of writing, editing and design tasks available to today's technical communicators, the program offers four areas of specialization:

1. Specialized journalism
2. Writing for business: advertising, public relations, corporate communications and the trade press
3. Documentation, usability testing and human-factors engineering
4. Writing for new media

GRADUATE CERTIFICATE

The Graduate Certificate in Technical Communication trains students in the fundamentals of technical communication through a combination of core courses and electives. To earn a certificate, students must complete 15 units. All units earned in the graduate certificate program are transferable to the Master of Science in Specialized Journalism. In general, all certificate students should take the following core courses:

Course No.	Course Title	Units
JW 600	Intro. to Technical Communication*	3
JW 601	Style for the Professional Writer	3
JW 602	Copyediting for Technical, Scientific & Business Publications	3

**Upon adviser approval, students with prior experience in technical communication may waive JW 600 and replace it with an elective course.*

It is recommended that students earn the remaining 9 to 12 units in courses within a particular area of specialization. Students work with an adviser to select elective courses most appropriate for their academic and professional goals.

ePOLY ONLINE GRADUATE CERTIFICATE

A Graduate Certificate in Documentation, Web Usability and Human Factors Engineering is available online. The following courses are required for the certificate: JW 6004, JW 6084 and JW 6094.

Two electives must be taken from the following: JW 6024, JW 6134 and JW 6234.

UNDERGRADUATE COURSES

TC 1014 Introduction to Technical Communication I 4:0:0:4

Introduction to the research, writing and design principles and practices of technical communication, particularly in the fields of specialized journalism, documentation, advertising and public relations, corporate communications, training and instructional design and new media. Emphasis on clarity and control in writing and effective information design; also covers the basic elements of effective document design. The focus is in traditional media. *Prerequisite: EN 1024.*

TC 1024 Introduction to Technical Communication II 4:0:0:4

Introduction to the research, writing and design principles and practices of technical communication, particularly in the fields of specialized journalism, software documentation, advertising and public relations, corporate communications, training and instructional design, and new media. Emphasis on clarity and control in writing and effective information design; also covers the basic elements of effective document design. The focus is in new and digital media. *Prerequisite: EN 1024; course does not require TC 1014, but both courses must be taken before 2000-level.*

TC 2104 Writing for Engineers and Scientists 4:0:0:4

Engineers and scientists must become adept at communicating their ideas in writing. In actual business situations, they are called upon to present their work to colleagues and management frequently. This workshop course focuses on the skills that must be acquired to succeed professionally. Course covers proposals, reports, new product reviews, technical descriptions and instructions as well as the basics of successful professional communication in the form of emails and memos. Students learn how to design documents. Style and organization are stressed. *Prerequisite: EN 1204.*

TC 2114 Introduction to Visual Communication Design 4:0:0:4

An introduction to the principles of design and how to apply these principles for effective visual communication. Students study the physiology and psychology of perception and the psychological, sociological and educational impact of design. During workshop sessions, students critique and create numerous design projects, including business documents, logos, brochures and product packages. The fundamentals of desktop publishing are covered. Students begin to develop a portfolio of class projects. *Prerequisites: EN 1024.*

TC 2124 Digital Graphics 4:0:0:4

An introduction to image creation and editing: Photoshop, Illustrator and a bit of Flash. Participants learn to optimize files for the Internet, color-correct and manipulate digital photographs and work with vector graphics. *Prerequisite: EN 1204.*

TC 2214 News and Feature Writing 4:0:0:4

A workshop in basic news and feature-writing techniques. Students learn methods of information gathering and interviewing for different types of news articles, including current events, meetings, speeches, human interest and news analyses. Students also learn the style and structure of news stories and feature stories, how to write effective leads and the basics of libel law and press ethics. Students learn how to write headlines, leads, decks and subheads for general, technical and industrial publications. Newspaper, magazine and online layout and design. The course includes practice in basic copyediting techniques, including editing, revising and rewriting copy intended for a variety of audiences, publications and media. Peer and self-editing projects and assignments. *Prerequisite: EN 1024.*

TC 2224 Introduction to Communication 4:0:0:4

Communication theory is the silent partner of all writing and media professions. It helps people to plan projects that must be communicated. At the same time, it helps people to be more astute readers of communication initiated by others. This

course develops strategies for the critical understanding of communication through the study of fundamental topics in its history and theory. Students consider how conceptions of the public sphere, freedom of expression and intercultural exchange have shaped mass media. Of particular concern is an understanding of fact, identity and entertainment in the age of instantaneous communication. Students seek answers to the following questions: What terminology and philosophical frameworks can provide people with a deeper understanding of communication? What is mass media and what are its effects on society? What legal and ethical considerations should be brought to the study of media—how have ideas of copyright and trademark influenced media and what are the effects of global English? How have computers and the age of new media transformed (or failed to transform) communications? *Prerequisite: EN 1204.*

TC2314 Computer Documentation 4:0:0:4

Introduction to the field of computer documentation. Students learn systems and software documentation procedures and techniques; computer documentation tools; and the fundamentals of project management, from needs analysis to usability testing. A portion of course is devoted to the fundamentals of online documentation. A major documentation project is required. *Prerequisites: EN 1204.*

TC 2324 Human Factors for Technical Communicators 4:0:0:4

This course focuses on designing, developing and testing technical information—the ergonomics of information design. Technical writers rely on a relationship between themselves and the people who use the information they disseminate. This course will teach the techniques human factors engineers take into account. Students learn to consider both the ergonomics of design as well as its cognitive implications. *Prerequisite: EN 1204.*

TC 2414 Technical Presentations 4:0:0:4

Principles of effective scientific and technical presentations. This skills-

based course focuses on effective ways to convey technical information to both professional and lay audiences by asking students to prepare weekly presentations they will deliver in class. Audience analysis, research, organization of material, the selection of appropriate media and the use of graphics are taught. Emphasis is placed on successful strategies for dealing with the presentation of numbers and other technical data. *Prerequisite: EN 1204.*

TC 2514 Marketing and Public Relations Writing 4:0:0:4

Almost all businesses depend on effective marketing for their survival. And many organizations seek to increase their visibility, heighten their profile and modify public perception of what they do by mounting public relations campaigns. In this course, students are introduced to, and experiment with producing, a full-range of print-based marketing and public relations materials, including resumes, brochures, project proposals, newsletters and other direct-mail advertising, commercial print advertisements, press releases, and story proposals for the trade press. The course examines the differing goals of marketing versus PR, explores the challenges of successfully “branding” an organization, and emphasizes the importance of strategic, targeted marketing and PR efforts. Connections are made, where appropriate, to marketing and PR writing for electronic and non-print media. *Prerequisite: EN 1204.*

TC 2524 Copyediting for Technical Scientific and Business Publications 4:0:0:4

Copyeditors play a crucial role in any media organization that conveys information through text. Beginning with an overview of the editorial process, this course addresses the many skills that copyeditors must master to produce clean, readable, internally consistent copy. Topics covered include using references, imposing editorial style, marking up manuscripts, organizing text, handling proper names and specialized terms, crediting sources, checking facts and resolving conflicts between an author’s voice and that of the editor or publication. Specific issues of grammar, punctuation and style are dealt with in a series of presentations—three or four

each week—over the course of the semester. *Prerequisites: EN 1204 and TC 1014.*

TC 3124 Introduction to Visual Communication Design II 4:0:0:4

The purpose of this course is to apply previously gained knowledge of design and design software to more complex design problems. Students create magazine layouts, package designs, promotional pieces, and multiple page booklets using primarily QuarkXPress and InDesign, along with Adobe Illustrator and Adobe Photoshop. In-class critiques and computer exercises also play an important role in the classroom. Trips to design-related exhibits complement ideas discussed in class. *Prerequisites: EN 1204 and TC 2114.*

TC 3134 Interactive Design for the Web and CD-ROM 4:0:0:4

An advanced seminar for those seriously interested in web design: interactivity, usability and the quality and appropriateness of look-and-feel are stressed, but participating students are also expected to develop content and complete a professional-quality site for the class. *Prerequisites: TC 2124.*

TC 3224 Critical Writing 4:0:0:4

Students learn how to research, structure and write critical, analytic and interpretive texts, including such genres as book reviews, journal articles, product reviews and scientific reports. For example, they may write about technical, scientific, medical, business, industrial or digital subjects for the lay audience. Particular attention is paid to assessing audience and purpose and constructing analytic arguments. Students hone revision and copyediting skills, as well as learn how to work as peer reviewers, editors and proofreaders. For final project, students research and write text targeted for specific publications. *Prerequisites: EN 1204.*

TC 3324 Writing for New Media 4:0:0:4

Planning, writing and designing an effective project for digital or new media formats such as intranet, Internet, news-groups and kiosks. Students learn HTML and software applications for

web-page development, integration of graphics and text and effective use of hypertext linking and structures. Students examine new media and the effects they have on reading, writing and information processing. Project including substantial development of original text required. Class is a hands-on lab, supplemented by discussion and short presentations of key writing concepts. Final project required. *Prerequisite: EN 1204.*

TC 3404 Special Topics in Technical Communication 4:0:0:4

Independent or small group work in an area of technical and professional communication selected by students in consultation with instructor. *Prerequisites: for majors only, TC 1014, TC 1024, TC 2114, TC 2214, TC 3XX4 and instructor's permission.*

TC 4404 Internship 4:0:0:4

Full- or part-time placement as a technical/professional communication intern. Intense, practical work experience focusing on student's area of specialization. Students work with a professional adviser within the sponsoring organization and a faculty adviser within the department. Weekly progress reports and a final report required. *Prerequisites: for Technical Communication majors and minors only, junior or senior standing, appropriate courses for internship project and approval of the sponsoring organization and the department.*

TC 4504 Senior Project and Portfolio Review 4:0:0:4

In this capstone course, students develop a major project that integrates the knowledge and skills they have acquired through the program. Students manage the project from start to finish under the guidance of their project adviser. In addition, students revise selected projects from previous classes to develop a professional portfolio of writing samples. *Prerequisites: for Technical Communication majors only, senior status and completion of 1000-, 2000- and 3000-level course requirements.*

GRADUATE COURSES

JW 600 Introduction to Technical Communication 2½:0:0:3

An overview of the research, writing, editing and design principles of technical and professional communication. Students learn how to gather, organize and present information effectively, according to audience and purpose. Writing projects range from procedures and explanations to articles and advertisements.

JW 6004 Introduction to Technical Communication (ePoly online course)

3:0:0:3.6

This course is equivalent to JW 600. It includes the same topics and requirements, with the addition of the following subjects: qualification packages and proposals and supplemental writing assignment to develop a boiler-plate proposal. Brochures and additional writing assignment to compose a brochure.

JW 601 Style for the Professional Writer 2½:0:0:3

Writing and editing workshop designed to strengthen students' command of usage, style, grammar, punctuation, precision, logical structure and color through intensive writing and copyediting practice.

JW 602 Copyediting for Technical, Scientific and Business Publications 2½:0:0:3

Copy editors are at the center of any print media organization. Course addresses skills copy editors must have to produce clean copy: correct grammar and punctuation; a precise and consistent style; fact checking, including the use of both standard references and electronic databases; editing leads; making news judgments when editing stories; legal concerns affecting writers and editors, including libel, invasion of privacy and copyright infringement; writing headlines; handling photographs and informational graphics; and designing and laying out pages.

JW6024 Copyediting for Technical, Scientific and Business Publications (ePoly online course) 3:0:0:3.6

Written work published by reputable organizations represents a collaboration between the author, an editor and (in many cases) a copyeditor. This graduate-level course offers a comprehensive introduction to the copyeditorial profession. It introduces students to the editorial process and provides training in the correction of manuscripts through the consistent application of rules of grammar, punctuation and style. Beyond this, it aims at helping students develop editorial expertise and judgment by focusing on topics such as factual accuracy, authorial voice and intellectual property, as well as through ongoing discussion of current issues in usage and rhetoric.

JW 603 Reporting on Medicine, Science and Technology 2½:0:0:3

Researching and reporting on medicine, science and technology. Students interview recognized medical, scientific and technology authorities in a given discipline to write and edit news and feature articles for a general reading audience. Course considers how science writers develop feature articles, how they translate technical information effectively and engagingly to the lay audience and how they follow articles through to publication. Students analyze several scientific, medical and technical magazines for content, style and editorial practices. Students are encouraged to submit the work they do in the course for publication. *Prerequisite: JW 600 or instructor's permission.*

JW 605 Libel Law and Press Ethics 2½:0:0:3

Based on a study of some classic cases, course familiarizes students with the essentials of libel law. Journalistic ethics; writer's responsibilities to sources and readers; avoiding libel pitfalls.

JW 606 Technical Presentations 2½:0:0:3

Principles of effective scientific and technical presentations. Topics include channeling content to audience, organization of material, appropriate media, design and production of visual aids and

audience text, effective delivery and non-verbal communication. Students prepare for and participate in speech-making situations and in panel discussions covering a wide variety of technical subjects. *Prerequisite: JW 600 or instructor's permission.*

JW 607 Writing News for Radio and Television 2½:0:0:3

Writing news for the electronic media. Focus on science and business news stories. Intensive practice in writing for radio and television; accepted format and style of media news writing; and requirements and limitations of the media and how these must be taken into account in news writing. Students use video and audio technology in class. *Prerequisite: JW 600 or instructor's permission.*

JW 608 Computer Documentation I 2½:0:0:3

Introduction to the field of computer documentation. Systems and software documentation procedures and techniques; computer documentation tools; and fundamentals of project management, from needs analysis to usability testing. History and future of documentation. *Prerequisite: JW 600 or instructor's permission.*

JW 6084 Computer Documentation I (ePoly online course) 3:0:0:3.6

This course is equivalent to JW 608. It includes the same topics and requirements, with the addition of the following subjects: Usability Testing I and supplemental writing assignment to perform usability test on software. Usability Testing II, how to edit.

JW 6094 Computer Documentation II (ePoly online course) 3:0:0:3.6

Available online in future semesters.

JW 613 Human Factors and Product Design 2½:0:0:3

Examines the elements of human-computer interaction and how it affects knowledge transfer and product design. Students learn how to design user-friendly programs by studying perception, cognition and software psychology. *Prerequisite: JW 600 or instructor's permission.*

JW 6134 Human Factors and Product Design (ePoly online course) 3:0:0:3.6

Available online in future semesters.

JW 620 Financial and Business Reporting 2:1½:0:0:3

Workshop in business and financial news writing. Students write news reports and interpretive pieces for business periodicals and the financial sections of newspapers. Topics include economic trends, marketing, corporate activities, the stock market, government regulations, industrial technology, labor-management relations, advertising, energy, industry and the environment. Students analyze corporate annual reports, investment company research reports, stock analysis reports, financial press releases and the editorial practices of several financial and business publications. *Prerequisite: JW 600 or instructor's permission.*

JW 621 Reporting and Editing for the Trade Press 2½:2:0:3

Survey of the diverse editorial opportunities in trade press journalism. Students learn to write, edit and interview for trade publications. Among the assignments are writing short news stories; copyediting (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.); and 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 trade magazines serve a particular field of industry (computers, electronics, petrochemicals, pharmaceuticals, automotive, etc.), many of the articles appearing in them are contributed by industry authorities. Course emphasizes responsibility of the editor to cultivate good working relationships with such people to induce them to write for publication in trade journals. *Prerequisite: JW 600 or instructor's permission.*

JW 623 Project Management

2½:0:0:3

Managing publication projects for scientific and technical organizations. All phases of publication: project conception, design, coordination, production and costs; planning, organizing, staffing, directing and budgeting. *Prerequisite: JW 600 or instructor's permission.*

JW 624 Writing Product-Information Copy

2½:0:0:3

Consideration of the mass of sales-promotional and technical catalogues, brochures, manuals, spec sheets, flyers and news releases that promote a company's products. Emphasis is on approaches to writing such material. In addition to preparing copy for the shorter product-promotion bulletins, students are responsible for providing text for a major catalogue or brochure promoting a given product or technology and based on raw data either provided by the instructor or gathered by students. Course stresses need for product information of varying degrees of technical complexity to suit the technical competency of the prospective customer for whom the literature is intended. *Prerequisite: JW 600 or instructor's permission.*

JW 6234 Project Management

(ePoly online course) 3:0:0:3.6

Available online course in future semesters.

JW 625 Corporate Communications in Medicine, Science and Technology

2½:0:0:3

Considers the corporate communications writing tasks specific to a pharmaceutical, biotechnology or technology firm. Topics include in-house technical and semi technical reports, liaisons between researchers and management, writing and editing for scientists. *Prerequisite: JW 600 or instructor's permission.*

JW 626 Public Relations for Medicine, Science and Technology

2½:0:0:3

Workshop in public relations for medical, scientific and technological industries and organizations, including

research facilities, hospitals, medical schools, foundations and pharmaceutical companies. Students learn how to write effective press releases, brochures, technical articles, film scripts, case histories, speeches and various in-house publications, as well as how to prepare press kits for press briefings. *Prerequisite: JW 600 or instructor's permission.*

JW 627 Writing Copy on Pharmaceuticals and Biotechnology

2½:0:0:3

Course prepares students for expanding opportunities in writing copy for pharmaceutical and drug companies. Intensive practice in writing new-product data sheets, bulletins and other technical literature generally used by "detail" men; research reports, progress reports and other technical papers based on information supplied by the instructor and gathered on trips to local pharmaceutical companies; technical speeches; advertising and public relations copy. A major paper will be assigned as a term project. *Prerequisite: JW 624 or JW 626 or instructor's permission.*

JW 628 Business-to-Business Advertising

2½:0:0:3

Covers the objectives of business-to-business advertising and how to achieve them through three basic ingredients of the magazine ad: copy, artwork and layout. Emphasis is on principles of writing effective copy and heads, the process of media selection for a given ad (product promotion, institutional), the preparation of an ad campaign, how to set up booths for industrial displays and exhibits, conducting the direct mail campaign, the value and preparation of sales literature and an analysis of business publication advertising today. The roles of the company advertising manager and the agency's account executive and their interrelationship are delineated. Completion of a special project and several ad-writing assignments is required. *Prerequisite: JW 600 or instructor's permission.*

JW 631 Proposal Writing

2½:0:0:3

Writing proposals in government and industry. Students analyze the components of specific in-depth proposals and then research and write their own as a major course project. Analysis of parts

of text, including statement of problem, methods, key personnel and budgeting; use of graphic and tabular material; organization, clarity, layout and editing. *Prerequisite: JW 600 or instructor's permission.*

JW 632 Writing Technical Manuals and Procedures

2½:0:0:3

Intensive practice in preparing industrial, technical, administrative and instructional manuals and procedures. Training in how to write these documents according to government and client specifications. Integration of text with graphics, tables and lists; organization, indexing and parts lists. Every aspect from compiling information to evaluating final product. Major project required on subject in student's area of specialization. *Prerequisite: JW 600 or instructor's permission.*

JW 635 Online Journalism

2½:0:0:3

Examination of the growing field of online journalism. Similarities to and differences from traditional print journalism; available markets in electronic journalism, such as electronic publishing, videotext publications and electronic magazines; techniques for writing for the videotext market, including digest techniques and writing to fit the format of an electronic publication. *Prerequisite: JW 600 or instructor's permission.*

JW 636 The Feature Article

2½:0:0:3

The practice and principles of good, solid feature articles about science, technology and business. Students learn how to write several specific types of feature articles through weekly writing assignments and the creation of their own magazine (print or online). Types of articles may include book reviews, product reviews, "how-to" articles and columns. Topics include effective interview techniques and online journalism applications and concerns. *Prerequisite: JW 600 or instructor's permission.*

JW 641 Desktop Production Workshop

2½:0:0:3

Workshop in desktop publishing software and applications. Students use QuarkXPress, PageMaker and other desktop publishing tools to write, design

TECHNICAL COMMUNICATION PROGRAM

and produce effective business and technical documents: newsletters, brochures, etc. *Prerequisites: JW 600 and JW 604 or instructor's permission.*

JW 647 Computer-Based End-user Training 2½:0:0:3

Workshop in using computer-based training programs to develop a tutorial training package. Students learn and practice principles of effective computer-based training, including breakdown of steps and skills; formulation of questions and answers; and use of graphics, references charts. *Prerequisite: JW 609, JW 645, JW 646 or instructor's permission.*

JW 650 Special Topics in Writing about Medicine, Science and Technology 2½:0:0:3

Special topics courses are offered periodically by the department to address topics in science journalism not currently covered in the curriculum. Topics, faculty and prerequisites may vary. *Prerequisite: JW 600 or instructor's permission.*

JW 651 Special Topics in Writing for Business 2½:0:0:3

Special topics courses are offered periodically by the department to address topics in business writing not currently covered in the curriculum. Topics, faculty and prerequisites may vary. *Prerequisite: JW 600 or instructor's permission.*

JW 652 Special Topics in Documentation, Training and New Media 2½:0:0:3

Special topics courses are offered periodically by department to address topics in documentation, training and new media not currently covered in curriculum. Topics, faculty and prerequisites may vary. *Prerequisite: JW 600 or instructor's permission.*

JW 701 Special Project in Technical Communication 2½:0:0:3

Students, working in conjunction with faculty member, pursue independent study in a special facet of technical and professional communication. Students produce original, thought-provoking interpretive project or report to be submitted to department for faculty review and approval. *Prerequisite: adviser's approval.*

JW 702 Special Topics in Technical Communication 2½:0:0:3

Special topics course is offered from time to time by faculty members, visiting scholars and professionals. Special titles and prerequisites are announced prior to registration. May be repeated for credit. *Prerequisite: JW 600 or instructor's permission.*

JW 703 Internship 0:0:3:12

Full- or part-time placement as a technical and professional communication intern. Intense, practical work experience focusing on student's area of specialization. Students work with a professional adviser within the sponsoring organization and a faculty adviser within the department. Weekly progress reports and term project required. *Prerequisites: completion of four or more graduate courses in technical communication; approval of sponsoring organization and department.*

JW 704 Master's Project 2½:0:0:3

Students work with faculty adviser to write and produce master's project in technical communication. After project proposal is approved, students research and develop technical communication project in area of specialization. *Prerequisites: completion of 27 units or more toward MS in Specialized Journalism and instructor's permission.*

TECHNOLOGY MANAGEMENT PROGRAM

Academic Director: Bharat Rao

Modern technologies are redefining products, services, processes, organizational forms, business models and industry structures. Understanding the managerial implications of these technologies has become a fast-growing and highly important arena for business research. High-quality scholars, capable researchers and expert professionals are needed to expand the knowledge base in technology management through significant intellectual and educational contributions. Additionally, these developments have created a huge international demand for new kinds of managers who can strategically integrate technology and management to innovate and achieve a sustainable competitive advantage for a company. To prepare these managers, qualified educators with the ability to teach technology management are increasingly in demand.

The Doctor of Philosophy in Technology Management (PhD-TM) Program focuses on the increasingly important technology management field and develops scholars, researchers and other academics who aim to contribute to knowledge-generation and education relevant for the technology-centered business environment. The program is under the auspices of the Department of Management and is currently offered under the full-time and part-time formats.

Faculty in the Department of Management possesses significant research strengths in a diverse range of technology management-related fields. The faculty's major professional commitment is to research, thereby contributing to the theory and practice of technology management in important and fundamental ways.

Located in the high-technology heart of New York City, the PhD-TM Program provides immediate access to the world-leading business community and industries (such as financial services, entertainment and media, health care and pharmaceuticals, publishing,

advertising and fashion). This broad industrial base serves as a platform for conducting research, obtaining research support and discovering diverse opportunities for scholarly and educational collaboration.

The department's Institute for Technology and Enterprise (ITE) is a New York City research and educational hub for bridging management and innovation. ITE is a focal point where practitioners, researchers and professionals can interact and learn from one another. ITE offers a portfolio of round tables, seminars, leadership forums and other research-based activities.

The Department of Management offers a full range of academic programs and knowledge-generation activities all related to technology management in same essential fashion. These programs include the executive master's programs Management of Technology (MOT) and Telecommunications and Information Management (TIM); evening master's programs in management, financial engineering and organizational behavior; and the BS in Business and Technology Management (BTM). Together, these programs create a broad value chain of educational efforts in which courses and students with a strong interest in technology management provide PhD-TM students with a host of opportunities for intellectual and educational experiences.

This terminal degree program is designed for research-oriented students who are largely interested in research-based positions at academic and research institutions. Universities with undergraduate and graduate programs that emphasize the integration of technology and management will be a primary source of career opportunities for PhD-TM graduates. In addition, government agencies, not-for-profit research organizations, corporate research centers and research-based consulting firms will also seek PhD-TM graduates.

For more information, please visit www.phd-tm.poly.edu.

SAMPLE THEMES

The following are examples of the themes that a PhD-TM student can select:

- Innovation strategy and management
- Sector-specific patterns of innovations
- Disruptive technologies and innovations
- Information technology-enabled innovations
- High-tech marketing and innovation diffusion
- Strategic alliances for innovation
- Technology life cycle
- Technology strategy
- Supply-chain management and integration
- Knowledge management
- Management of information systems and technologies
- Strategic uses of information technologies
- Information economics and strategy
- Leadership in high-tech firms
- Cross-cultural leadership
- Leadership measurement
- Management of knowledge workers
- Managing the human aspects of technological change
- Impacts of technology upon individuals, organizations and society
- Technical competencies
- Real options in decision making
- Design patterns for information-less trading
- Global technology management

ADMISSION INFORMATION

Admission to the PhD-TM Program is based on an in-depth evaluation of an applicant's academic record, professional experience, research potential, interest in the doctoral study and overall intellectual and professional qualifications. Students must submit the following to be considered for admission:

- Application form with required application fee.
- Official transcripts of all previous undergraduate and graduate records indicating a bachelor's degree with at least a B average from an accredited college or university. The transcripts must be sent directly to the Office of Graduate Admissions.

- Official score from either the Graduate Management Aptitude Test (GMAT) or Graduate Record Examination (GRE).
- Official score from the Test of English as a Foreign Language (TOEFL) if the applicant earned a bachelor's degree from an institution in a non-English-speaking country or if English is the second language. A minimum score of 600 for the paper test (250 for the computer test) is required for admission.
- Three letters of recommendations from persons qualified to comment on the applicant's aptitude for doctoral study and research. Preferably two should be from academics.
- A statement of purpose that at least covers why applicants wants to pursue the PhD-TM at Polytechnic University and how well they are prepared for this study.

Note that part-time and full-time students have to submit the same documentation. There is no financial aid available for part-time students.

In some cases, applicants are contacted for a telephone or face-to-face interview.

In rare cases, the PhD-TM Admissions Committee may admit an applicant who does not meet all required admissions criteria as a non-degree student. Such a student will then have a subsequent opportunity to apply for admission to the PhD-TM Program.

DEGREE REQUIREMENTS AND CURRICULUM

The curriculum for the PhD-TM Program is designed to foster a research-intensive doctoral education relevant for the rapidly emerging area of technology management. Management core courses provide a necessary foundation in management. Technology management courses provide the exposure to the fundamental and most current research and thinking in the broadly defined technology management field. Research methods courses help students develop quantitative and qualitative research skills and management research methods. Thematic elective courses help students gain in-depth knowledge in a focused thematic area related to technology management. Working together, students and doctoral advisers select which of these courses are appropriate for the

student's course of study in the PhD-TM Program. As part of each thematic elective course, students also take an associated thematic independent research course in order to thoroughly investigate previous research works in the selected theme. All PhD students are required to undertake a doctoral research project, preferably in the second summer semester of the study. This course will introduce students to research requirements of management research. Finally, students work on the dissertation, an original investigation of a research question(s) related to technology management. Students are required to complete 90 graduate units, including 66 units from the coursework and 24 units from the dissertation.

1. Management Core Courses

Management core courses should be taken as early in the program as possible.

- MG 601 Organizational Behavior
- MG 607 Marketing
- MG 608 Managerial Economics and the Economic Environment
- MG 609 Managerial Accounting and Finance
- MG 630 Operations Management
- MG 650 Management of Information Systems and Technologies

2. Technology Management Courses

- MG 631 Theory and Design of Organizations
- MG 651 Inter-organizational Information Systems
- MG 660 Management of New and Emerging Technologies
- MG 865 Managing Technological Change and Innovation

Associated Doctoral Seminars

Each 1½ unit doctoral seminar course must be taken with an associated technology management course. These seminars provide strong research background required for doctoral studies in technology management area.

- MG 920 Seminar in Managing Knowledge-Workers in Innovative Organizations (Co-requisite MG 631)
- MG 921 Seminar in Information Systems Management (Co-requisite MG 651)
- MG 922 Seminar in Business Process Innovation (Co-requisite MG 660)
- MG 923 Seminar in Managing Technological Change and Innovation (Co-requisite MG 865)

3. Research Methods Courses

- MG 933 Business Research Methods
- MG 930 Quantitative Analysis I
- MG 931 Quantitative Analysis II
- MG 932 Qualitative Analysis

4. Thematic Courses

Four thematic elective courses to be selected jointly by students and their adviser.

Associated Thematic Independent Research Courses

Students must take a 1-unit thematic doctoral independent research course that is associated with each thematic elective course. These courses will be organized/offered by students' doctoral adviser.

- MG 991 Independent Thematic Doctoral Research Review I
- MG 992 Independent Thematic Doctoral Research Review II
- MG 993 Independent Thematic Doctoral Research Review III
- MG 994 Independent Thematic Doctoral Research Review IV

5. Doctoral Research Project

- MG 990 Doctoral Research Project

6. Comprehensive Examinations

Each student must successfully pass two comprehensive examinations before starting the dissertation.

Part One: This examination includes material covered in the master's level management core and technology management courses. It can be taken after 30 graduate units are accumulated.

Part Two: This examination includes material from the thematic elective and associated thematic research courses, doctoral seminars and research methods courses. It can be taken after the completion of the required coursework.

Students can take both examinations together. Results are provided within one month of the examination. Students have only two chances to pass each examination.

7. Doctoral Dissertation

The dissertation will be evaluated in two parts: Proposal Defense and Final Defense. For details, contact the PhD-TM Program academic director.

- MG 999 Doctoral Dissertation Research

8. Prerequisites

All PhD-TM students should have a fundamental knowledge of probability and statistics. Students without such a background are required to take MG 505 Probability and Managerial Statistics. Students without any background in professional writing and communications are required to take JW 600 Introduction to

Technical and Professional Communications or JW 631 Proposal Writing. All students are required to take MG 599 Management Pedagogy (1? units). Units obtained for these prerequisite courses will not count toward the degree.

Students who already have a master's degree or who are transferring from other institutions (or other departments within Polytechnic) are admitted based on the same qualification standards as for new students. For each required MS- or PhD-level course, if students have taken a similar course, they are eligible to transfer units for the course. However, students still have to take and pass both qualifying exams. A minimum of 30 units, including all dissertation units, must be taken at Polytechnic University. No dissertation unit from other institutions can be transferred.

All students must take the required coursework as assigned and follow the curriculum as stipulated. The coursework must be finished within the first three years and the dissertation thesis within the next three years. Thus, all students (full-time and part-time) must complete all the work for the doctorate within six years of initiation.

COURSE DESCRIPTIONS

The following courses are unique to this doctoral program. For course descriptions of other required courses, please refer to the Master of Science in Management Program section of this catalog.

MG 599 Management Pedagogy

1½:0:0:1½

This course deals with issues related to teaching in management and business administration areas. Various teaching methods including lectures, discussions, case studies, team-based project learning, action learning, tutorials and integrating technology into the learning process are examined. The course is designed to provide preliminary teaching skills and strategies to doctoral candidates.

MG 651 Inter-organizational Information Systems

2½:0:0:3

This course serves as an advanced course on information technology and systems in the organizations with a special focus on inter-organizational systems. In

today's network economy, firms are increasingly dependent on alliance partners in addition to customers and suppliers. For continuous information exchange and to bring efficiencies and effectiveness to business processes, companies are building inter-organizational systems. This course reviews all aspects related to these types of information systems. Co-prerequisite: MG 650.

MG 920 Seminar in Managing Knowledge Workers in Innovative Organizations

1½:0:0:1½

Knowledge workers, who are primarily in professional and technical occupations, have come to represent the most important segment of the labor force in the United States. The success of innovative organizations today is largely a result of the knowledge and skills applied by their professional and technical employees. The effective management of such a work force has become one of the most critical problems faced by innovative organizations in both the private and public sectors. This seminar closely examines theory and research as well as various management techniques that can improve the utilization and development of knowledge workers in innovative organizations. Prerequisite: doctoral standing or instructor's permission. Co-requisite: MG 631.

MG 921 Seminar in Information Systems Management

1½:0:0:1½

This course provides PhD-TM students and other related fields with a perspective on modern information systems methodologies, technologies and practices. State-of-the-art research on frameworks for analysis, design and implementation of various types of information systems is presented. Economic and strategic issues related to information technology are presented, with emphasis on research in organizational, inter-organizational and strategic settings. The course follows a seminar format; paper-based and Web-based assigned readings are assigned, and student contribution during class sessions (both as participant and, for one class, as moderator.) is expected. Prerequisite: doctoral standing or instructor's permission. Co-requisite: MG 651.

MG 922 Seminar in Business Process Innovation

1½:0:0:1½

This Doctoral seminar explores dimensions and issues pertaining to the technology-business process interface that are critical to superior performance in today's modern networked corporations. We discuss how technology has impacted everything from common business tasks to complex and global supply chain integration. Qualitative and quantitative aspects in these areas will be addressed. Articles pertaining to leading-edge research and management thought will be discussed in class. The underlying objective is to expose the student to the rich and emergent literature in modern supply chain management, technology integration, and business model evolution. Major themes addressed by this seminar include technology integration, product and process innovation, marketing, logistics, operations, IT and channel management issues in supply chains across various industries. There will be a strong emphasis on understanding the role of technology in the supply chain, and its relation to business processes and innovation. The course follows a seminar format, with dynamically assigned readings and strong student contribution during class sessions (both as participant and, for one class, as moderator.). Prerequisite: Doctoral Standing or Instructor's Permission. Co-requisite: MG 660.

MG 923 Seminar in Managing the Innovative Enterprise

1½:0:0:1½

This course explores the enduring, evolving and new elements of managing the innovative enterprise. Course takes an in-depth look at such issues as what it means to "compete on Internet time," the role of the professional manager and the entrepreneur, attracting human talent and managing in an increasingly global environment. A major purpose of the course is for students to examine their own notions of management, and to begin to assemble the elements that they believe should be incorporated into the ideal enterprise of the future. The course follows a seminar format, with relevant assigned readings and URLs. Student contribution during class sessions (both as participant and, for one class, as moderator.) is expected. Prerequisite: doctoral standing or instructor's permission. Co-requisite: MG 865.

MG 930 Quantitative Analysis I*2½:0:0:3*

An introductory PhD-level course in quantitative analysis. Topics include specification, estimation and inference in the context of models that start with the standard linear regression framework. After reviewing the classical linear model, the asymptotic distribution theory necessary for analysis of generalized linear and nonlinear models is developed. The course then analyzes estimation methods such as instrumental variables, maximum likelihood, generalized method of moments (GMM) and others. Inference techniques used in the linear regression framework (such as t and F tests) is extended to Wald, Lagrange multiplier, likelihood ratio and other tests. Finally, the linear regression framework is extended to models for panel data, multiple equation models and models for discrete choice. Prerequisite: doctoral standing or instructor's permission.

MG 931 Quantitative Analysis II*2½:0:0:3*

This doctoral-level course covers advance quantitative analysis techniques, including multivariate analysis, time-series analysis non parametric methods in statistics and structural equations used in management research. Prerequisite: doctoral standing or instructor's permission.

MG 932 Qualitative Analysis*2½:0:0:3*

This course introduces students to the various underlying assumptions and historical roots of qualitative data collection, description, analysis and interpretation. It examines different ways of collecting, analyzing and interpreting qualitative data. It also explores generic issues in conducting and presenting qualitative research such as demonstrating validity and reliability, and provides students hands-on experience with different qualitative methods. Prerequisite: doctoral standing or instructor's permission.

MG 933 Business Research Methods*2½:0:0:3*

This course serves as an introduction to theory and techniques of research methods in business. The course includes an introduction to philosophy of science and to the principles of investigation in the social sciences. Students learn to design a study, sample and choose a research design. Also discussed are basic data preparation, measurement and analysis procedures, focusing on univariate and multivariate statistics. Prerequisite: doctoral standing or instructor's permission.

MG 990 Doctoral Research Project*3 units*

Original investigation of a limitedly scoped topic chosen by students based on suggestions by their doctoral adviser. This course should be taken preferably in the second summer semester of the study. Conferences and progress reports are required during work, and a final written report is required at completion. The final report should be submitted for presentation/publication at a high-level conference or journal. Prerequisite: doctoral standing.

MG 991-994 Independent Doctoral Research Review I-IV*1 unit*

Directed individual study or supervised readings in advanced areas of the thematic electives advised by the doctoral adviser. Prerequisite: doctoral standing. Co-requisite: Associated Thematic Elective when offered.

MG 999 Doctoral Dissertation Research*3 units*

Original investigation of an important research question(s) related to technology management. Research must demonstrate creativity, originality and substantive research worthy of publication in a recognized journal. Students must successfully defend dissertation proposal and final thesis orally. Registration of total 24 units required; continuous dissertation registration is required. Prerequisites: doctoral standing and passing both comprehensive examinations or academic director's approval.

TELECOMMUNICATION NETWORKS PROGRAM

Program Director: Shivendra S. Panwar

Telecommunications is a rapidly growing field. From the military communications networks of the early 1950s, telecommunications technology has evolved to find applications in almost all areas of modern society including, banking, reservation systems, office information systems, corporate networks and the Internet and World Wide Web. Recent challenges include gigabit optical networks, multimedia communications and wireless network access.

The rapid evolution of telecommunications technology demands a broad educational background including today's technological breakthroughs. Polytechnic's master's program in telecommunication networks contains a wide variety of courses ranging from fundamental topics to recent technological advances.

GOALS AND OBJECTIVES

The objective of the Master of Science in Telecommunication Networks is to prepare students for a profession in telecommunication networks. The program trains students to understand, design, manage and operate telecommunication networks.

The unique features of the program are:

- An exceptionally wide range of course offerings in telecommunications
- Graduate laboratory courses in networking offering hands-on experience
- Professors with extensive experience in research, industry and teaching
- Interaction with Polytechnic's New York State Center for Advanced Technology in Telecommunications, where students have access to research and development projects

REQUIREMENTS FOR THE MASTER OF SCIENCE

Admission to a Master of Science in Telecommunication Networks requires an undergraduate degree in computer science, computer engineering or electrical engineering, with a superior undergraduate record from an accredited institution. The Graduate Record Exam (GRE) is recommended. Applicants having comparable degrees in other fields will be considered for admission on an individual basis. Generally, entering students are expected to have a basic knowledge of computer fundamentals, such as programming in C++, data structures and computer architecture.

Students having superior academic credentials but lacking sufficient background are admitted with conditional status pending satisfactory completion of several individually specified preparatory courses. These preparatory courses include CS 530 Introduction to Computer Science, CS 540 Data Structures and Algorithms and CS 580 Computer Architecture and Organization. However, no credit will be allowed for any of the preparatory courses toward this degree. Other preparatory courses may be required. In some cases 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 GPA or better is a necessary condition for transfer to regular status.

Admission with advanced standing is accepted in accordance with Polytechnic regulations published in this catalog. A maximum of 9 units may be applied to the MS in Telecommunications Networks from previous graduate work at an acceptable institution.

To satisfy the requirements for a master's degree, students 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 courses group, as indicated below. Students with an exceptionally strong telecommunications background may be allowed to replace required courses with more advanced electives. Permission of the program director is required for all courses.

GROUP 1: Core Courses 18 Units

EL 536	Principles of Communication Networks (formerly EL 635)
EL 537	Internet Architecture and Protocols or
CS 684	Network Protocols I
EL 637	Local and Metropolitan Area Networks
CS 613	Computer Architecture I or CS 623 Operating Systems I
CS 627	Performance Evaluation of Computer Systems
CS 682	Network Management & Security

In certain rare circumstances, and with approval of the program's director, other computer science and electrical engineering courses may be used to fulfill the core requirement. Students with the appropriate background may replace CS 627 with EL 735 Communications Networks I. Students may not take both CS 684 and EL 537.

GROUP 2: Project Requirement

3 Units

All students in the Telecommunication Networks Program are required to take a project course, either CS 687 Project in Telecommunication Networks or EL 995 Advanced Project I. Students must obtain a project adviser and have a project plan approved before registering. The project should be completed in one semester. After obtaining the program director's approval, students may substitute a traditional ECE or CS master's thesis or project as long as it is telecommunications related. Additional thesis credits will replace free elective courses.

TELECOMMUNICATION NETWORKS PROGRAM

GROUP 3: Program Elective Courses

9 Units

Students are required to take three courses (not already counted towards the core requirement) from the following partial list of courses. Other courses are possible with the approval of the program director.

EL 501	Wireless Personal Communication Systems
EL 514	Multimedia Laboratory
EL 601	Principles of Digital Communication
EL 602	Wireless Communications
EL 603	Modern Wireless Communication Techniques & Systems
EL 606	Information Theory
EL 630	Probability
EL 631	Engineering Applications of Stochastic Processes
EL 638	High-Speed Networks
EL 735	Communications Networks I
EL 736	Communications Networks II
EL 737	High-Performance Routers and Switches
EL 930	Wireless Information Systems Lab
CS 603/4	Design & Analysis Algorithms I/II
CS 613/4	Computer Architecture I/II
CS 623/4	Operating Systems I/II
CS 606	Software Engineering I
CS 608	Principles of Database Systems
CS 905	Introduction to Java Programming
MG 652	Telecommunications Regulation, Policy & Law
MG 654	Economics & Strategy for Information Sectors

GROUP 4: Free Elective Courses

6 Units

Any two graduate elective courses, usually from EE or CS, approved by the program director.

Total: 36 Units

Descriptions of electrical engineering, computer science and graduate management courses used in the Telecommunications Networks Program are located, respectively, in the Electrical and Computer Engineering, Management and Computer Science program sections of this catalog.

TELECOMMUNICATIONS AND INFORMATION MANAGEMENT PROGRAM

Academic Program Co-Directors: Mel Horwitch and Nina D. Ziv

GOALS AND OBJECTIVES

The objective of the Telecommunications and Information Management Executive Program is to deliver a high level learning experience focusing on the intersection of broadly defined information technology and management, which is at the heart of the modern economy. The Telecommunications and Information Management [TIM] Executive Master's degree program focuses on the crucial challenges facing managers in telecommunications and information management sectors which have been radically transformed as a result of digital-based and mobile innovations, changes in telecommunications regulations, and the globalization of firms and industries. IT managers must learn how to innovate in an world in which the use of wireless and Internet-based technologies has:

- Changed traditional organizational structures into a seamless, 24/7 global entities.
- Created a knowledgeable and demanding customer base.
- Become the impetus for the convergence of technology, content and devices, which has resulted in the rise of competitors that are hybrid content/technology firms.
- Led to the emergence of users of technology in diverse firms as an important source of technology innovation.
- Led to the creation of new organizational forms and managerial imperatives.

The TIM Program serves a wide variety of executives faced with new challenges and opportunities in the broad arena where telecommunications, information technology and management intersect. The perspective of TIM is high-level, yet grounded. The orientation of TIM is pragmatic and managerial. TIM is a rigorous 16-month, four-semester state-of-the-art program. The TIM Program is based on a cohort system in that all participants enter at the same time and take the same sequence of courses throughout the pro-

gram except where choices may be offered such as in the mini-modules. The cohort system is an intrinsic part of the philosophy of the TIM Program and is essential for developing a cohesive group of participants. It enables participants to establish relationships with one another, easily develop project teams, and promotes a sense of camaraderie among the participants. The entire curriculum is 36 units.

TIM is an executive program with the following general features:

- Close interaction and teamwork
- A professional, modern and informal learning environment
- Participants viewed as real partners in the learning process (in class and in the joint generation of intellectual capital as presentations, reports or cases—in paper and digital formats)
- A curriculum that is continually updated
- Close collaboration with respected partners in industry and the relevant scholarly community
- Full courses and new half-semester courses to make the most of the limited time available
- Carefully selected elective courses to maintain flexibility in meeting diverse professional needs
- Blend of live class experience with use of modern, web-based technology
- Effective remote-collaboration learning and teamwork that are also enabled by technology
- Learning materials that are often in digital web-based format to take advantage of Internet-based technologies and methods
- The incorporation of technology is undertaken with ease of use and access as key watchwords

TIM is geared for the growing set of professionals who must use information and networking technology and the Internet for carrying out critical tasks and in developing and delivering value within their organizations and for customers.

TIM classes are held every other week on Thursday evening and all day Saturday at the New York Information Technology Center, 55 Broad Street, in Manhattan. An

all-inclusive fee covers tuition and fees, textbooks and other educational material, special tutorials and lectures and meals on class days. Visit the program's website at www.mot-tim.poly.edu for the most current information.

ADMISSIONS INFORMATION

Admission to the TIM Program is based on an in-depth evaluation of a candidate's academic record, work experience and overall intellectual and professional qualifications and potential. Applicants must demonstrate strong commitment and an ability to benefit professionally from a rigorous 16-month executive program. Because of the heavy demands of these programs, it is important that employers also explicitly support such professional education.

In general, GRE and GMAT tests are not required for applying to the MOT or MOT Programs. But the MOT Executive Master's Management Degree Programs office may ask an applicant to submit scores later in the admissions process.

How to apply:

The Executive Master's Degree Program uses an admission process called the Self-Managed Application (SMA). Applicants must gather the materials required by the program and forward them in a single envelope to:

Administrative Director
MOT-TIM Executive Master's Degree Programs
Polytechnic University
55 Broad Street, Suite 13B
New York, NY 10004
Tel: 718-260-4014

TO APPLY

1. Complete the application and, attach a copy of your professional resume and the application fee.
2. Please ask the registrar at all colleges and universities you attended to send official transcripts directly to you. In order for them to remain official, they must be sealed in the original envelope. Opened transcripts are not considered official.
3. Please arrange for two (2) letters of rec-

ommendation to be sent directly to you. These letters are generally from a supervisor or high-level colleague who is familiar with your professional work. As with transcripts, to be considered official, recommendations must be sent directly from the recommender to the applicant unopened. Use the enclosed forms for this purpose. Write your name at the top, sign the waiver if you wish and give one form and one of the enclosed envelopes to each person writing in support of your application.

4. The final step for admission is a personal interview with one of the Academic Co-Directors to discuss career objectives and to make sure the Program fits your goals.

For more information, contact the TIM program administrative director:
Tel: 718-260-4014
Fax: 212-547-7029
E-mail: mot-tim@poly.edu
Web: www.mot-tim.poly.edu

PROGRAM CURRICULUM

The courses that constitute the TIM program curriculum (the order in which courses are given may vary):

First Semester

- MG 609 Managerial Accounting & Finance
- MG 690 Managerial Decision Making in Information-Intensive Businesses
- MG 790 Foundations of Telecommunications & Networking Technology

Second Semester

- MG 608 Managerial Economics
- MG 693 Information, Technology, Systems & Management in Organizations
- MG 791 Principles of Modern Networking

Third Semester

- MG 607 Marketing
- MG 820 Project Management
- MG 792 Modern Network Environment Management

Fourth Semester

- MG 774 Advanced Trends in Technology Management & Innovation*
- MG 782 Competitive Information Strategy*
- MG 793 Global Management in the Networking, Telecommunications & Information Industries*
- MG 960 TIM Capstone Project Course Elective Course I** (select one from the list below)

Elective Course Portfolio

- MG 781 Selected Topics in Networking & Information Technologies**
- MG 784 Negotiation in Technology-Intensive Sectors**
- MG 785 High-Technology Leadership**
- MG 786 High-Technology Entrepreneurship**

- MG 787 Intellectual Property for Technology & Information Managers**
- MG 788 Modern Supply Chain Management: Integration Through Technology**
- MG 789 Special Elective Topics for MOT & TIM**
- MG 797 Financing for Value Creation**

* variable credit (1½/3 credit) course

** half-semester courses offered in third or fourth semesters

SPECIAL TIM TRACK:

The e-Business Track

For many professionals in the TIM environment e-business constitutes an important arena for value creation. e-Business can enhance market performance and can make organizations more efficient and effective. Those TIM participants wishing to be formally recognized as knowledgeable in e-Business focus may choose to enter the TIM e-Business Track. Choosing this track requires the completion of a final project dealing specifically with an important topic in the e-Business world as part of the Capstone Course in the final semester. The e-Business track is open to all TIM students.

COURSES

The following courses are unique to the TIM Executive Program. For other course descriptions, refer to the Management Program or Financial Engineering Program sections of this catalog.

MG 607 Marketing 3:0:0:3

Emphasizes the imperative to be customer-focused in the information sectors. Market definition and redefinition due to technological change. Analysis of customer decisions. Strategic choices of markets and products. Positioning for competitive success. Product pricing, distribution and communications decisions. New product development. Market system dynamics and the value chain.

MG 608 Managerial Economics and the Economic Environment 2½:0:0:3

The fundamentals of microeconomics needed by managers. Demand theory (theory of the consumer) including models of demand, demand elasticities and demand forecasting. Supply theory (theory of the firm) including diminishing returns, profit maximizing production levels, labor/capital tradeoffs and long-run vs. short-run issues. Market structures

and how they affect optimal production and profit levels. Positive and negative externalities and government intervention including regulation, tariffs and subsidies. Selected applied topics. All topics are presented with emphasis on managerial application.

MG 609 Managerial Accounting and Finance 2½:0:0:3

Principles and practices of the modern finance function including accounting and corporate finance, and their relevance for all information business managers. Strategic perspectives—balancing long-term development and short-term returns. Financing of ventures and innovative activities. Project selection, capital budgeting and risk analysis. Special emphasis is placed on financial decision making in the information-business sectors and the financial assessment of increasingly important knowledge-intensive assets.

MG 674 Project Management and Assessment for Technology Managers 3 units

Managing technology-based projects ranging from individual research and development to large-scale and complex technological systems. Feasibility and risk analysis. Project selection and portfolio optimization. Alternative financing methods. Functional and administrative structures, coordination and scheduling of activities, personnel planning, negotiations, contracts and computer-based techniques. Cost estimation, capital budgeting, cost controls and effective matrix management. Actual case studies are used in this course, as are relevant and modern project management software applications.

MG 690 Managerial Decision Making for Information-Intensive Businesses 2½:0:0:3

An introductory course in managerial decision making and strategies with an emphasis on information-intensive businesses and the fast-changing environment in which they compete. This course explores such issues as competing in both the digital and physical spaces, technology as an enabler of change, the role of the professional manager and managing in an increasingly globalized environment.

MG 693 Information Technologies, Systems and Management in Organizations 2½:0:0:3

Designed for managers who need to understand the role and potential contribution of information technology (IT) within organizations. The focus of the course is on information technology and its business applications. The course concentrates on the current state of IT in organizations, challenges and strategic use of IT, IT infrastructure and architecture, the technical foundation of IT, building and implementing organization information systems, emerging issues in IT such as intelligent systems, business process re-engineering, knowledge management and group support systems. The course format is interactive with concept presentation followed by open discussion on real-world applications of IT and business cases.

MG 774 Advanced Trends in Technology Management and Innovation 2½:0:0:1½

This course explores several trends that have emerged in the technology management and innovation arena in the past decade. These include the advent of digital-based innovation in the late 1990s, which has had a profound effect on how many firms conduct business; the effect of the crash of the NASDAQ in March 2000 and 9/11, which had a major effect on corporations that now had to operate within major economic and creative constraints; the development of the concept of networks as it relates to the organization and strategy of the firm; the development of the wireless-technology platform and its effect on technology innovation; and the development of a new innovation paradigm that suggests a relationship between information technology, creativity and business practices. The course emphasizes classroom discussions as well as team-based and individual projects.

MG 781 Selected Topics in Networking and Information Technologies 1½:0:0:1½
(half-semester course)

An in-depth exploration of selected modern networking and information technologies. The specific topics studied vary from year to year. Examples are mobile communications, IP telephony, enterprise

data systems, etc. The course builds on previous TIM courses and provides a solid technology grounding in a learning context, which also emphasizes how these selected technologies affect markets, industries, providers, integrators and users. The technical content of this course is supplemented with actual case examples and relevant guest speakers.

MG 782 Competitive Information Strategy 1½:0:0:1½
(half-semester course)

Course in applied competitive strategy, which draws upon recent experiences associated with the impact of information technology upon diverse industries, ranging from securities trading to consumer-packaged goods retailing. Students master a basic understanding of the competitive implications of information technology and the strategies for using information technology in business. This competence in analysis is arrived at through understanding how availability of information (through technology or otherwise) affects the basic strategic options available and how firms and industries are likely to be affected. In addition, students are introduced to the often poorly structured process of evaluating potential systems innovations. They are then able to participate in strategic planning and systems planning from a managerial point of view.

MG 784 Negotiation in Technology-Intensive Sectors 1½:0:0:1½
(half-semester course)

Negotiation is the art and science of creating good agreements. This course covers the science of negotiation by discussing and applying theories of negotiation. Students develop the art of negotiation by negotiating with each other in realistic cases. A wide variety of negotiation applications is covered in this class, including one-time and repeated negotiation, single and multi-issue negotiations, and two-party and multi-party bargaining. Special emphasis is placed on negotiations in technology-intensive environments. Course is taught using the case method. Many of the examples used in this course are cases that the students actually negotiate with each other. Students' grades are based on their performance in these negotiations and on their class participation.

MG 785 High-Technology Leadership
(half-semester course) 1½:0:0:1½

Focuses on the essential role of multifaceted leadership in diverse high-technology management settings. Discusses different forms of modern high-technology leadership, e.g., the general management leader, the project leader, the technology leader, the visionary leader and the operational team leader. Case studies and actual examples of high-technology leadership are emphasized.

MG 786 High-Technology Entrepreneurship 1½:0:0:1½
(half-semester course)

Focuses on entrepreneurship as a critical engine for wealth creation in the high-technology and innovation-intensive economy. Deals with such key issues as: (1) assessing attractiveness of opportunities; (2) launching a new venture; (3) obtaining the necessary financial, human and technology resources; (4) managing the transition from a small entrepreneurial firm to a large, sustainable professionally managed but still entrepreneurial corporation; and (5) being an entrepreneur and promoting entrepreneurship in a large corporation.

MG 787 Intellectual Property for Technology and Information Managers 1½:0:0:1½
(half-semester course)

Focuses on the role of intellectual property (e.g., patents, trade secrets, copyrights, trademarks) as a major element in modern technology and information strategy. Relevant concepts and case studies are used, with examples representing both classical and digital innovations.

MG 788 Modern Supply Chain Management: Integration Through Technology 1½:0:0:1½
(half-semester course)

An introduction to the role of information technology in supply chain management. It builds on some of the concepts covered by MG 783 New Frontiers in Electronic Business. Both qualitative and quantitative aspects of supply chain management are covered. Articles pertaining to leading-edge research and management thought are discussed and analyzed by students. The underlying objective is to prepare participants to develop skills that

are useful in analyzing technology, marketing, logistics, operations and broader channel-management issues. Classes are conducted using the case method, and a high level of class interaction is expected.

MG 789 Special Elective Topics for MOT and TIM *1½:0:0:1½*
(half-semester course)

Covers selected key emerging trends and issues in the MOT and TIM domains. Discussion with industry leaders and specialists from business, government and academia. Topical treatment of technologies, markets, business practices, government regulations and the relationships among them.

MG 790 Foundations of Telecommunications and Networking Technology *2½:0:0:3*

Introduction of the basic concepts of telecommunications and networking technologies. Course examines on a macro-level how data communications and networking have become integral, vital parts of an organization. It discusses business information requirements and applications of data communications and networking, such as e-mail, Groupware, document sharing and the Internet and World Wide Web. It reviews the following technical concepts and discusses their managerial implications: components of network architecture; data communications hardware; data transmission concepts; data communications models, such as OSI, TCP/IP and IPX/SPX; detailed study of data link layer and network layer; components of Local Area Networks (LANs); and types of LANs. It further reviews the importance of networking standards and standards-making organizations.

MG 791 Principles of Modern Networking *2½:0:0:3*

Focuses on advanced concepts and issues in enterprise networking. Course reviews technical concepts and managerial implications of: client/server architecture; components of Wide Area Networks (WANs); dedicated and switched circuit services, such as T-1 lines, ISDN, SMDS and DSL; high speed/ broadband/backbone networks; network components, such as hubs, bridges, switches, routers, brouters and gateways; fiber distributed data interface (FDDI); internetworking;

IP addressing and routing; wireless/mobile networks; electronic data interchange (EDI); multimedia networking. It focuses on high-level managerial issues, such as network design and implementation, network management tools, WAN performance and fault management, cost management, network security and regulatory issues. It also introduces other aspects of the networking environment, including software and appliances.

MG 792 Modern Network Management *2½:0:0:3*

Explores emerging issues and trends in modern enterprise networking. It examines implications of such developments in the business environment and infrastructural needs of organizations and clusters of organizations. It reviews ramifications of the TCP/IP revolution leading to commercialization of the Internet/World Wide Web. Course discusses the network infrastructure required to implement Intranets/Extranets, electronic commerce and interorganizational business communication and collaboration generally. It evaluates electronic business and emerging technologies (such as data warehouses, electronic payment systems, corporate digital libraries, multicasting, firewalls and digital signatures). It also deals with the implications of internetworking, such as digital cities, smart buildings, distance learning, telecommuting and teleconferencing and appliances that are merging.

MG 793 Global Management in the Networking, Telecommunications and Information Industries
(variable 1½/3 units)

In viewing the modern telecommunications, managerial and IT value chaining, this course assumes a global perspective. Focuses on key aspects of the modern telecommunications and information sectors, e.g., changing strategies related to infrastructure/equipment; reconfigured role of operators and providers; the role of IT outsourcing and professional-services firms; the emergence of wireless on a global scale (including the wireless Internet). Also discusses implications of changing technologies and regulation policies.

Mg 797 Financing for Value Creation
(half-semester course) *1½:0:0:1½*

Covers the key-creating strategies and financial skills required by managers of entrepreneurial and innovative firms at various stages of evolution: from new, stand-alone entrepreneurial ventures to innovative, technology-driven projects of established corporations.

MG 820 Project Management and Assessment For Technology Managers
(variable 1½/3 units) *1½:0:0:1½*

Managing technology-based projects ranging from individual research and development to large-scale and complex technological systems. Feasibility and risk analysis. Project selection and portfolio optimization. Alternative financing methods. Functional and administrative structures, coordination and scheduling of activities, personnel planning, negotiations, contracts and computer-based techniques. Cost estimation, capital budgeting, cost controls and effective matrix management. Actual case studies are used in this course, as are relevant and modern project management software applications.

MG 960 TIM Capstone Project Course *2½:0:0:3*

A capstone, integrative and state-of-the-art intellectual experience for participants at the conclusion of the program. The whole class focuses on an over-arching theme that is of broad and compelling managerial concern and that is related in important ways to the innovation, technology-intensive and/or information business arenas. The class is initially divided into small groups to tackle various aspects of the overall subject. Individual participants are expected to submit their own analysis of a specific issue or firm associated with the general subject. Participants are encouraged to employ relevant concepts and insights that they have acquired during the course of the program.

TRANSPORTATION PROGRAM

Program Adviser: Elena S. Prassas

The Department of Civil Engineering offers graduate degree programs in transportation leading to the degrees of:

- MS in Transportation Planning and Engineering
- MS in Transportation Management
- PhD in Transportation Planning and Engineering

A number of graduate certificate programs are also available in:

- Traffic Engineering
- Transportation Planning
- Transportation Management and Economics

Graduate certificates, which entail completion of 15 focused units of study, offer the opportunity for students to specialize in one of the areas of transportation planning and engineering. It also allows students not ready to embark on a full Master of Science degree program to receive formal recognition for more focused study.

Master of Science programs are practice-oriented with a strong foundation in underlying principles and methods. The PhD is intended for students with a strong research interest and a desire to advance the state-of-the-art as a result of that research.

REQUIREMENTS FOR MASTER OF SCIENCE PROGRAMS

ADMISSION REQUIREMENTS

To be eligible for admission as a MS candidate, applicants must hold at least a baccalaureate degree from an acceptable institution. Students pursuing degrees in transportation planning and engineering must also have a firm background in quantitative analytic skills. If admitted, students lacking such skills will be required to take remedial courses in addition to degree requirements to strengthen analytic competency.

All foreign students admitted to

transportation programs must take an examination in English before registration. Based upon an evaluation of the examination, they may be required to take up to two additional courses in English as a Second Language (ESL) for which no graduate credit is given.

GRADE REQUIREMENTS

To earn master of science degrees or graduate certificates, students must have a 3.0 GPA or better in all graduate courses and in all guided studies (readings, projects, theses). Averages are separately computed for courses and guided studies. Transfer credits from other institutions are not included in this average.

In addition, transportation program students are required to have an overall 3.0 GPA in all courses required for their degree or certificate program. Students may not repeat a course toward any of the transportation degree programs more than once.

ANALYTIC BACKGROUND

All applicants for MS or graduate certificate programs in transportation must show evidence of quantitative analytic ability, generally including a minimum of two years of college mathematics and a college-level course in statistics.

ADVISING

Each student in the master of science program is assigned a faculty adviser. It is important that students maintain frequent contact with their adviser throughout the course of their studies.

Students must meet with their academic adviser prior to each registration and at any other time they need advice or consultation. Students must have a detailed program of study formally approved by the adviser prior to registration. Advisers also handle requests for waiver of certain degree requirements where warranted. Such waivers must be approved in writing and must be entered into the student's departmental file. Where specific courses are waived, the permission of the course instructor is also required. When waivers are granted, students may be required to take

other specific courses in their place, otherwise additional electives will be selected.

Students registering for any guided studies (readings, projects, theses) are assigned project advisers for each such activity. The project adviser may or may not be the same as the student's academic adviser, depending upon the subject matter selected. To register for any guided study activity, students must submit written proposals for the topic(s) to be covered to an appropriate project adviser before registration. To register, students must obtain the written approval of the project adviser and the academic adviser.

In addition to academic and project advisers, students studying under research or teaching fellowships are assigned fellowship advisers. Normally, these would be either the principal investigator of the research effort funding the fellowship or the director of the academic area in which the teaching fellowship is awarded.

While academic advisers consult and give advice to students, it is the student's responsibility to ensure that all degree requirements are fulfilled and to submit all proper forms and application when necessary.

TRANSFER CREDITS

The minimum number of units students must take at Polytechnic to be awarded a MS is 27 at Polytechnic. All units for a graduate certificate must be taken at Polytechnic.

Students may transfer up to 9 units of acceptable courses toward an MS degree, subject to the approval of the academic adviser. To be transferred, the course(s) must be relevant to the transportation program and from an acceptable institution. A grade of B or better is required for granting of transfer credit. Courses graded on a pass/fail basis are not considered for transfer unless accompanied by a detailed written evaluation by the instructor of the course. All transfer requests must be accompanied by an official transcript from the transferring institution. Applications for

TRANSPORTATION PROGRAM

transfer credits are accepted only after students have earned 12 units at Polytechnic. Validation credits by examination may not be used toward any transportation degree program.

MASTER OF SCIENCE IN TRANSPORTATION PLANNING AND ENGINEERING

The MS program has a strong foundation in traffic engineering, transportation planning, transportation economics, public transportation systems and intelligent transportation systems. Students are exposed to a learning atmosphere that provides a meaningful combination of theoretical and practical approaches. Courses include a mix of presentations, workshop and project exercises and practical problem solutions.

Courses in the MS program are primarily organized by application area, so students see a variety of techniques (functional design, control, operations, economics, etc.) applied to solve focused problems. In traffic engineering, for example, courses are organized along facility lines: intersections, freeways and arterials and networks. In each case, intervention techniques are applied to optimize total efficiency and safety.

The program includes a strong focus on the rapidly emerging field of intelligent transportation systems. This field applies telecommunications and information technology to the solution of a variety of transportation functions, from route guidance systems to automated toll collection systems to the automated highway.

GOALS AND OBJECTIVES

The primary goal of the MS in Transportation Planning and Engineering is to prepare transportation professionals to plan, functionally design, control and operate facilities, systems and services that satisfy the demand for both passenger and freight transportation. Specific objectives of the program are to provide the skills necessary to:

- Fundamentally understand the nature and generation of transportation demands
- Understand the political, policy and economic forces that affect transportation demands and the public framework in which they are addressed

- Functionally design transportation systems and components
- Control and operate traffic and other transportation facilities
- Apply information technologies to intelligent transportation systems

PROGRAM REQUIREMENTS

Course No.	Course Title	Units
TR 605	Travel Demand Forecasting	3
TR 607	Urban Transportation Planning & Congestion Management	3
TR 609	Transportation Economics & Finance	3
TR 681	Traffic Studies & Characteristics	3
TR 683	Intersections: Design & Control	3
TR 810	Introduction to Intelligent Transportation Systems	3
TR	Four Transportation Electives*	12
	Two Free Electives*	6
Total		36 Units

**Adviser approval is required for all elective selections.*

MASTER OF SCIENCE IN TRANSPORTATION MANAGEMENT

The program is intended for practicing professionals who deal with transportation system, agency and/or facility management. It combines basic management skills with a working knowledge of techniques and approaches to optimizing transportation system results.

GOALS AND OBJECTIVES

The primary goal of the MS in Transportation Management is to prepare professionals to effectively and efficiently manage various transportation enterprises, with an emphasis on agencies, facilities and services in the public sector. Specific objectives of the program are to provide:

- A basic background in management skills and techniques, specifically as applied to public and private transportation organizations
- A basic understanding of the economic aspects of the transportation sector
- An understanding of the importance of national, state and local transportation policy on public and private sector organizations
- Fundamental knowledge on some of the specific issues and problems in managing and operating public transportation facilities

PROGRAM REQUIREMENTS

Course No.	Course Title	Units
TR 609	Transportation Economics & Finance	3
TR 810	Introduction to Intelligent Transportation	3
TR 850	Transportation Management	3
TR 851	Transportation Policy	3
TR 852	Public Transportation Systems & Operations	3
MG	Two General Management Electives	6
TR	Four Transportation Electives*	12
	One Free Elective*	3
Total		36 Units

**Adviser approval is required for all elective selections.*

DOCTOR OF PHILOSOPHY IN TRANSPORTATION PLANNING AND ENGINEERING

The PhD in Transportation is a research-oriented degree intended for those whose goal is a career in basic transportation research and/or teaching at the university level or in private research organizations.

GOALS AND OBJECTIVES

The fundamental goal of the PhD in Transportation Planning and Engineering is to develop professionals with strong research skills capable of advancing the profession of transportation planning and engineering through their work. Specific objectives of the program are to provide the skills necessary to:

- Develop strong and deep fundamental knowledge concerning the profession of transportation planning and engineering
- Develop the knowledge and skills required to perform independent fundamental research in the field of transportation planning and engineering
- Produce a piece of fundamental research that meaningfully advances the state-of-the-art of the profession of transportation planning and engineering

PROGRAM REQUIREMENTS

Students pursuing the PhD in Transportation Planning and Engineering generally specialize in one of the following subject areas:

- Transportation planning.
- Traffic engineering.
- Intelligent transportation systems.
- Transportation safety.

Other focus areas are possible, and can be developed with the assistance of faculty advisers. All subject areas must be, of course, relevant to the degree sought, and there must be a faculty member who is willing and able to guide the student's research.

PROGRAM ADMINISTRATION

All graduate applications are processed through the civil engineering departmental office, which distributes applications to the appropriate graduate coordinator. Graduate program coordinators formally implement admission decisions in accordance with departmental regulations. Coordinators consult with other departmental faculty as needed. They are also responsible for keeping records for all graduate students within their program areas, and for processing all graduation audits for students within their program areas. The current coordinator for the transportation program is Professor Elena Prassas.

The graduate coordinators form the departmental Graduate Committee. All PhD applications are reviewed by the committee, and admissions decisions are made by the committee and implemented by the appropriate graduate coordinator.

For each registration, the student's program must be approved by the academic adviser and signed by the transportation program coordinator.

ADMISSION CRITERIA

Admission to the PhD in Transportation Planning and Engineering requires an MS in Transportation Planning and Engineering or equivalent, with a GPA of 3.5 or better (on a 0-4 scale).

Admission to PhD programs does not require GRE's (Graduate Record Examination), but applicants are encouraged to take these examinations. If these examinations are taken, the student must submit the results for consideration. Foreign applicants must take the TOEFL examination and submit the results for consideration.

In the criteria above, the "equivalent" can be achieved in several ways. The candidate may have an MS degree with a different title that covers substantially the same material. In more general terms, the applicant must demonstrate that he/she has the equivalent of all undergraduate and master's level course work to be able to pursue doctoral level

work in the major area chosen. Further, "equivalence" is evaluated based on the totality of the student's undergraduate and graduate record, not on a course-by-course basis.

Because admission to a PhD program requires an appropriate MS (or equivalent), those applicants who have not yet achieved a master's degree would normally be admitted as MS students. They are expected to earn an MS degree while completing their major and minor course requirements. In rare cases, an applicant with only a BS degree may be directly admitted into the PhD program with the written approval of the department head.

DOCTORAL COMMITTEES

Every PhD student is assigned an academic adviser, who is assigned by the department head upon admission. Any member of the civil engineering faculty can be an academic adviser to a graduate student. In cases where a student is being supported on a research contract, the principal investigator of the contract would normally be appointed as the academic adviser for the student. Where a student has a particular research interest and is working with a particular faculty member, the student may request that the faculty member be appointed as his/her academic adviser. In rare cases where a PhD student enters the program without a prior selection of a major area of study, the initial academic adviser will be the Graduate Coordinator of the transportation program.

In the course of fulfilling their academic requirements, PhD candidates, they will deal with two advisory committees:

Academic Advisory Committee: The student's academic adviser works out an appropriate program of courses to fulfill major and minor requirements for the PhD. The Academic Advisory Committee generally will consist of the academic adviser and one faculty member for each minor area of study. The Academic Advisory Committee guides the PhD student's work through the successful completion of a qualifying examination. A letter signed by the academic adviser and approved by the department head is placed in the student's file indicating the composition of the Academic Advisory Committee.

Dissertation Committee: The Dissertation Committee is formed immediately after the student passes the

qualifying examination. It consists of a major adviser, a dissertation adviser and a minor adviser for each minor the student has pursued. Additional faculty members may also be on the Dissertation Committee. The Dissertation Committee may be the same as the Academic Advisory Committee, or may be different. The Dissertation Committee guides the student's course and research work after the student has passed the qualifying examination. The Dissertation Committee must be formally assigned with the approval of the department head and is filed with the Office of Graduate Studies. The major adviser must be a full-time faculty member of the Department of Civil Engineering. The major and dissertation advisers may be the same individual where appropriate.

DOCTORAL DEGREE REQUIREMENTS

To earn a PhD in Transportation Planning and Engineering, the following requirements must be met:

1. 60 units of graduate work (not including the PhD dissertation) in relevant major and minor areas of study beyond the bachelor's degree, with an average grade of B or better (cumulative average of 3.0 or better on a 0-4 scale).
2. Completion and successful defense of a 30-unit dissertation related to the major area of study. Dissertations must consist of original research that meaningfully advances the state-of-art in the subject area of the research, and should result in the publication of at least one paper in a strictly peer-reviewed technical journal appropriate to the subject. A grade of B or better must be achieved for the dissertation.
3. Completion of two minor areas of study, each consisting of between 9 and 12 units of graduate work. At least one minor area must be outside the transportation area.
4. Residency requirements for the PhD in Transportation Planning and Engineering include the 30-unit dissertation plus a minimum of 12 units of applicable graduate course work taken at the Polytechnic.

In satisfying the 60-unit course requirement, the student must satisfy all requirements for the major and minor areas selected, or their equivalent.

TRANSPORTATION PROGRAM

In satisfying these basic PhD requirements, students must also satisfy one of the two following conditions:

1. 48 units of appropriate graduate course work, not including individual guided studies (readings, projects, theses, etc.) beyond the bachelor's degree, with an average grade of B or better (cumulative average of 3.0 or better on a 0-4 scale).
2. 24 units of appropriate graduate course work, not including individual guided studies (readings, projects, theses, etc.) beyond the master's degree, with an average grade of B or better (cumulative average of 3.0 or better on a 0-4 scale).

Satisfying condition 2 requires that the department accept the student's MS degree in toto without regard to its specific content. This requires a recommendation from the department's Graduate Committee and the approval of the department head.

TRANSFER CREDITS

Transfer credits for PhD students can be awarded on a course-by-course basis, or an MS degree from another institution may be accepted for transfer in toto. In the former case, a maximum of 48 units of appropriate graduate work may be transferred. The latter requires a recommendation from the department's Graduate Committee, and the approval of the department head. Transfer units are generally awarded at the time of admission, and must be approved by the academic adviser, the transportation graduate coordinator and the department head.

QUALIFYING EXAMINATION

Departmental qualifying examinations for the PhD in Transportation Planning and Engineering are given once per year (usually in May or June), and are coordinated with other qualifying examinations in the department. If sufficient demand exists, a second qualifying examination may be scheduled in December or January. Every PhD student must pass a qualifying examination in the major area of study, and in any in-department minor areas of study before becoming a candidate for the PhD Further:

- No student may register for dissertation units until the Qualifying Examination is passed.

- A dissertation committee cannot be formed until the student passes the Qualifying Examination.
- A student may take the Qualifying Examination twice. A third attempt is permitted only with the written recommendation of the Academic Advisory Committee and the approval of department head. In no case may a student take the examination more than three times.

Students normally take the Qualifying Examination (for the first time) after successfully completing most of their course requirements in the major and in-department minor areas of study.

The Qualifying Examination consists of a six-hour written portion (generally given in two three-hour blocks on the same day) and an oral portion of approximately one hour. Both written and oral portions of the examination focus on the student's major and in-department minor. The oral portion may also explore higher-level skill areas required to successfully conduct independent research. Students are deemed to have passed the examination based upon an overall evaluation of results of both the written and oral portions. While some students may not be invited to the oral examination if they have done poorly in the written portion, invitation to the orals does not imply that the student has "passed" the written portion of the exam.

The Qualifying Examination is either "passed" or "failed." A letter indicating the result of each examination is placed in the student's graduate file. In rare cases, a student may be deemed to have "conditionally passed" the Qualifying Examination. This occurs in cases where the student does extremely well in all areas except for a single subject area in which weakness has been noted. Such a student must follow a prescribed preparation plan for strengthening their knowledge and skills in the area of weakness, and must pass a special examination on the area of weakness within one calendar year. A student who has "conditionally passed" the Qualifying Examination may register for dissertation credits, and may form a Dissertation Committee.

All transportation faculty members participate in submitting written problems for the qualifying examination, in the grading process, and in the oral examination. All departmental faculty members are welcome to observe any

oral examination and to ask appropriate questions. Each student's Academic Advisory Committee will have the opportunity to review the entire exam before it is administered, and may suggest changes if it deems that the examination as presented is not an equitable test of the student's abilities. Recommendations on the results of the examination are submitted by each student's Academic Advisory Committee, augmented by any departmental faculty in the sub-disciplines tested. The departmental faculty, acting as a whole, votes to accept or reject such recommendations at a meeting scheduled for this purpose.

DISSERTATION PROPOSAL

Following passage of the Qualifying Examination and the appointment of a Dissertation Committee, the PhD candidate must submit a written dissertation proposal outlining the subject of the proposed research. This proposal should be between 15-20 pages long, and should address the following specific items:

- Description of the topic.
- Literature review sufficient to insure that the work contemplated is original.
- Methodology(ies) to be employed in the research.
- Data and/or laboratory needs, and their availability to the student.
- Anticipated outcomes.

The Dissertation Proposal must be submitted within one semester of full-time study, or before 9 units of dissertation credit are completed.

The Dissertation Proposal is orally presented and defended before the Dissertation Committee and any other interested departmental faculty. The date of the oral defense and copies of the draft Dissertation Proposal must be made available to departmental faculty at least two weeks (14 calendar days) prior to the defense.

When the Dissertation Proposal is formally accepted, the Dissertation Adviser enters a letter into the student's graduate file indicating this, together with a copy of the proposal. While the Dissertation Committee has reasonable flexibility in modifying the proposal as appropriate during the course of the research, any significant change in focus area or methodology requires that an amended Dissertation Proposal be written and formally accepted following the same procedure noted herein.

DISSERTATION DEFENSE

The culmination of the student’s PhD work is the oral presentation and defense of the final draft dissertation. A defense is generally scheduled after the Dissertation Committee has reviewed the draft dissertation and determined that it is complete and of sufficient quality to be presented and defended.

The defense is organized and scheduled by the Dissertation Committee. All University faculty members are invited to observe and ask appropriate questions at all Polytechnic dissertation defenses. Therefore, the date of the defense must be announced University-wide at least one month prior to the event, and copies of the draft dissertation must be made available to any faculty member who requests one in a timely fashion and in no case less than two weeks prior to the defense.

GRADUATE CERTIFICATE PROGRAMS

The Transportation Program offers graduate certificates to students completing 15 units of study in specified areas of concentration. These are intended for students who do not wish to commit to a full advanced degree program. Applicants may be students with bachelor’s degrees seeking to specialize in an aspect of transportation or those with advanced degrees wishing additional course work in a highly focused area of the profession.

Students in certificate programs may apply for transfer to degree programs without any loss of credits, assuming they are admitted to the degree program and that the courses are appropriate to the degree. Admission to a certificate program does not guarantee admission to a full degree program.

The Department of Civil Engineering offers the following certificate programs with their requirements:

Certificate in Traffic Engineering:

Course No.	Course Title	Units
TR 681	Traffic Studies & Characteristics	3
TR 682	Freeways & Rural Highways	3
TR 683	Intersections: Design & Control	3
TR 684	Arterials & Networks	3
TR 810	Introduction to Intelligent Transportation Systems	3
		15 Units

Certificate in Transportation Planning:

Course No.	Course Title	Units
TR 605	Travel Demand Forecasting	3
TR 607	Urban Trans Planning & Congestion Management	3
TR 609	Transportation Economics & Finance	3

Select two from:

TR 810	Introduction to Intelligent Transportation Systems	3
TR 851	Transportation Policy	3
TR 852	Public Transportation Systems & Operations	3
TR 920	Transportation Analysis I	3
TR 921	Transportation Analysis II	3

15 Units

Certificate in Transportation Management:

Course No.	Course Title	Units
TR 609	Transportation Economics & Finance	3
TR 850	Transportation Management	3
TR 851	Transportation Policy	3
TR 852	Urban Public Transportation Systems & Operations	3
MG	Management Elective	3

15 Units

GRADUATE COURSES

TRANSPORTATION PLANNING, ANALYSIS AND EVALUATION

TR 605 Transportation Demand Forecasting *2½:0:0:3*

This course covers the theory and application of travel demand forecasting methods for the prediction of the amount and nature of travel on urban transportation systems. The course covers the four-step process of urban travel demand forecasting: trip generation, trip distribution, modal split and traffic assignment modeling. Collection and use of data for travel demand forecasting is also covered, as are models of land use development. Introductions to available software packages are included.

TR 607 Urban Transportation Planning and Congestion Management *2½:0:0:3*

The theory and practice of urban transportation planning is covered in this course, with specific attention to methods and techniques for alleviating traffic congestion in urban areas. Travel demand and transportation systems management techniques are emphasized. Application areas include travel corridors, major activity centers and residential neighborhoods. This is a “hands on” course with an emphasis on practical implementation of techniques.

TR 609 Transportation Economics and Finance *2½:0:0:3*

Basic principles of engineering economic analysis and their application to transportation projects are covered in detail. Concepts of present worth, capital recovery, sinking funds and annual cost are applied to economic comparisons and evaluations of alternatives. Unit costs of various transportation systems are investigated. Private and public transportation operations and agencies are studied with respect to such issues as profit, depreciation and return on capital. Historical perspectives on the financing of highway systems, public transportation systems and transportation agencies are presented. Other subjects include privatization, balance sheets, financial control, cash flow and preparation of a private-venture business plan.

TR 920 Transportation Analysis I *2½:0:0:3*

Focuses on regression analysis and discrete choice models and their applications in transportation planning and engineering. The course covers estimation and model testing techniques, statistical tests and sampling methods. Application of regression and discrete choice models is selected from demand, supply and management areas. *Prerequisites: undergraduate calculus, statistics and TR 681 or equivalents.*

TR 921 Transportation Analysis II *2½:0:0:3*

Focuses on the formulation of traffic assignment models and the application of commonly-used software packages to traffic assignment modeling. The course covers optimization methods, their formulation and their application to the traffic assignment process. Hands-on experience using case studies is provided. *Prerequisite: TR 605 or equivalent.*

TRANSPORTATION PROGRAM

TRAFFIC ENGINEERING

TR 681 Traffic Studies and Characteristics 2½:0:0:3

This course focuses on the characteristics of traffic flow and their quantification and analysis through field studies and statistical analysis. Parametric measures—speed, flow, density, headway and spacing—will be defined and illustrated. Uninterrupted and interrupted flow characteristics will be compared and discussed. Specific study techniques and applications for traffic volumes, speeds, travel times, parking and accidents will be covered. A review of basic statistical techniques will also be provided.

TR 682 Freeways and Rural Highways 2½:0:0:3

This course provides an integrated treatment of freeway and rural highway facilities. Functional classification and use of such facilities is treated. Capacity and level of service analysis, geometric characteristics, control and operations and management of freeways and rural highways are included as applications. Current software applications are presented. *Prerequisite: TR 681 or equivalent.*

TR 683 The Intersection: Design and Control 2½:0:0:3

Issues of design and control of at-grade intersections are covered in detail in this course. Options for intersection control are discussed and guidelines for determining the most effective measures are applied. Sight distance requirements and warrants for various forms of control are reviewed and applied. Signing and marking of intersections are illustrated. Signal timing methods are presented and applied. Capacity and level of service analysis for signalized and unsignalized intersections is treated in detail. Current software applications are presented. *Co-requisite: TR 681 or equivalent.*

TR 684 Arterials and Networks 2½:0:0:3

This course focuses on the design, operation, control and management of arterial and street networks. Coordination of signal systems on arterials and in networks is covered in detail. Management and control strategies for preserving the function of arterials and local streets are discussed, including access management, curb-parking controls, traffic calming techniques and progressive signal systems are discussed and applied. Traffic simulation models for analysis of arterial and network performance are introduced and used, including CORSIM, PASSER and TRANSYT 7F. *Prerequisite: TR 681, TR 683 or equivalents.*

TRANSPORTATION MANAGEMENT AND FACILITY OPERATIONS

TR 850 Transportation Management 2½:0:0:3

This course presents an overview of the transportation management profession. Levels of management and unique objectives of management in the transportation sector are presented and discussed. Management structures for private and public transportation organizations are analyzed. Management practices are treated from the perspectives of organizations, optimization of the use of public resources, legislative and legal contexts and operations.

TR 851 Transportation Policy 2½:0:0:3

This course focuses on analysis of transportation policies, regulations and controls established or imposed by federal, state and local governments. The short-term and long-term impacts of such policies on various sectors of the transportation industry are examined. Historical and case studies are extensively used to illustrate policy impacts on all modes of transportation.

TR 852 Public Transportation Systems and Operations 2½:0:0:3

This course is intended to provide a comprehensive understanding of modern public transportation systems, with emphasis on their technology and operational practices. Planning and management aspects

are also covered. Such operational and management issues as maintenance practices, scheduling and dispatching, street management, procurement and labor relations are broadly outlined and discussed. Planning and capital programming issues are also treated.

INTELLIGENT TRANSPORTATION SYSTEMS

TR 810 Introduction to Intelligent Transportation Systems 2½:0:0:3

This course presents a compact introduction to the field of Intelligent Transportation Systems (ITS) by providing a system framework for ITS. Working within the framework, individual subsystems are described and explored. Specific systems are treated: freeway surveillance and management, traffic signal control, transit management, electronic toll collection, electronic fare payment, regional multi-level traveler information centers, emergency response, commercial vehicle operations and management, grade-crossing protection and rural ITS applications.

TR 811 ITS: System Architecture 2½:0:0:3

This course describes and analyzes typical ITS architectures. Basic subsystems and data flow are examined in some detail. The mission and vision of various architectures is examined. Applications of architecture in deploying specific ITS systems are illustrated. *Co-requisite: TR 810 or equivalent or instructor's permission.*

TR 812 ITS: GIS, GPS and Communications 2½:0:0:3

This course introduces Geographic Information Systems (GIS), Global Positioning Systems (GPS) and communications applied in ITS. Fundamental system concepts are presented. Hands-on experience will be gained through use of the ArcView GIS package. Satellite-based positioning systems are described and discussed. The course will introduce various communications media, technologies, architectures and options, as well as approaches to the design of a communications system for ITS. *Prerequisite: TR 810 or equivalent or instructor's permission.*

**GUIDED STUDIES
AND PROJECTS****TR 860-863 Selected Topics in
Transportation I-IV** *2½:0:0:3*

Periodic presentations of topical material of current interest form the basis for these courses. Each presentation generally involved a different topic or collection of topic(s) that is (are) currently relevant. Sample topics in recent years include parking and pedestrian issues, traffic calming techniques, functional design of specified facilities, legal and legislative issues, transportation safety and others. *Prerequisites: instructor's and adviser's approval.*

**TR 901/902 Readings in
Transportation I/II** *each 3 units*

An individual subject is studied under the direct supervision of a specified faculty member, resulting in a formal written report. Subjects must supplement topics given in regular courses and the prior approval of the supervising faculty member is required prior to registration. *Prerequisite: instructor's permission.*

**TR 962 Project in Transportation
Planning and Engineering** *each 3 units*

An independent project in transportation planning and engineering leading to a comprehensive report demonstrating professional competence. Reports must be orally defended and submitted in formal (unbound) written form. *Prerequisites: degree status and adviser's approval.*

TR 963 Internship in Transportation
each 3 units

Internships with relevant transportation organizations leading to a report demonstrating the student's professional competence. Reports must be orally defended and submitted in formal (unbound) written form. *Prerequisites: degree status and adviser's approval.*

**TR 966 Project in Transportation
Management** *each 3 units*

An independent project in transportation management leading to a comprehensive report demonstrating professional competence. Reports must be orally defended and submitted in formal (unbound) written form. *Prerequisites: degree status and adviser's approval.*

**TR 999 PhD Dissertation in
Transportation** *each 3 units*

An original investigation embodying the results of comprehensive research in a specific area of transportation worthy of publication in a recognized, formally refereed transportation journal. Students are required to take an oral examination on the subject of the dissertation and related topics and must submit a formally bound written document. *Prerequisites: degree status, passage of the Qualifying Examination in Transportation and adviser's approval.*

URBAN SYSTEMS ENGINEERING AND MANAGEMENT PROGRAM

Program Director: Ilan Juran

The Department of Civil Engineering offers a graduate program in Urban Systems Engineering and Management, leading to the Master of Science. This program was developed as part of the Institute for Civil Infrastructure Systems (ICIS), supported by the National Science Foundation. Polytechnic University is a major partner institution in ICIS, a consortium effort led by New York University.

The primary objective of ICIS, and of the Urban Systems Engineering and Management Program, is to educate professionals with both engineering and non-engineering backgrounds to understand and manage major urban infrastructure systems and the problems they pose to society and government. It is not sufficient to have a technical understanding of the engineering aspects of urban infrastructure systems and their components. To manage this sector effectively, professionals must also understand the societal and political contexts that affect them. Issues of public policy, finance, monitoring and maintenance must all be understood more clearly.

This Master of Science program attempts to provide a broader exposure to the range of knowledge and skills needed to play a leading role in infrastructure management in an urban setting. Thus, the program includes elements of engineering and technology, management, economics, finance and public policy.

GOALS AND OBJECTIVES

The specific objectives of the Urban Systems Engineering and Management Program are to provide students with the following:

- A broad base of understanding of infrastructure management and policy issues
- Analytic and decision-making skills that account for the political, economic and social impacts of infrastructure technologies
- A broad overview of the full range of urban infrastructure systems

- An integrated knowledge of the interactions and interdependencies of various urban infrastructure systems
- Specialized management skills and techniques to apply to unique problems of the infrastructure segment

ADMISSION REQUIREMENTS

Admission to the MS in Urban Systems Engineering and Management is open to professionals with BS or BA degrees and backgrounds in engineering, science, public policy, management, economics and/or finance. Appropriate mathematics background, usually including undergraduate calculus, would be required, as would an undergraduate GPA of 3.0 or better.

GRADE REQUIREMENTS

To earn graduate degrees or certificates, students must have 3.0 GPA or better in all graduate courses and guided studies (readings, projects, theses, dissertations). Averages are separately computed for courses and guided studies. Transfer credits from other institutions are not included in this average.

ANALYTIC BACKGROUND

All applicants for this MS program must show evidence of quantitative analytic ability, generally including a minimum of two years of college mathematics and a college-level course in statistics.

ADVISING

Each student in the graduate program is assigned a faculty adviser. It is important that students maintain frequent contact with the adviser throughout the course of their studies.

Students must meet with their academic adviser prior to each registration and at any other time they need advice or consultation. Students must have a detailed program of study formally approved by their adviser prior to registration. Advisers also handle requests for waiver of certain degree requirements where warranted. Such waivers must be approved in writing and must be entered into the student's departmental file.

Where specific courses are waived, the approval of the course instructor is also required. When waivers are granted, students may be required take other specific courses in their place, or to select additional electives.

Students registering for any guided studies (readings, projects, theses) are assigned project advisers for each such activity. The project adviser may or may not be the same as the student's academic adviser, depending upon the subject matter selected. To register for any guided study activity, students must submit written proposals for the topic(s) to be covered to an appropriate project adviser before registration. To register, the written approval of the project adviser is required in addition to the approval of the academic adviser.

While academic advisers consult and give advice to students, it is the student's responsibility to ensure that all degree requirements are fulfilled and to submit all proper forms and application when necessary.

TRANSFER CREDITS

The residency requirement for the MS degree is 27 units. This is the minimum number of credits that must be taken at the Polytechnic to be awarded a Polytechnic MS degree.

Students may transfer up to 9 units of acceptable courses towards an MS degree, subject to the approval of the academic adviser. To be transferred, the course(s) must be relevant to the program and from an acceptable institution. A grade of B or better is required for granting of transfer credit. Courses graded on a pass-fail basis are not considered for transfer unless accompanied by a detailed written evaluation by the instructor of the course. All transfer requests must be accompanied by an official transcript from the transferring institution. Applications for transfer credits are accepted only after the student has earned 12 units at Polytechnic.

REQUIREMENTS FOR THE MASTER OF SCIENCE

Program Core:

All students must complete the following five courses:

Course No.	Course Title	Units
CE 781	Infrastructure Planning, Engineering & Economics	3
CE 784	Introduction to Urban Systems Engineering	3
CE 785	Concepts & Implementation of Infrastructure Management Systems	3
CE 767	Environmental Impact Evaluation	3
CE 873	Infrastructure Financing: Structuring a Deal*	3
Total units		15

* Course is part of the Exec21 program; special requirements (see Civil Engineering Program) or permission of adviser required.

Minor, Technical and Free Electives:

Each minor area of study includes: (1) three minor courses, required for the minor; and (2) two to three technical electives, available to all program students.

Students may elect not to take a specified minor area. They may, instead take five or six technical electives from the approved list in any of the specified areas. The number of technical electives is influenced by whether the student elects to do a 3-credit case-study report or a 6-credit MS thesis, as described in a later section.

Minor areas of concentration are available in:

- Transportation Systems Management (TSM)
- Construction Management (CM)
- Environmental Systems Management (ESM)
- Civil Infrastructure Systems Management (CISM)

Because of course content, students selecting the CISM minor should hold a BS in Civil Engineering or the equivalent.

Minor in Transportation Systems Management

Course No.	Course Title	Units
Required for Minor:		
TR 850	Transportation Management	3
TR 810	Introduction to Intelligent Transportation Systems	3
TR 852	Public Transportation Systems and Operations	3

Approved Technical Electives in Transportation		
TR 605	Travel Demand Forecasting	3
TR 607	Transportation Planning & Congestion Management	3
TR 609	Transportation Economics & Finance	3

Additional electives may be approved by the adviser.

Minor in Construction Management

Course No.	Course Title	Units
Required for Minor:		
CE 825	Project Management for Construction	3
CE 871*	Construction & the Law	3
CE 872*	How to Succeed in Construction: Business Management Essentials & Risk Assessment	3

Approved Technical Electives in Construction:		
CE 827	Contracts & Specifications	3
CE 798	Advanced Construction Systems	3
CE 870*	Managing & Leading in the 21st Century	3

Additional electives may be approved by the adviser.

* Course is part of the Exec21 program; special requirements (see Civil Engineering Program) or permission of adviser required.

Minor in Environmental Systems Management

Course No.	Course Title	Units
Required in Minor:		
CE 775	Environmental Systems Management	3
CE 753	Hazardous/Toxic Waste Management	3
CE 756	Environmental Law	3

Approved Technical Electives in Environmental Studies:		
CE 747	Stream and Estuary Analysis	3
CE 752	Air Pollution	3
CE 754	Hazardous/Toxic Site Management	3

Additional electives may be approved by the adviser.

Minor in Civil Infrastructure Systems Management

Course No.	Course Title	Units
Required in Minor:		
CE 786	Infrastructure Monitoring & Performance Assessment	3
CE 606	Bridge Engineering	3
CE 653	Forensic Engineering	3

Approved Technical Electives in Infrastructure Systems:		
CE 614	Steel Structures	3
CE 843	Urban Geotechnology	3
CE 849	Environmental Geotechnology	3

Additional electives may be approved by the adviser.

CAPSTONE EXPERIENCE

Students fulfill the requirement for a meaningful capstone experience by completing an independent case study in urban systems management and engineering (3 credits) or a master's thesis on a topic of independent study (6 credits).

CE 990	Case Study in Urban Systems Engineering & Management	3 units
CE 991	MS Thesis for Urban Systems Engineering and Management	3 units each

GRADUATE COURSES

CE 775 Environmental Systems Management *2½:0:0:3*

An overview of information technologies as applied to the remote sensing of environmental infrastructure systems. Development of infrastructure system databases to assist in complex decision-making on environmental infrastructures.

CE 781 Infrastructure Planning, Engineering and Economics *2½:0:0:3*

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, meets local and regional needs and takes advantage of opportunities for development. Financial and economic analyses, including sensitivity and risk analysis. Mathematical models for evaluation of alternatives and optimization. Impacts of projects: environmental, social, regional economic growth, legal and institutional and public involvement.

CE 784 Introduction to Urban Systems Engineering *2½:0:0:3*

A descriptive overview of the key infrastructure systems and technologies that must be managed, operated and maintained. Systems treated include buildings and structures, water supply, solid and liquid waste handling and disposal, transportation, power, communications and information systems, health and hospitals, police and fire protection. Course treats the financial, political, administrative, legal and institutional settings of these systems and technologies. A portion of the course features distinguished guest lecturers who are experts in some of the systems and technologies included.

CE 785 Concepts and Implementation of Infrastructure Management Systems *2½:0:0:3*

Review of state-of-the-art performance monitoring and system condition assessment methodologies as part of infrastructure management systems. Emphasis is placed on information technologies as applied to remote sensing and data base development for urban systems management. Infrastructure tools, such as GIS and dedicated databases for condition assessment are presented in a laboratory environment. Invited experts participate in such areas as transportation, water distribution and utilities.

CE 786 Infrastructure Monitoring and Performance Assessment *2½:0:0:3*

Introduction to the physical nature of infrastructure materials and systems. Concept of performance is introduced from the point of view of strength and durability. Lectures and laboratory demonstrations identify the mechanism of degradation and cover techniques for condition assessment and quality assurance.

CE 990 Case Study in Urban Systems Engineering and Management *3 units*

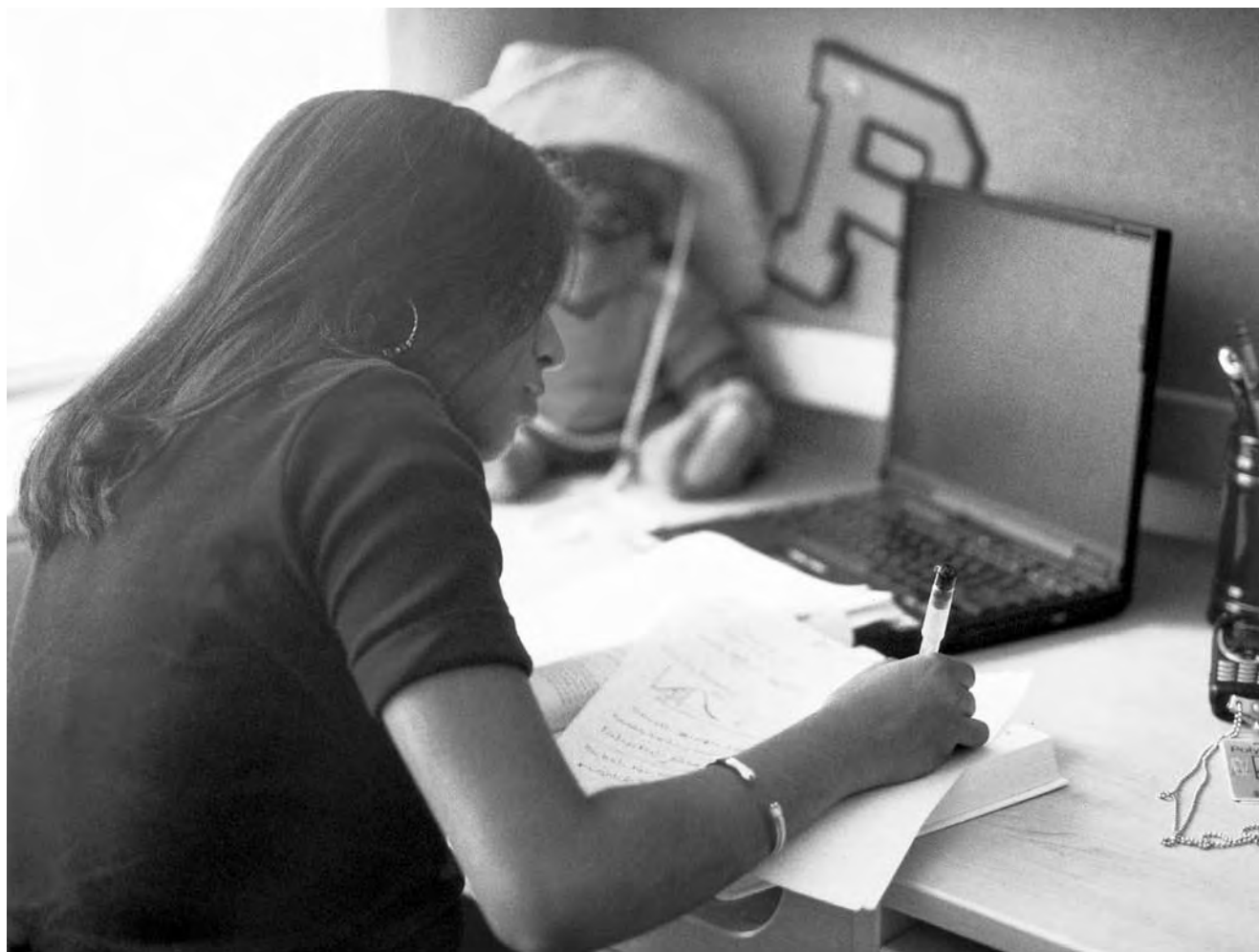
A comprehensive independent case study involving a specific urban infrastructure engineering and management project under the guidance of a faculty adviser and generally in coordination with a participating infrastructure agency. Case studies are submitted as formal reports and must be formally presented and defended.

CE 991 MS Thesis in Urban Systems Engineering and Management *3 each*

A 6-unit thesis focusing on a topic of current importance in infrastructure engineering and management. Thesis generally involves the development of a system approach to some aspect of infrastructure and may include elements of case studies. Thesis is under the guidance of a faculty adviser and thesis committee and may involve cooperative elements with an infrastructure agency. All theses are formally submitted as bound reports (see University requirements for bound theses and dissertations).

PART 4

SPECIAL PROGRAMS



GENERAL STUDIES PROGRAM

The General Studies (GS) Program was created to provide students, who do not meet the traditional admissions requirements, an opportunity to obtain a science, engineering, humanities and management based education in a supportive environment. To ensure student success, the General Studies students are provided with a broad variety of services beginning with a mandatory summer program prior to the start of their freshman year and continuing throughout the academic year with mandatory, weekly tutoring and advisement sessions. Once admitted into Polytechnic, students must successfully participate in the program for one year before they are allowed to officially declare their major.

For further information, visit www.poly.edu, or call 718-260-3391.

ADMISSION AND APPLICATION PROCEDURES

Consideration for the General Studies program involves a multi-step process, beginning with the completion of the general Poly admissions application. The admissions committee determines the applicants' eligibility for the GS program. Qualified candidates are invited in for an interview with the program director to determine the congruence of the applicant's goals with the program's objectives and services. Students who are accepted and plan on attending the program must come in to take a math and writing skills assessment test before the start of the summer program.

ACADEMIC SUPPORT SERVICES

GS students are provided an array of services to help them adjust to the rigorous curriculum at Polytechnic. The services include, but are not limited to the following:

- A seven-week summer program prior to the start of their freshman year. Students take computer skills for engineers class, along with pre-college math and writing courses.
- Scheduled writing consultant sessions
- College survival skills course
- Individualized tutoring and group review sessions
- Individual and group advisement sessions

ADVISEMENT

Weekly advisement meetings are held to provide an opportunity for students to discuss any questions and/or concerns related to the academic curriculum and general college adjustment issues. The individual advisement sessions act as a more personal continuation of the group meetings. Students meet with the General Studies director each week to discuss a broad range of topic such as academic, financial and personal concerns, to name a few.

FINANCIAL AID

General Studies students financial aid packages are based on the information entered on the Free Application for Federal Student Aid (FAFSA) form. It is recommended that students complete the FAFSA forms as early as possible in order to get the best financial aid package available.

COURSES

GS 101 Computer Skills for Engineers

Course focuses on the basic functions and intricacies of AutoCAD, Microsoft Word, Excel, Project, and PowerPoint. Course requirements consist of weekly lab assignments, a midterm and final exam and an individual project synthesizing the course content.

GS 102 Pre-college Writing

Course is designed to prepare students for writing at the collegiate level. Class time is composed of reading and writing exercises, grammar quizzes and lessons, and a close examination of student writing (workshops).

GS 103 Pre-college Math

Course focuses on preparing students for the Introduction to Pre-calculus course. Course requirements consist of daily participation, weekly quizzes, daily homework assignments and a midterm and final exam.

STAFF

Melinda Parham, Director of the General Studies Program
MSW, Stony Brook University

CENTER FOR YOUTH IN ENGINEERING AND SCIENCE (YES CENTER)

The Center for Youth in Engineering and Science (YES Center) promotes activities to nurture and develop high school students' scientific curiosity and encourage them to study and pursue careers in engineering and science. Special attention is paid to attracting students from populations underrepresented in engineering and science, specifically women and minorities. The center directs the following outreach programs: Summer Research Institute, the Mathematics and SAT Prep Program, Exploring Program, Ace Mentor Program, College Preview Programs, Inner Force Outreach Program and Venture Scholars Program. In addition, the center sponsors seminars, tutorial programs in math and science, competitions (science fairs, JETS Team Competitions), University tours and seminars for high school teachers.

SUMMER RESEARCH INSTITUTE
The Summer Research Institute (SRI) gives talented high school students educational opportunities in science, engineering and mathematics beyond what is normally taught in high schools. Students do independent research in the University's laboratories under the guidance of Polytechnic faculty members in a one-to-one relationship.

SRI has three components:

Preparation Pre-Program: depending upon the research area selected by the student, some pre-summer preparation may be necessary to develop specific skills needed to successfully complete a project. This may take the form of one-to-one contact with a faculty mentor, attending special seminars and programs or taking a college preview course before enrolling in the Summer Research Institute.

Research: the Summer Research Institute lasts seven weeks each summer. High school students work full time on a self-proposed research project, either individually or as part of a group, and are overseen by a faculty member.

Seminars: seminars supplement students' research experiences. Sessions are devoted to drafting preliminary essays, learning appropriate formats for science papers, compiling data profiles and presenting research results. Several seminars feature speakers from Polytechnic and industry. The institute organizes field trips for students to augment their research. Students also attend preparatory seminars to learn to maximize their progress during the required time period.

Students are encouraged to submit their research results to regional and national competitions, including the Intel Westinghouse Talent Search, the Siemens Westinghouse Science and Technology Competition and the New York City Mathematics, Science and Technology Fair, hosted by Polytechnic.

Qualifications: Admissions to the SRI is very selective, and is determined by the student's scholastic record, evidence of successfully completing science and or technology courses, expressed interest in the program and the strength of recommendations from high school teachers, principals or counselors. Eligible applicants are current high-school juniors who will begin their senior year after completing the SRI, although applications from outstanding sophomores will also be considered. Potential SRI students can obtain application forms from the YES Center or at www.poly.edu/yes.

ACE MENTOR PROGRAM

The ACE Mentor Program promotes the challenges and rewards of a career in architecture, construction and engineering. The program is a unique partnership of high school schools, universities, architect and interior design firms, engineering and construction companies, professional organizations and related corporations.

The mission of the ACE Mentor Program is twofold:

1. To enlighten and motivate students toward architecture, construction, engineering and related careers.

2. To provide mentoring and scholarship opportunities for future designers and constructors.

Companies involved in the program are leaders in their field, many with international reputations, who share a desire to provide career directions to interested high school students. They donate the time of selected employees to serve as mentors, as well as other resources on an as-needed basis.

The companies join into teams and "adopt" a group of 20 to 30 high school students for the duration of a school year, meeting with them after school on a bi-weekly basis. The teams comprise companies from complementary disciplines, thereby exposing students to a wide range of fields.

COLLEGE PREVIEW PROGRAM

On-Site: Polytechnic offers introductory college courses 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, but charges a non-refundable registration fee per course. Students earn college credits for satisfactorily completed course work, and a transcript is produced. Introductory college courses offered include mathematics, computer science, physics, chemistry and selected courses in the humanities and social sciences. Students must submit an application in the first week of September to enroll in fall courses and in mid-January for spring courses. Applications are available at area high schools and at the YES Center.

Off-Site: High school students may earn college credits at their high school by satisfactorily completing advanced science, mathematics and computer science courses offered through Polytechnic. Associate faculty, selected and paid by the University, teach the courses and use approved curricula and evaluation materials. Polytechnic waives students' tuition, charging only a registration fee per course, and issues a transcript to certify the earned college credits.

INNER FORCE OUTREACH PROGRAM

Inner Force prepares middle-school students for future careers by developing their ability to problem solve using mathematics and to communicate effectively while working on teams. Through various workshops, students learn about the interrelationship of physical health, mental health and the impact of technology and economics on their lives. The Inner Force program offers a six-week, full-day summer program for middle-school and junior-high school students that covers math, science, economics, dance, music, writing, critical thinking and leadership training. Students also participate in one educational trip per week. Inner Force also offers an academic program during the school year.

Objectives:

- To prepare students for successful careers, developing their ability to identify and solve problems by utilizing mathematics, work in teams, communicate effectively and take pride in their achievements
- To create a positive, safe, and motivating learning environment, challenging students to explore new field and achieve their full potential
- To prepare students for a technological world
- To educate students about the interrelationship of physical health, mental health, economics and the impact of technology on their lives
- To enable students to understand budgets and key economic processes

VENTURES SCHOLARS PROGRAM

The Ventures Scholars program is dedicated to increasing the number of professionals historically under represented in health, math, science, engineering and technology-based careers. This national program links minority 10th- and 11th-grade high school students with a variety of pre-college enrichment programs at undergraduate institutions. Students are invited to participate in this program based on their PSAT scores, grade point average, and academic interests in sciences or engineering. Several Venture Scholars participate in programs at Polytechnic University each year.

PROGRAMS FOR HIGH SCHOOL STAFF MEMBERS

Polytechnic offers high school teachers various staff development and training workshops, led by professional workshop facilitators and specialists. Polytechnic also offers a 50 percent tuition discount to full-time teachers taking courses at Polytechnic. Documentation from the home school is required.

THE MATHEMATICS INSTITUTE AND SAT PREP PROGRAM

The Mathematics Institute at Polytechnic is a six-week summer program that focuses on giving high school students real-world, problem-solving experience with an emphasis on pure and applied mathematics. Students build their skills within areas such as number theory, geometry, combinatorics and elementary analysis. Pre-calculus and calculus are taught in small classes and are designed to prepare students for the rigor of college study. Polytechnic faculty members teach these essential courses using state-of-the-art equipment and software such as IBM ThinkPad and Matlab software. Through Matlab, students learn how to combine their knowledge of mathematics and computer programming to use this powerful tool that is used by engineers and others who use computational mathematics in their work. Participating students who experience a high degree of success are invited to become a part of the multi-year program. Additionally, students receive a voucher from Polytechnic to apply the tuition-paid portion for these courses to the tuition costs, freshman year, at Polytechnic.

SPECIAL SEMINAR PROGRAMS

High school students and faculty are invited to attend the various seminars, conferences and lectures that Polytechnic sponsors throughout the year in science, technology, engineering, social science, mathematics and computer science. Several yearly programs are specifically designed for high school students and faculty, and program information is distributed to area high schools. High schools interested in seminars on particular topics should contact the YES Center.

TUTORIALS

High school students interested in being tutored in mathematics and science by a Polytechnic student should contact the YES Center.

UNIVERSITY TOURS

Polytechnic regularly gives tours of its laboratories and facilities. The tours include demonstrations, lectures on careers in engineering and science and presentations on college planning and financial aid. High schools interested in a University tour should call the YES Center.

SCHOLARSHIPS

High school students involved in YES Center programs are eligible for a Promise Scholarship if they choose to attend Polytechnic.

STAFF

Beverly Johnson, Executive Director

Alberta Sanchez, Administrative Assistant

THE DAVID PACKARD CENTER FOR TECHNOLOGY AND EDUCATIONAL ALLIANCES

Created in 1996, the David Packard Center for Technology and Educational Alliances develops opportunities connecting Polytechnic with educational, business and community organizations to enhance and disseminate information on electronically mediated learning, and to encourage advanced studies in mathematics, science and technology.

The center seeks to:

- Ensure equity of availability, opportunity and access for women and under-represented minorities in the use of computers and information-age technology and in the study of mathematics and science.
- Build alliances of stakeholders, enabling information-age technology to impact the learning process and social, economic and educational institutions.
- Serve as a resource for the professional development of teachers to enhance learning in science, mathematics and technology.
- Utilize technology as a tool to assist learning, and disseminate findings through publications, multimedia communications, symposia and lectures.

COLLEGE AND UNIVERSITY ALLIANCES

Through the Knowledge Workers Educational Alliance (KWEA), a consortium of five colleges and universities, students at participating liberal arts institutions prepare to become knowledge workers, well versed in technology and well rounded by a traditional liberal arts education. As upperclassmen, undergraduate students study in “bridge courses” in technical areas and then continue as graduate students at Polytechnic. At the end of five years, these students are armed with two degrees: a bachelor’s degree from their original college and a master’s from Polytechnic. They are qualified for specialized jobs that require sophisticated technical knowledge. Programs currently offered for a master’s degree include computer science, integrated digital media,

organization behavior/human resources information management, transportation engineering and planning, bioinformatics, and construction planning and management. KWEA also conducts faculty development conferences, which are designed to improve faculty skills in information technology and student learning.

SECONDARY SCHOOL ALLIANCES

The Packard Center serves to extend the University’s commitment to pre-college students by providing a contact point for learning initiatives. Polytechnic students and staff serve as mentors, interns and instructors. In addition, high school teachers form alliances with Polytechnic faculty, and professional development programs yield long-term advantages for high school and college learners.

The Packard Center provides leadership for a variety of activities that allow middle and high school students to participate in scientific research competitions and exhibitions, meet noted scientists and engineers, and attend academic symposia. Among these programs and events are the Principal’s Scholars Dinner–Symposia; the Future City Regional Competition; the New York City FIRST! Competition, a national robotics and design competition for high school students; and the FIRST LEGO League Competition, a similar program for middle school students.

High school teachers attend specially designed workshops, courses and conferences at Polytechnic to learn how to use information-age technology in their classrooms. A companion program seeks to develop varied teaching strategies in science and mathematics that emphasize hands-on learning experiences.

Polytechnic is a partner with a community school district in a major New York State Education Department grant through which the district’s teachers receive training in mathematics. Participants can earn graduate credits while improving their knowledge of mathematical concepts. The University also provides on-site coaching for teachers of mathematics in area schools.

In 2003, Polytechnic hosted the Student

Leadership Conference of the National Consortium of Specialized Secondary Schools in Mathematics, Science and Technology (NCSSSMST), thus extending the University’s reach to include high-school students across the country in its program.

COMMUNITY ALLIANCES

Polytechnic University has enjoyed an alliance with settlement houses aligned with United Neighborhood Houses Inc., which serves economically disadvantaged populations, to introduce young people to new communications technologies. The University has also worked closely with Brooklyn Technical High School to support the high school’s efforts to align its engineering curriculum with that found at a university. Additional programs have brought Polytechnic faculty and students directly into high schools, where they serve as resources for science study, as is the case with Project RAISE (Revitalizing Achievement through Instrumentation in Science Education), a National Science Foundation-supported G K-12 program in which Polytechnic undergraduate and graduate students are posted at local high schools as RAISE Fellows. There, they teach classroom units, assist teachers with their understanding of instrumentation and robotics, and provide students with opportunities for active learning experiences.

Polytechnic is a partner for a community school district in a major New York State Education Department grant through which the district’s teachers receiving training in mathematics. Participants can earn graduate credits while improving their knowledge of mathematical concepts. The University also provides on-site coaching for teachers of mathematics in area schools.

STAFF

Noel N. Kriftcher, Executive Director
EdD, Hofstra University

Carmen Seda, Administrative Coordinator

HIGHER EDUCATION OPPORTUNITY PROGRAM (HEOP)

The Higher Education Opportunity Program (HEOP) is a New York State-funded program designed to provide broad and varied educational instruction to capable students who, due to limited academic and financial resources, might otherwise not have the opportunity to attend Polytechnic. Once admitted to the HEOP program, students are provided with financial assistance, counseling, tutoring, advisement and other support services throughout their college career. HEOP's goal is to retain and graduate students who are traditionally under-represented in the fields of engineering and science.

ADMISSION AND APPLICATION PROCEDURES

To qualify for the program, applicants must be residents of New York State and demonstrate both academic and economic need. Applicants are either referred by an admissions counselor, or may indicate on their application that they are interested in being considered for HEOP. Economic eligibility is determined by income guidelines issued by the New York State Education Department.

Since SAT scores may not thoroughly reflect a student's potential for success at Polytechnic, an intake interview with each applicant is an essential part of the HEOP admissions process. During the interview the counselor will discuss the applicant's academic strengths and weaknesses, and give a basic overview of what to expect at Polytechnic.

TRANSFER STUDENTS

Students wishing to transfer into HEOP at Polytechnic must have been in an opportunity program (HEOP, EOP, SEEK, etc.) at their previous institution. Each applicant must also complete an admissions transfer application. Transfer applicants are considered based on their academics and their individual circumstances. The HEOP director reviews college transcript(s) and recommendations from counselors or pro-

fessors, and a decision is sent to the Office of Admissions.

ACADEMIC SUPPORT SERVICES

To help students reach their full academic potential and succeed at Polytechnic, HEOP provides freshmen and continuing students with academic support services. These services include:

- A mandatory pre-freshmen summer program, which includes courses in Pre-Calculus, Chemistry and Computer Science
- A Study Skills course offered during the fall semester. Topics include time management, test-taking, note-taking and other college survival skills
- Individual and group tutoring sessions
- Monthly group meetings and seminars

COUNSELING

HEOP offers students one-on-one academic, financial, personal and career counseling. Group and individual counseling sessions are scheduled to assist students in making the transition to college, as well as maintaining and managing their academic career throughout their stay at Polytechnic.

FINANCIAL AID

HEOP students receive a financial aid package, which includes funding from HEOP, Tuition Assistance Program (TAP), PELL, Supplemental Educational Opportunity Grant (SEOG), Polytechnic grants, College Work Study Program, Stafford Loans and other educational loans. It is important that students complete the Free Application for Federal Student Aid (FAFSA) and the Tuition Assistant Program (TAP) applications as early as possible.

For further information, please visit the HEOP website at www.heop.poly.edu, or call 718-260-3370.

COURSES

CM 000 Pre-College Chemistry

6:0:NC

Covers 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 that includes a close examination of a student's expectations and college survival skills; note taking and textbook use; reevaluation of goals and career objectives.

MA 000 Pre-College Math

6:0:NC

Review of trigonometry, quadratic and absolute value questions and inequalities, limits and differentiation of both algebraic and trigonometric functions.

CS 000 Pre-College Computer Science

6:0:NC

General topics covered include the fundamentals of programming, software development practices and problem solving using the C++ programming language. Other topics include compiling, running and debugging a program, program testing, documentation, variables and data types, assignments, arithmetic expressions, input and output, top-down design, functions, conditionals and loops.

STAFF

Teresina Tam, Director

MSW, Wilfred Laurier University (Canada)

Edna Kapp, Counselor/Tutor Coordinator

MSW, Yeshiva University

Tara Fitzgerald, Counselor

BS, College of Staten Island

PART 5

THE CORPORATION THE ADMINISTRATION THE FACULTY



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Director, External Programs and Academic Budget

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David and Gregory Chudnovsky, PhD

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John Falcocchio, PhD

Director, Transportation Research Institute (TRI)

Fletcher H. (Bud) Griffis, PhD

Director, Center for Construction Management Technology (CCMT)

Richard A. Gross, PhD

*Director, Herman F. Mark Polymer Research Institute (PRI);
Director, NSF Industry/University Cooperative Research
Center for Biocatalysis and Bioprocessing of Macromolecules
(NSF-BBM)*

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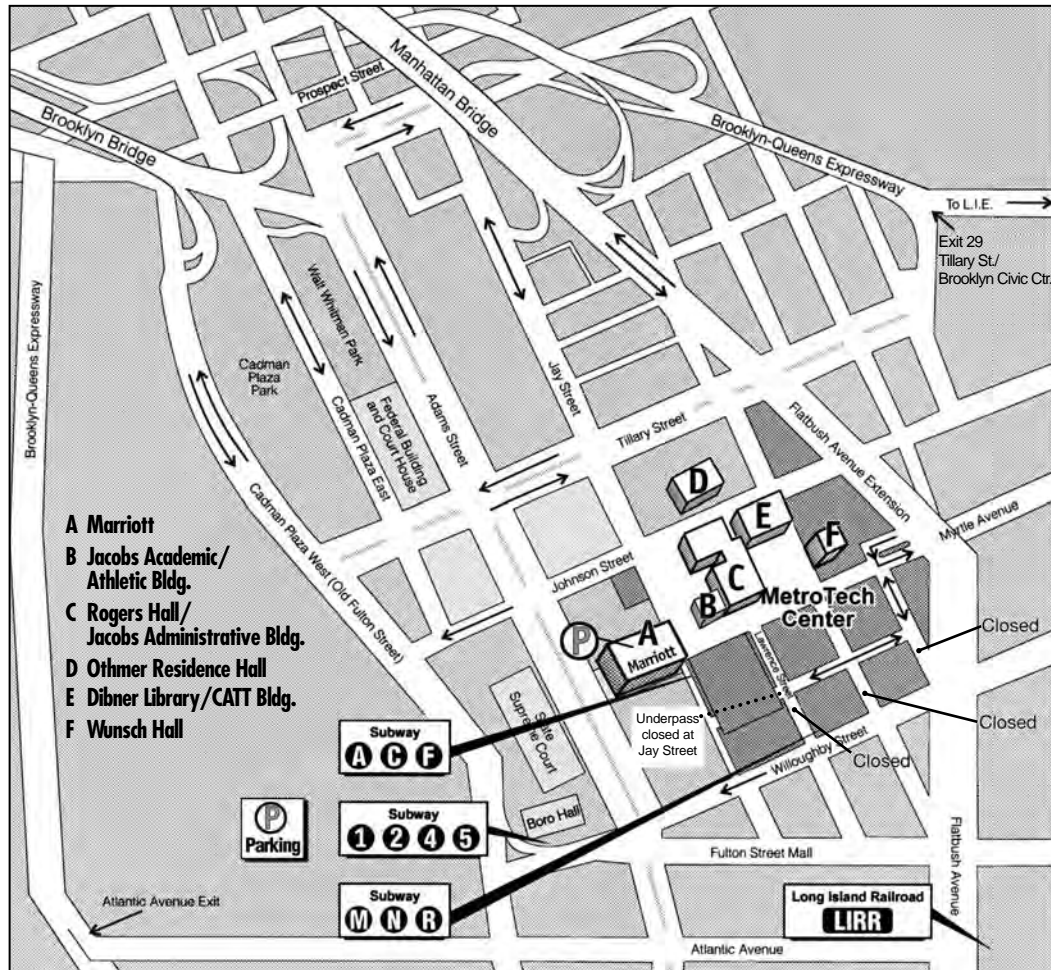
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By Subway from all Boroughs

A, C or F train to Jay St.-Borough Hall; or the 1, 2, 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 from Manhattan

Take the FDR Drive to the Brooklyn Bridge, make the first left after the bridge onto Tillary, and a right onto Jay St.

By Car from Queens or the Bronx

Take the Brooklyn-Queens Expwy. to Tillary St. and then left onto Jay St.

By Car from Staten Island

Take the Verrazano Narrows Bridge to the Brooklyn-Queens Expwy. to the Tillary St. exit. Make a left onto Jay St.

By Car from New Jersey

From the George Washington Bridge take the Harlem River Drive to the FDR Drive or Holland Tunnel to Brooklyn Bridge. (Continue as from Manhattan.)

By Train from Brooklyn or Long Island

Take the Long Island Railroad to Flatbush Ave. Then take a taxi or 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 from Brooklyn or Long Island

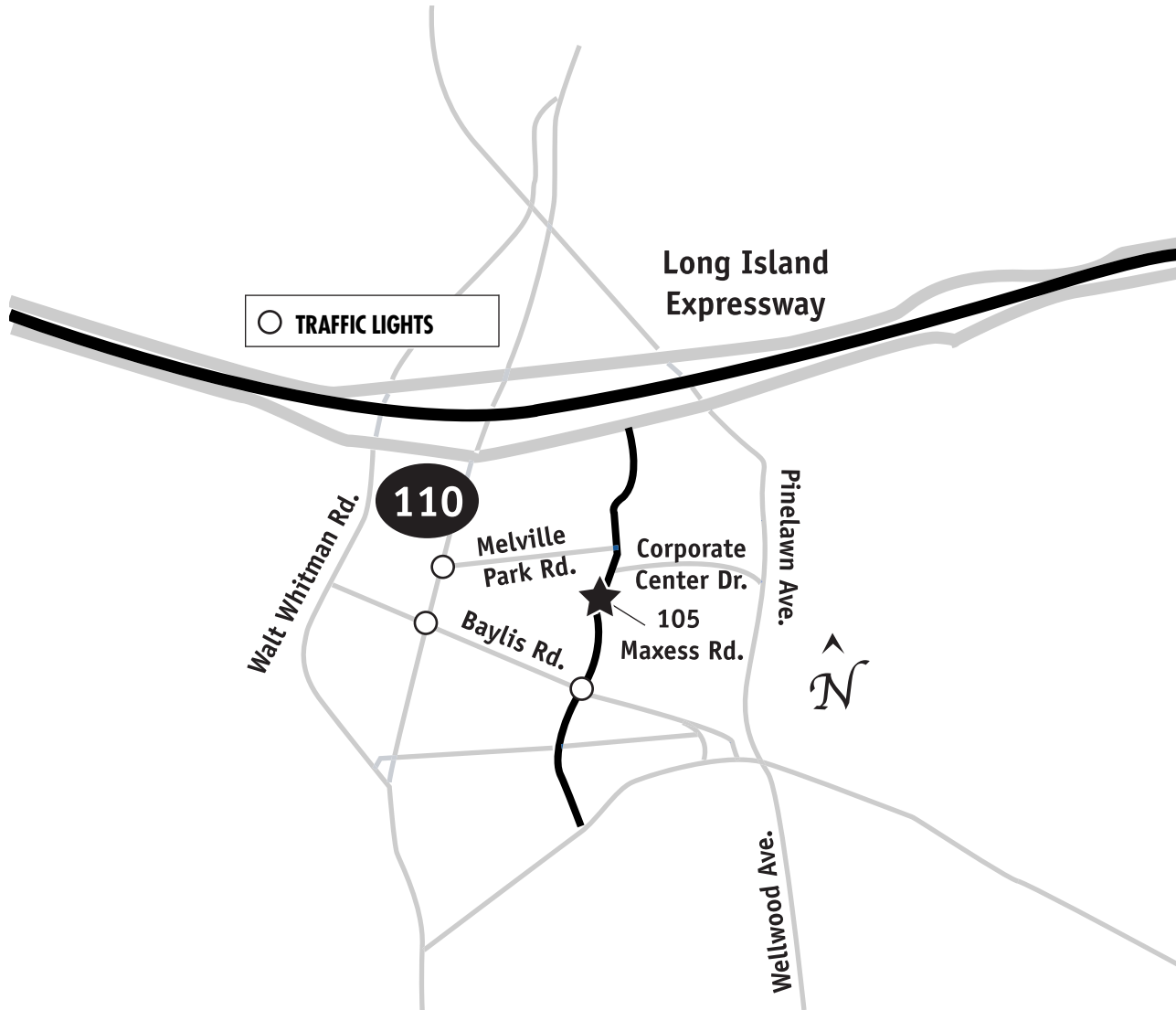
Take Brooklyn-Queens Expwy. to the Tillary St. exit. Go left onto Jay St.

By Car from Westchester

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 Jay St.

PUBLIC PARKING is available at the Marriott Hotel on Jay St., across from Polytechnic.

LONG ISLAND GRADUATE CENTER



From New York City & Long Island

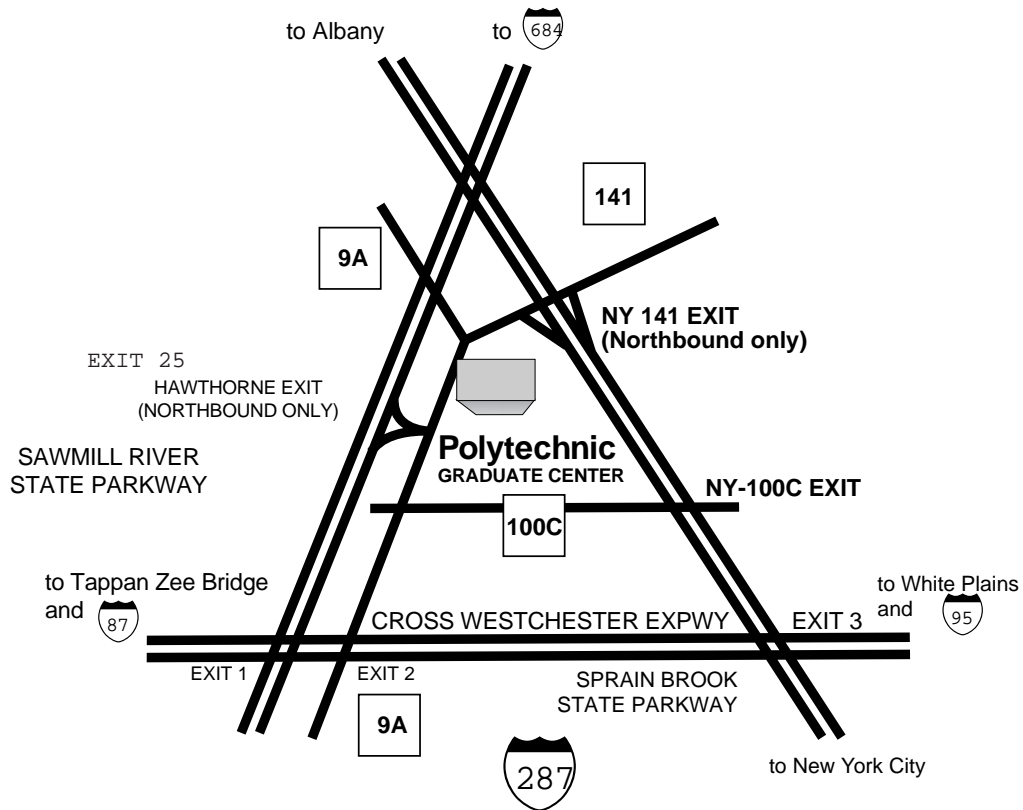
Take the Long Island Expressway (I-495) East to exit 49S (Rt. 110 S/Amityville). Merge onto the S. Service Rd. and turn right onto NY-110 S. (approximately half a mile). Turn left onto Baylis Rd. (approximately half a mile). Turn left onto Maxess Rd. (The Long Island Graduate Center is on the right within 150 yards. Enter through North entrance of 105 Maxess Road).

From Westchester

Take the Hutchison River Parkway South to the I-95 S/Stillwell Ave exit. Keep right at the fork in the ramp. Merge onto New England Thwy. New England Thwy becomes Bruckner Exwy. Take the I-695 exit- exit number 7A- on the left towards I-295/Throgs

Neck Bridge/Long Island. Merge onto Throgs Neck Exwy. Take I-695 S. I-695 S becomes Throgs Neck Exwy. Throgs Neck Exwy becomes I-295 S. Take the Cross Island Pkwy exit towards Eastern L I. Merge onto Cross Island Pkwy S. Take the I-495/Long Island Expressway exit- exit number 30- towards Eastern L I. Merge onto LI Expressway. Take the exit- exit number 49S- towards RT-110 S/Amityville. Merge onto S. Service Rd. Turn right onto NY-110 S. Turn left onto Baylis Rd. Turn left onto Maxess Rd. (The Long Island Graduate Center is on the right within 150 yards. Enter through North entrance of 105 Maxess Road).

WESTCHESTER GRADUATE CENTER



BY CAR

From New York City: Take NY-9A West Side Highway to Saw Mill River Parkway North. Or I-278 to Triboro Bridge to I-87 North, exit at I-287 East to Saw Mill River Parkway North (Exit 1). Travel North on Saw Mill River Parkway for 3 miles after interchange for I-287 to Exit 25 for Hawthorne (Route 9A). Turn left at light onto Route 9A northbound. Polytechnic is on the right side of road.

From New Jersey and Downstate New York: Take I-87 South (New York State Thruway) to Tappan Zee Bridge. After bridge, take I-287 East to Saw Mill River Parkway North (Exit 1). Travel north 3 miles to Exit 25 for Hawthorne (Route 9A). Turn left at light on to Route 9A northbound. Polytechnic is on the right side of road.

From Northern Westchester and the Hudson Valley: Take the Taconic State Parkway South or Saw Mill River Parkway South to the Sprain Brook Parkway. Exit at Route 100C. Make a right on to Route 100C westbound and travel 3/4 mile to Route 9A North, entrance on right. Travel north on Route 9A for 2 miles; Polytechnic is on the right.

From Connecticut and Southern Westchester: Take I-95 to I-287 West (Cross Westchester Expressway) to Route 9A (Exit 2) North. Travel north 3 miles; Polytechnic is on the right.



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Inquiries about the above policies may be directed to the Office of Affirmative Action, Polytechnic University, Six MetroTech Center, Brooklyn, New York 11201.

The University is authorized under federal law to enroll non-immigrant alien students.

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