

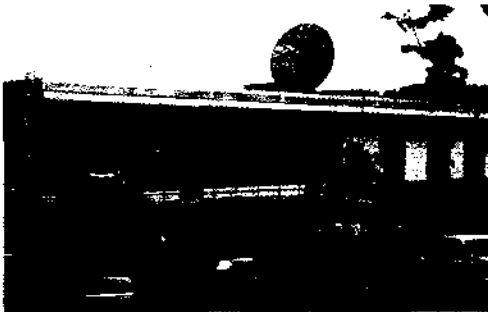
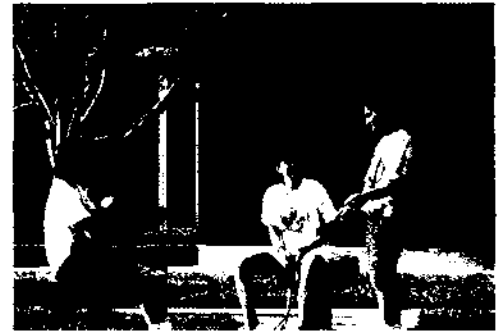
POLYTECHNIC UNIVERSITY

**UNDERGRADUATE AND
GRADUATE CATALOG
2001-2003**



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

Long Island Campus
901 Route 110
Farmingdale, NY 11735
Phone: 631/755-4200
Fax: 631/755-4404
E-mail: admitme@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: 212/547-7030
Fax: 212/547-7029
E-mail: ite@poly.edu



MISSION

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.

Visit our Web site: www.poly.edu

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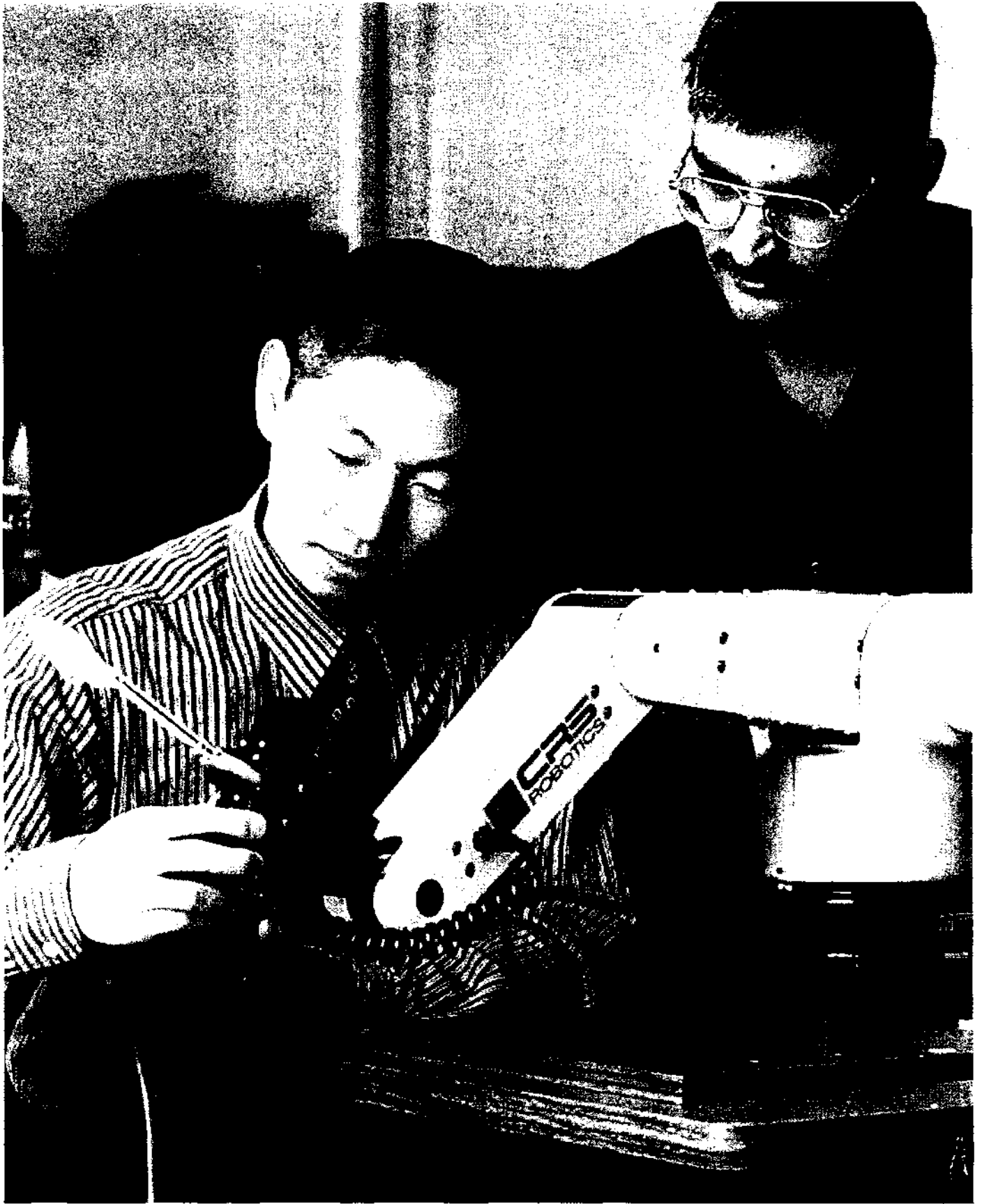
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PART 1

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 as accurate as possible, but requirements, deadlines, tuition, fees, curricula, courses and staffing are subject to change at any time without advance notice or obligation. This catalog was prepared well in advance of its effective date; therefore some course descriptions may vary from actual course content due to advancements in the discipline, interests of individual instructors or decisions of the faculty to change the scope and/or content of the course. The *Schedule of Classes* supplements this catalog and is issued for each semester and summer sessions. It includes updated information about course offerings, tuition, fees, registration and academic procedures.

ADMINISTRATIVE OFFICES

EXECUTIVE OFFICES

Office of the President
Jacobs Bldg., Room 555
Tel: 718/260-3500
Fax: 718/260-3755
E-mail: chang@poly.edu

Office of the Chancellor
Jacobs Bldg., Room 551
Tel: 718/260-3330
Fax: 718/260-3974
E-mail: gbugliar@poly.edu

Office of the Provost
Jacobs Bldg., Room 555
Tel: 718/260-3990
Fax: 718/260-3755
E-mail: ifrisch@poly.edu

Office of Academic Affairs
Dean of Engineering and Applied Sciences
Rogers Hall, Room 321
Tel: 718/260-3550
Fax: 718/260-3063
E-mail: bmshane@poly.edu

Office of Development and University Relations
Jacobs Bldg., Room 555
Tel: 718/260-3880
Fax: 718/260-3755
E-mail: rthorsen@poly.edu

Office of Finance and Administration
Jacobs Bldg., Room 555
Tel: 718/260-3608
Fax: 718/260-3755
E-mail: gsmith@poly.edu

Office of Student Affairs
Jacobs Bldg., Room 356
Tel: 718/260-3137
Fax: 718/260-3924
E-mail: chartiga@poly.edu

ACADEMIC SUCCESS

Brooklyn Campus
Jacobs Bldg., Room 341
Tel: 718/260-3560
Fax: 718/260-3136
E-mail: hfung@poly.edu
Hours: Monday–Friday, 9AM–5PM

ADMISSIONS–GRADUATE

www.poly.edu/admissions
Brooklyn and Long Island Campuses
Jacobs Bldg., Room 158
Tel: 718/260-3200
Fax: 718/260-3446
E-mail: admitme@poly.edu
Hours: Monday & Thursday, 9AM–6PM
Tuesday, Wednesday, Friday, 9AM–5PM

Westchester Graduate Center

Administration Bldg.
Tel: 914/323-2000
Fax: 914/323-2010
E-mail: westinfo@west.poly.edu
Executive Programs
Tel: 914/323-2023
Hours: Monday–Thursday, 9AM–8PM
Friday, 9AM–5PM

ADMISSIONS–UNDERGRADUATE

www.poly.edu/admissions
Brooklyn Campuses
Jacobs Bldg., Room 158
Tel: 718/260-3100
Fax: 718/260-3446
E-mail: admitme@poly.edu
Hours: Monday & Thursday, 9AM–6PM
Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Bassett Bldg., Room A105
Tel: 631/755-4200
Fax: 631/755-4229
E-mail: admitme@poly.edu
Hours: Monday & Thursday, 9AM–6PM
Tuesday, Wednesday, Friday, 9AM–5PM

ALUMNI RELATIONS

www.poly.edu/alumni
Brooklyn Campus
Jacobs Bldg., Room 468
Tel: 800/FON-POLY
Fax: 718/260-3114
E-mail: alumni@poly.edu
Hours: Monday–Friday, 9AM–5PM

ATHLETICS

www.poly.edu/athletics
Brooklyn Campus
Wunsch Hall, Room 107
Basement, Fitness Center
Tel: 718/637-5900
Fax: 718/637-5959
E-mail: mbrazil@poly.edu
Office: Monday–Friday, 10AM–3PM, 6–8PM
Fitness Center:
Monday–Thursday, 10AM–9PM
Friday, 10AM–8PM
Saturday, 12–4PM

Long Island Campus

Gymnasium
Tel: 631/755-4325
Hours: Monday–Thursday, 9AM–11PM
Friday, 9AM–6PM
Saturday, 12–11PM
Sunday, 12–11PM

BOOKSTORE

www.nybex.com
Brooklyn Campus
Rogers Hall, 1st Floor
Tel: 718/260-3778, 3882
Fax: 718/246-4166
E-mail: nybooks@nybex.com
Hours: Monday–Thursday, 8:30AM–6PM
Friday, 8:30AM–3PM

Long Island Campus

Bassett Bldg., 1st Floor
Tel: 631/755-4367
Fax: 631/694-8915
E-mail: nybooks@nybex.com
Hours: Monday–Friday, 9AM–3PM

Westchester Graduate Center

Tel: 914/323-2000
E-mail: nybooks@nybex.com

BUDGET**Brooklyn Campus**

Jacobs Bldg., Room 452
 Tel: 718/260-3635
 Fax: 718/260-3202
 E-mail: pkatz@poly.edu
 Hours: Monday–Friday, 9AM–5PM

BUSINESS**Brooklyn Campus**

Jacobs Bldg., Room 454
 Tel: 718/260-3958
 Fax: 718/260-3752
 E-mail: jmcgrisk@poly.edu
 Hours: Monday–Friday, 9AM–5PM

CAFETERIA**Brooklyn Campus**

Metro Café@Poly
 Rogers Hall, Room 112
 Tel: 718/260-3271
 Hours: Monday–Thursday, 7AM–9PM
 Friday, 7AM–6PM

Long Island Campus

Weeping Willow Cafeteria
 Main Bldg., 1st Floor
 Tel: 631/755-4337
 Hours: Monday–Thursday, 7–8PM
 Friday, 7AM–6PM
 Saturday & Sunday, 10AM–6PM

**CAREER SERVICES/
COOPERATIVE EDUCATION**

www.poly.edu/special/cserv/home/cfm

Brooklyn Campus

Jacobs Bldg., Room 359
 Tel: 718/260-3650
 Fax: 718/260-3325
 E-mail: raina@poly.edu
 Hours: Monday & Thursday, 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Main Bldg., Room 118
 Tel: 631/755-4270
 Fax: 631/755-4697
 E-mail: raina@poly.edu
 Hours: Monday & Thursday, 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

**CENTER FOR YOUTH IN
ENGINEERING AND SCIENCE
(YES CENTER)**

web.poly.edu/yes/index.cfm

Brooklyn Campus

Jacobs Bldg., Room 356
 Tel: 718/260-3033
 Fax: 718/260-3941
 E-mail: bjohnson@poly.edu
 Hours: Monday & Thursday, 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Bassett Bldg., Room A105
 Tel: 631/755-4200, ext. 3033
 Fax: 631/755-4229
 E-mail: bjohnson@poly.edu
 Hours: Monday & Thursday, 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

**DAVID PACKARD CENTER
FOR TECHNOLOGY AND
EDUCATIONAL ALLIANCES**

www.poly.edu/packard/index.html

Brooklyn Campus

Jacobs Bldg., Room 358
 Tel: 718/260-3524
 Fax: 718/260-3733
 E-mail: nkrift@poly.edu
 Hours: Monday–Friday, 9AM–5PM

DEVELOPMENT**Brooklyn Campus**

Jacobs Bldg., Room 461
 Tel: 800/765-9929 or 718/260-3636
 Fax: 718/260-3449
 E-mail: develop@poly.edu
 Hours: Monday–Friday, 9AM–5PM

FACILITIES**Brooklyn Campus**

Jacobs Bldg., Room 152
 Tel: 718/260-3020
 Fax: 718/260-3753
 E-mail: orourke@poly.edu or
 facility@poly.edu
 Hours: Monday–Friday, 8AM–5PM

Long Island Campus

Administration Office
 Tel: 631/755-4300
 Fax: 631/755-4404
 E-mail: jquinn@poly.edu
 Hours: Monday–Friday, 9AM–5PM

FINANCIAL AID

web.poly.edu/finaid/index.cfm

Brooklyn Campus

Jacobs Bldg., Room 256
 Tel: 718/260-3300
 Fax: 718/260-3062
 E-mail: finaid@poly.edu
 Hours: Monday & Thursday,
 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Main Bldg., Room 121
 Tel: 631/755-4345
 Fax: 631/755-4321
 E-mail: ggee@poly.edu
 Hours: Monday & Thursday,
 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

Westchester Graduate Center

Administration Office
 Tel: 914/323-2000
 Fax: 914/323-2010
 E-mail: westinfo@west.poly.edu
 Hours: Monday–Friday, 9AM–5PM

**HIGHER EDUCATION
OPPORTUNITY PROGRAM
(HEOP)**

web.poly.edu/heop/index.cfm

Brooklyn Campus

Jacobs Bldg., Room 355
 Tel: 718/260-3370
 E-mail: heop@poly.edu
 Hours: Monday & Thursday, 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Bassett Bldg., Room 104
 Tel: 631/755-4252
 E-mail: heop@poly.edu
 Hours: Monday & Thursday, 9AM–6PM
 Tuesday, Wednesday, Friday, 9AM–5PM

HUMAN RESOURCES

www.poly.edu/hr

Brooklyn Campus

Rogers Hall, Room 104
 Tel: 718/260-3840
 Fax: 718/260-3981
 E-mail: sdagos@poly.edu or
 askhr@poly.edu
 Hours: Monday–Friday, 9AM–5PM

ADMINISTRATIVE OFFICES

INFORMATION SYSTEMS

Brooklyn Campus
Rogers Hall, Room 325
Tel: 718/260-3123
Fax: 718/260-3680
E-mail: ddintino@poly.edu or
help@poly.edu
Hours: Monday–Friday, 9AM–5PM

INSTITUTIONAL RESEARCH

Brooklyn Campus
Jacobs Bldg., Room 551
Tel: 718/260-3060
Fax: 718/260-3084
E-mail: mmainer@poly.edu
Hours: Monday–Friday, 9AM–5PM

INTERNATIONAL STUDENT OFFICE

Brooklyn Campus
Jacobs Bldg., Room 158
Tel: 718/260-3805
Fax: 718/260-3446
E-mail: mgendel@poly.edu
Hours: Monday & Thursday, 9AM–6PM
Tuesday, Wednesday, Friday,
9AM–5PM

LIBRARY

dibner.poly.edu
Brooklyn Campus
Dibner Library, 3rd Floor
Tel: 718/260-3530
Fax: 718/260-3756
E-mail: blibrary@poly.edu
Hours: Monday–Thursday, 9AM–10PM
Friday, 9AM–7PM
Saturday, 12PM–6PM
Sunday, 12PM–6PM

Long Island Campus

Main Bldg., 1st Floor
Tel: 631/755-4320
Fax: 631/755-4379
E-mail: flibrary@poly.edu
Hours: Monday–Thursday, 9AM–10PM
Friday, 9AM–5PM
Saturday, 1PM–6PM
Sunday, 3PM–10PM

MAILROOM

Brooklyn Campus
Jacobs Bldg., Room 151
Tel: 718/260-3396
Fax: 718/260-3136
E-mail: mpollard@poly.edu
Hours: Monday–Friday, 9AM–5PM

Long Island Campus

Main Bldg., Room 121
Tel: 631/755-4383
Fax: 631/755-4404
Hours: Monday–Friday, 9AM–5PM

PRINTING SERVICES

Brooklyn Campus
Jacobs Bldg., Room 150
Tel: 718/260-3392
Fax: 718/260-3136
E-mail: mpollard@poly.edu
Hours: Monday–Friday, 9AM–6PM

REGISTRAR

www.poly.edu/registrar/index.cfm
Brooklyn Campus
Jacobs Bldg., Room 256
Tel: 718/260-3486
Fax: 718/260-3052
E-mail: register@poly.edu
Hours: Monday & Thursday, 9AM–6PM
Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Main Bldg., Room 112
Tel: 631/755-4450
Fax: 631/755-4404
E-mail: mflcury@poly.edu
Hours: Monday & Thursday, 9AM–6PM
Tuesday, Wednesday, Friday, 9AM–5PM

RESIDENCE LIFE

Brooklyn Campus
Jacobs Bldg., Room 356
Tel: 718/260-3137
Fax: 718/260-3197
E-mail: jswanson@poly.edu
Hours: Monday & Thursday, 9AM–6PM
Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Athletic Student Center
Tel: 631/755-4325
Fax: 631/755-4404
E-mail: jnorthru@duke.poly.edu
Hours: Monday–Friday, 9AM–5PM
24-Hour Campus Coverage Via Pager:
800/652-0556

SECURITY

Brooklyn Campus
Rogers Hall, Front Entrance
Tel: 718/260-3537
Rogers Hall, Rear Entrance
Tel: 718/260-3213
Dibner Library/CATT Bldg.
Tel: 718/260-3727
Goldsmith Student Activities
Union/Wunsch Hall
Tel: 718/637-5901

Long Island Campus

Administration Bldg.
Tel: 631/755-4353

Westchester Graduate Center

Administration Bldg.
Tel: 914/323-2000

SPECIAL SERVICES*media.poly.edu/specialservices***Brooklyn Campus**

Jacobs Bldg., Room 341

Tel: 718/260-3560

Fax: 718/260-3136

E-mail: ssbkc@poly.edu

Hours: Monday & Thursday, 9AM–6PM

Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Main Bldg., Room 114

Tel: 631/755-4340

Fax: 631/755-4404

E-mail: sslic@poly.edu

Hours: Monday & Thursday, 9AM–6PM

Tuesday, Wednesday, Friday, 9AM–5PM

STUDENT ACCOUNTS**Brooklyn Campus**

Jacobs Bldg., Room 256

Tel: 718/260-3700

Fax: 718/260-3052

Email: mlangbar@poly.edu

Hours: Monday & Thursday, 10AM–6PM

Tuesday & Wednesday, 10AM–5PM

Friday, 10AM–3PM

Long Island Campus

Main Bldg., Room 112

Tel: 631/755-4225

Fax: 631/755-4321

E-mail: ccampbel@poly.edu

Hours: Monday & Thursday, 10AM–6PM

Tuesday & Wednesday, 10AM–5PM

Friday, 10AM–3PM

Westchester Graduate Center

Administration Bldg.

Tel: 914/323-2000

Fax: 914/323-2010

E-mail: westinfo@west.poly.edu

Hours: Monday–Friday, 9AM–5PM

STUDENT ACTIVITIES*www.poly.edu/students-office***Brooklyn Campus**

Wunsch Hall, Room 108

Tel: 718/637-5920

Fax: 718/637-5959

Hours: Monday–Friday, 8AM–11PM

Saturday, 9AM–6PM

Sunday, 12PM–5PM

Long Island Campus

Athletic Student Center

Tel: 631/755-4325

Fax: 631/755-4404

E-mail: jnorthru@duke.poly.edu

Hours: Monday & Thursday, 9AM–5PM

Tuesday, Wednesday, Friday, 9AM–5PM

STUDENT AFFAIRS*www.poly.edu/student-affairs***Brooklyn Campus**

Jacobs Bldg., Room 356

Tel: 718/260-3137

Fax: 718/260-3924

E-mail: chartiga@poly.edu

Hours: Monday & Thursday, 9AM–6PM

Tuesday, Wednesday, Friday, 9AM–5PM

STUDENT DEVELOPMENT**Brooklyn Campus**

Jacobs Bldg., Room 352

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Fax: 718/260-3197

E-mail: cmcnear@poly.edu

Hours: Monday & Thursday, 9AM–6PM

Tuesday, Wednesday, Friday, 9AM–5PM

Long Island Campus

Athletic Student Center

Tel: 631/755-4325

Fax: 631/755-4404

E-mail: jnorthru@poly.edu

Hours: Monday & Thursday,

9AM–5PM

Tuesday, Wednesday, Friday, 9AM–5PM

STUDENT NOTEBOOK COMPUTER HELP DESK**Brooklyn Campus**

Rogers Hall, Room 117

Tel: 718/260-3368

Fax: 718/260-3188

E-mail: notebook@poly.edu orjsiandre@poly.edu

Hours: Monday–Friday, 8AM–6PM

Long Island Campus

Administration Bldg., Room 217

Tel: 631/755-4276

Fax: 718-260-3188

E-mail: notehook@poly.edu orjsiandre@poly.edu

Hours: Monday–Friday, 10AM–4PM

Westchester Graduate Center

Administration Bldg.

Tel: 914/323-2000

Fax: 914/323-2010

E-mail: westinfo@west.poly.edu

Hours: Monday–Friday, 9AM–5PM

UNIVERSITY RELATIONS**Brooklyn Campus**

Jacobs Bldg., Room 551

Tel: 718/260-3400

Fax: 718/260-3084

E-mail: univ_rel@poly.edu

Hours: Monday–Friday, 9AM–5PM

WEBMASTER*www.poly.edu/webmaster/index.cfm***Brooklyn Campus**

Dibner/CATT Bldg., Room 108

Tel: 718/260-3902

Fax: 718/260-3136

E-mail: webmaster@poly.edu

Hours: Monday–Friday, 9AM–5PM

2001-2003 ACADEMIC CALENDAR

FALL 2001

Tuesday-Thursday, August 28–30
Registration

Monday, September 3
SCHOOL CLOSED—Labor Day

Tuesday, September 4
Classes begin

Monday, September 17
NO CLASSES AFTER 3:35 PM

Tuesday, September 18
NO CLASSES

Wednesday, September 26
NO CLASSES after 3:35 PM

Thursday, September 27
NO CLASSES

Thursday, November 15
Last day to withdraw from course with a W grade

Wednesday, November 21
Thursday classes meet—No Wednesday classes (make-up for Thanksgiving Day)

Thursday–Friday, November 22–23
SCHOOL CLOSED—Thanksgiving recess

Friday, December 7
Day classes end

Monday, December 10
Monday evening classes meet (make-up for September 17)

Tuesday, December 11
Wednesday evening classes meet (make-up for September 26)

Monday–Wednesday, December 10–12
Reading days

Thursday–Friday, December 13–21
Final exams

Monday–Monday, December 24–31
SCHOOL CLOSED—Winter recess

Monday–Friday, January 7–18
Winter mini-session

SPRING 2002

Monday–Thursday, January 14–17
Registration

Monday, January 21
SCHOOL CLOSED—
Martin Luther King Jr. Day

Tuesday, January 22
Classes begin

Monday, February 18
NO CLASSES—President's Day

Monday–Friday, March 25–29
NO CLASSES—Spring break

Tuesday, April 2
Last day to withdraw from course with a W grade

Tuesday, April 30
Classes end

Wednesday–Friday, May 1–3
Reading days

Monday–Wednesday, May 6–15
Final exams

Thursday–Thursday, May 16–30
Summer mini-session

Monday, June 3
Commencement

SUMMER 2002

Monday, May 27
SCHOOL CLOSED—Memorial Day

Thursday–Friday, May 30–31
Registration

Monday, June 3
Classes begin for X and Z sessions

Thursday, June 27
Last day to withdraw from X session course with a W grade

Monday, July 1
Thursday classes meet—No Monday classes (make-up for Independence Day)

Thursday, July 4
SCHOOL CLOSED—
Independence Day

Monday, July 15
Classes end for X session

Tuesday, July 16
Classes begin for Y session

Thursday, July 25
Last day to withdraw from Z session course with a W grade

Friday, August 9
Last day to withdraw from Y session course with a W grade

Monday, August 26
Classes end for Y and Z sessions

FALL 2002

Monday–Wednesday, August 26–28
Registration

Monday, September 2
SCHOOL CLOSED—Labor Day

Tuesday, September 3
Classes begin

Friday, September 6
NO CLASSES AFTER 3:35 PM

Saturday, September
NO CLASSES

Monday, September 16
NO CLASSES

Tuesday, September 17
Monday classes meet—No Tuesday classes

Monday, October 14
NO CLASSES—Columbus Day observed

Wednesday, October 16
Monday classes meet—No Wednesday classes

Friday, November 15
Last day to withdraw from course with a W grade

Thursday–Friday, November 28–29
SCHOOL CLOSED—Thanksgiving recess

Saturday, December 7
Classes end

Monday–Wednesday, December 9–11
Reading days

Thursday–Thursday, December 12–19
Final exams

Wednesday–Wednesday,
December 25–January 1
SCHOOL CLOSED—Winter recess

Monday–Friday, January 6–17
Winter mini-session

SPRING 2003

Monday–Wednesday, January 13–15
Registration

Monday, January 20
SCHOOL CLOSED—Martin Luther King Jr. Day

Tuesday, January 21
Classes begin

Monday, February 17
NO CLASSES—President's Day

Monday–Friday, March 17–21
NO CLASSES—Spring break

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

Monday, May 5
Classes end

Tuesday–Thursday, May 6–8
Reading days

Friday–Friday, May 9–16
Final exams

Monday–Monday, May 19–June 2
Summer mini-session

SUMMER 2003

Wednesday–Thursday, May 28–29
Registration

Monday, May 26
SCHOOL CLOSED—Memorial Day

Tuesday, June 3
Classes begin for X and Z sessions

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

Friday, July 4
SCHOOL CLOSED—Independence Day

Tuesday, July 15
Friday classes meet— No Tuesday classes (make up for Independence Day)

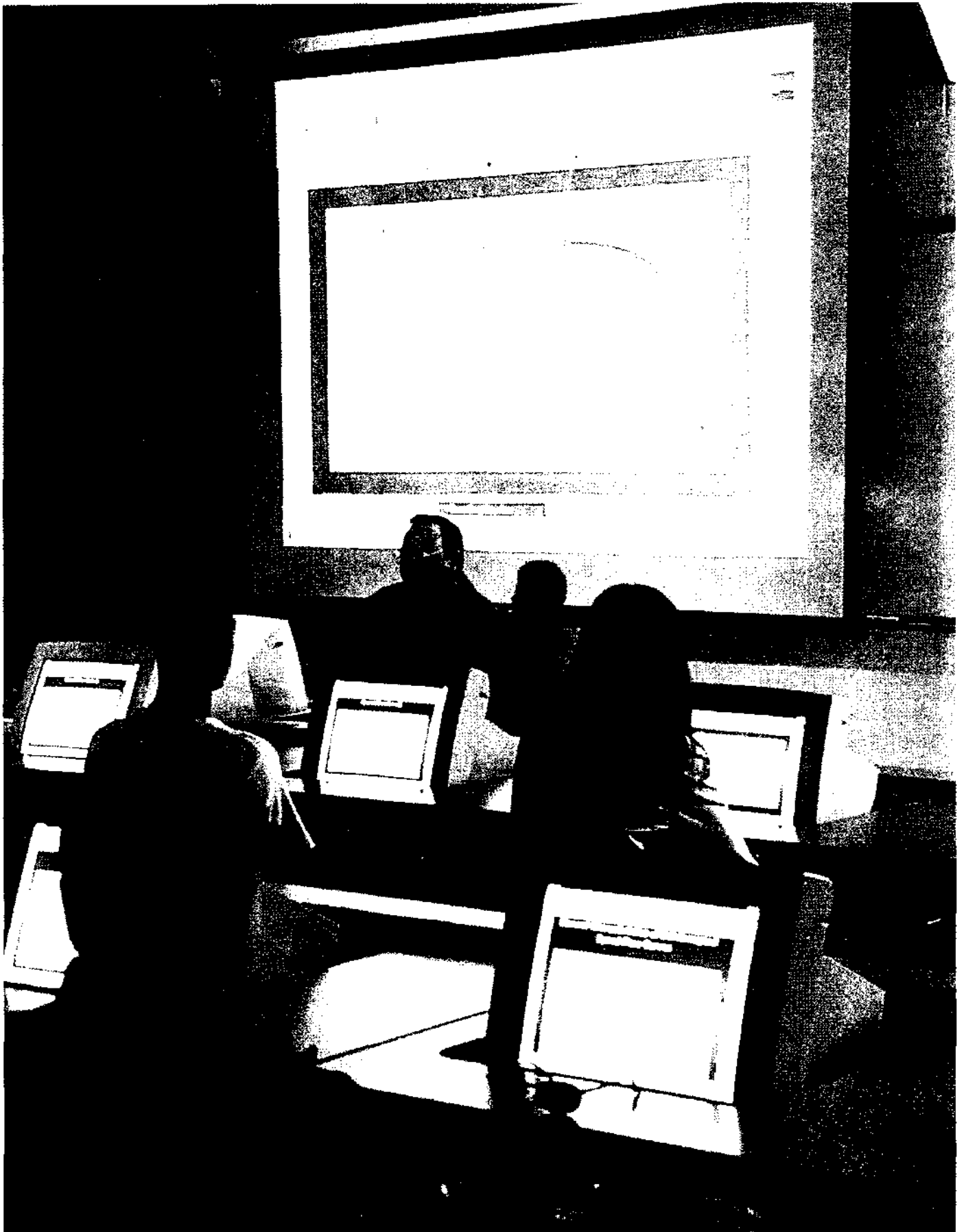
Tuesday, July 15
Classes end for X session

Wednesday, July 16
Classes begin for Y session

Wednesday, July 23
Last day to withdraw from Z session course with a W grade

Wednesday, August 13
Last day to withdraw from Y session course with a W grade

Wednesday, August 27
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 over 1,700 undergraduates and almost 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 to study at Polytechnic as well. Nineteen percent of the undergraduate population are women; 10 percent are black, 6 percent Hispanic and 39 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 PhD 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 outstanding 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 1869, the Board of Regents authorized Polytechnic's collegiate department to confer the degrees Bachelor of Science and Bachelor of Arts, the first of which were conferred in 1871. In 1889, the institution adopted the name Polytechnic Institute of Brooklyn and, in 1901, offered its first degree Master of Science. In 1917, the Institute separated from the preparatory department, which moved and renamed itself. An evening graduate program was instituted in 1926, and Polytechnic's first PhD was granted in 1935.

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 Topp Othmer, the largest single cash gift ever made to an 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, as Polytechnic redirects its education programs, refocuses graduate programs on Long Island, upgrades its classrooms and laboratories and broadens wireless computing capabilities throughout the University. A new academic building with athletic facility is currently under construction on the Brooklyn campus, as well as the campus' first residence hall.

ACADEMIC PROGRAMS

Polytechnic offers the degree Bachelor of Science in 11 disciplines, covering computer science, engineering, the physical sciences, mathematics and liberal arts. The degree Master of Science is offered in 28 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

Faculty in the University 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 two cooperating departments). Instructional laboratories and some research laboratories are 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 Engineering, Chemistry and Materials Science
- 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 2000, Polytechnic University conducted over \$9.5 million of sponsored research under contracts and grants, of which 78 percent were funded by the federal and state governments and 22 percent by private industry. Over 75 faculty members were involved in these efforts, which also provided support for over 70 research fellows. Research at Polytechnic is conducted either through academic department structures, or through one of the major interdisciplinary research centers.

Many of these research centers sponsor continuing 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. W²RI, PRI and TRI 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 Department of Chemical Engineering, Chemistry and Materials Science 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 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.

CENTER FOR CONSTRUCTION MANAGEMENT TECHNOLOGY (CCMT)

The primary mission of the Center for Construction Management Technology (CCMT) is to employ 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 future Master of Science in Civil Engineering (Construction) will draw 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 and three-dimensional Computer Assisted Design (CAD).

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, please e-mail philtech@poly.edu.

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.

INSTITUTE FOR TECHNOLOGY AND ENTERPRISE (ITE)

The Institute for Technology and Enterprise (ITE), supported by the Department of Management, is New York City's premier research and education hub for bridging management and technology-enabled innovation.

Through ITE's state-of-the-art and growing portfolio of learning materials, programs and research activities—and based on the findings of high-quality scholarship and the lessons of pacesetter business practices—the institute nurtures and builds managerial knowledge needed for success in today's technology-intensive competitive arenas. ITE focuses on such key areas as modern technology and innovation management, e-business in established firms and new enterprises, technology entrepreneurship and value creation and management in

information-intensive and knowledge-intensive sectors.

ITE functions as a high-level research and development "engine" for the Department of Management. ITE is also a unique starting point for firms embarking on major managerial changes or transformation that modern, especially digital-based, innovation requires. In fulfilling these roles, ITE designs and hosts a series of regional and international round tables, workshops and conferences and sponsors extensive research and curriculum development—all of which are incorporated into various departmental programs as well as into programs at other institutions.

ITE is located in the heart of Manhattan's high technology and financial districts at the New York Information Technology Center, 55 Broad Street. The location enables ITE to be a broad-based learning gateway for companies and managers into high-tech New York and beyond.

For further information on ITE, call 212/547-7030, fax 212/547-7029, e-mail: ite@poly.edu or visit Web site www.ite.poly.edu.

INSTITUTE OF IMAGING SCIENCES (IIS)

Imaging sciences are concerned with all aspects of information presented in visual form. Founded in 1981, the Institute of Imaging Sciences is currently specializing in the science of photoactive materials. IIS is a national leader in this subject area.

NSF 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.

POLYMER RESEARCH INSTITUTE (PRI)

The Polymer Research Institute (PRI) was founded in 1943 by Dr. Herman F. 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 Dr. Ilan Juran.

The Institute currently involves the following four centers:

- Urban ITS Center (UITSC); Director: John C. Falcochio (<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: 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). It's principal investigator in that partnership is John C. Falcochio.

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. Under the leadership of director Dr. Henry L. Bertoni, 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 and Science conduct the research.

FACULTY

The heart of Polytechnic is its distinguished teaching and research faculty. There are more than 480 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 160. 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 semester 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 POLYTECHNIC ALUMNI supports chapters established by alumni to provide opportunities for formal and informal alumni gatherings and to represent Polytechnic in the community. Currently, 14 chapters exist worldwide. Alumni are also encouraged to 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.

Alumni are entitled to audit Polytechnic courses at reduced tuition and use the Bern Dibner Library for Science and Technology. Alumni may also open a free Polytechnic e-mail account.

Cable, the alumni publication of Polytechnic University, 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 offers tickets for Broadway shows and opera concerts and sponsors yearly international trips at a discount. Most importantly, through its numerous activities, the POLYTECHNIC ALUMNI provides opportunities for alumni to maintain ties to each other and the University.

CAMPUSES

**The Brooklyn Campus
Six MetroTech Center
Brooklyn, NY 11201
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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 Academy of Music and the

Brooklyn Museum. The Brooklyn campus forms the nucleus of MetroTech Center, the largest urban university-corporate park in the United States. Launched in 1982, 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:

- **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 co-tenant of the building in 1992.
- **Chase Manhattan Bank** opened two major office facilities totaling approximately 1.5-million square feet in 1992. The buildings house its U.S. technology and operations functions.
- **The 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.
- **Other MetroTech companies** include the New York City Fire Department Headquarters 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, and Polytechnic maintains a small parking facility.

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

- **Rogers Hall** is the main academic building and named after the late Harry S. Rogers, Polytechnic's fifth president. The building houses faculty and administrative offices, classrooms, research and teaching laboratories and student areas. Starting in 1999, it underwent significant improvements and renovations. Three new facilities opened during the 2000–2001 academic year: a 9,000-square-foot interdisciplinary laboratory for undergraduate students in civil, chemical and mechanical engineering; an undergraduate lab center for the Department of Computer and Information Science; and a new facility for Polytechnic's computing infrastructure, containing all of the University's central servers and system monitoring software. A new Student Union opens in September 2002 and comprises an expanded cafeteria, quiet study lounge, bookstore and orientation center. By the end of the 2002–2003 academic year, Rogers Hall's elevators, bathrooms, windows and exterior appearance have received major makeovers.
- **The Bern Dibner Library for 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, a prominent Polytechnic alumnus, trustee and benefactor; the prestigious research center, CATT; and the Departments of Management, Electrical and Computer Engineering, and Computer and Information Science.
- **The Joseph J. and Violet J. Jacobs Building** opens for classes in fall 2002. Named after Dr. Jacobs, alumnus, former chairman of the Polytechnic Board of Trustees and major benefactor, and his wife, the eight-story building will contain a complete athletic facility on the first two floors and state-of-the-art classrooms and laboratories on the top floors. The athletic facility will include a basketball court, marital arts rooms and complete locker rooms. The academic floors will include lecture halls, laboratories for chemistry, biology and environmental engineering, a general engineering classroom and studio classrooms, equipped with audiovisual equipment and student computer stations tied to a dedicated server supporting state-of-the-art software.
- **The Donald F. and Mildred Topp Othmer Residence Hall** opens in fall 2002. The 18-story building is named after Dr. Othmer, a longtime Polytechnic professor of chemical engineering, and his wife, who, in 1998, bequeathed the University \$175 million, the largest single cash gift ever made to an American university. The residence hall will house 400 students in 100 four-student suites with kitchenettes and data, voice and cable television ports for every student. The building will include student lounges, study rooms, laundry facilities, health offices and storage space. A professional housing staff, made up of graduate student resident assistants and security personnel, will supervise the students and building 24 hours a day.
- **The Clifford H. Goldsmith Student Activities Union/Joseph W. and Samuel Wunsch Student Center Building** 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 a stop on the Underground Railroad for slaves. Polytechnic bought the property in 1968 and closed it for renovation in 1990 when MetroTech construction began. It was authentically restored through the generosity of the Wunsch family, in memory of brothers and Polytechnic alumni Joseph and Samuel Wunsch, and reopened in 1996. The center's student activity rooms were built with donations in tribute to Clifford H. Goldsmith, vice chairman of the Board of Trustees. It now houses student government, student publications and cultural and social organizations. In addition, the building provides students with fitness facilities, a television room and a lounge. The Offices of Athletics and Physical Education and Student Activities and Leadership Development are also located in this building.
- **The Joseph J. Jacobs Administration Building** is named after Dr. Jacobs. The building contains offices for administration, including the president, provost,

and vice presidents. Most student service offices are also located in Jacobs, including admissions, student accounts and records, financial aid, student development and career services, as well as alumni, university relations and development. Many business-related functions are hosted in Jacobs' Silleck Lounge.

The Long Island Campus

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Polytechnic is consolidating its undergraduate operations into its MetroTech campus in Brooklyn. The last entering class of undergraduates to the Long Island campus is September 2001, with the entering class scheduled to transfer to MetroTech and its new dormitory and academic building in September 2002.

This consolidation at the undergraduate level enables the University to focus on Long Island's needs for graduate education. The center of activity will continue to be the Route 110 corridor on Long Island that will serve as the headquarters for the new Long Island Graduate Center. Polytechnic is expanding its graduate part-time evening offerings and is planning continual innovation to meet the needs of Long Island.

Long Island has a technology-based economy and society. The focus used to be aerospace and defense electronics but is now information sciences, knowledge workers and biotechnology. The keystone in these volatile and growing areas is education, re-education and continuing education. Polytechnic is dedicated to continuing to deliver outstanding graduate programs for working professionals on Long Island.

In response to these needs Polytechnic is developing new courses offerings, including:

- Special offerings based upon a New York State-approved interdisciplinary program leading to the Master of Engineering degree. The first structured offering under this degree focuses on wireless innovation
- Executive format programs offered on weekends
- On-site degree programs at company locations
- Distance learning programs
- Alternative locations as need and opportunity suggest

The current Long Island campus is located on 25 acres on Route 110 near the Nassau-Suffolk border, at the economic center of the two suburban counties. Twenty-five percent of Polytechnic's undergraduates are located at this campus, and one-third of those live in the three residence halls. The undergraduate programs are in several engineering disciplines, computer science and information management at this campus.

Approximately one-sixth of all Polytechnic's graduate students pursue their degrees in engineering, computer science and technology-related management at this campus.

The Long Island Campus Advisory Board includes members from Symbol Technologies, Computer Associates, Spectrum Information Technologies, Shah Associates, Long Island Business News and Marketspan. 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 campus, Polytechnic interacts with Long Island industry through its Center for Advanced Technology in Telecommunications, its Weber Wireless Research Institute and other research efforts. The aerospace research facilities, unique in the region, are located on the campus.

The following are the campus' primary facilities:

- **The Main Building** houses administrative and faculty offices, support services, classrooms, library, cafeteria and several undergraduate laboratories. Also located in the building are the distance learning facilities, wireless communications laboratory and controls/robotics lab. The library stresses global access, using Internet search capability and specialized computer services, as well as a collection matching the academic concentrations.
- **The Bassett Building** is named after alumnus Preston R. Bassett, former chairman of Republic Aviation, and houses the admissions office, bookstore, student societies and clubs, the Jasik Undergraduate Lounge, the Weber Wireless Research Institute and the Department of Mechanical, Aerospace and Manufacturing Engineering. The building also contains the electric vehi-

cle laboratory, the civil/environmental laboratory and spaces for incubator businesses in electronics and software.

- **The Three Residence Halls** are located at different points on the campus. West Hall primarily houses freshmen, in two distinct areas (by gender), with two students per room. North Hall primarily houses sophomores, also with two students per room. East Hall houses others in suites accommodating four to five students. All residence halls have in each room or suite cable television, campus phones and fiber-optic connections to the computer network.
- **The Gymnasium** serves as a recreational facility for students on-campus and the home court for a number of Polytechnic's intercollegiate teams. It includes a weight room, ping-pong and pool tables and a basketball court.

Other facilities include a baseball field, a soccer field, two tennis courts, a beach volleyball court and an outdoor basketball court.

The 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 more than 25 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 of Science 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 popular Master of Science degree program in Information Systems Engineering (ISE). ISE is offered in the Executive Degree Program format, where classes meet on alternate Fridays and Saturdays over four semesters. Students complete their degrees in a total of 28 weekends over 20 months.

A modern facility, the Graduate Center is equipped with wired classrooms, an advanced computer laboratory with high-speed Internet connection and ample free parking.

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Polytechnic's Institute for Technology and Enterprise (ITE) is located in the heart of New York City's Silicon Alley and financial district and serves the area's burgeoning population of technology workers. It offers graduate courses in management, computer science, financial engineering and telecommunication networks. In the Executive Degree Program format, classes meet on Fridays and Saturdays of alternate weeks over a four-semester period. Students complete their degree in a total of 28 weekends over a 20-month period. The degree Master of Science is offered exclusively in the Executive Degree Program format and includes Management of Technology, Information Systems Engineering and Telecommunications and Computing Management.

POLYTECHNIC LIBRARIES

THE BERN DIBNER LIBRARY FOR SCIENCE AND TECHNOLOGY

The Bern Dibner Library for Science and Technology opened in 1992 on the Brooklyn campus. This state-of-the-art facility 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, or from other campus locations. Network jacks are also available throughout the library for users to connect their laptops by Ethernet cable.

The library offers electronic access from various instructional locations 24 hours a

day, seven days a week. Its resources are available through the main Polytechnic University Web site (www.poly.edu) or directly through the library's site (<http://dibner.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 provide additional opportunities for 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 (eight participating libraries), the New York Metropolitan Reference and Research Library Agency (over 300 participating 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 with over 4,000 participating libraries.

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

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

POLYTECHNIC COMPUTING FACILITIES

Polytechnic University has superlative computing facilities reflecting its course offerings in computer science and engineering and its role in educating and training knowledge workers of the future.

Beginning fall 2000, Polytechnic required its entering freshmen to lease a notebook computer from the University. By fall 2003, all undergraduate students will have notebook computers. Polytechnic has joined IBM's ThinkPad University. Each computer is equipped with the latest processor and hardware technology, relevant programs and wireless connectivity.

The heart of the Windows-based student notebook computer program is the software that the University licenses and installs in each computer. The software includes current releases of Auto Cad Lite, Labview Common Space, Matlab, Microsoft Front Page, Microsoft Internet Explorer, Microsoft Office Professional, Microsoft Project, Microsoft Visual Studio and Norton Antivirus.

Students with notebook computers access the University network through hard-wired ports located conveniently throughout the Brooklyn and Long Island campuses, most notably in the libraries and student lounge spaces. The University also provides access through a new state-of-the-art wireless network. Each student notebook contains a wireless card that permits campus-wide access to the Internet and University network.

In 2000, Polytechnic installed the Spectrum 24 Wireless local area network product. The 11-megabit-per-second product adheres to the current IEEE 802.11b wireless standard and is the highest speed wireless access currently available that meets the IEEE standard. The University will continue to migrate to the highest access speed meeting these professional standards.

In addition, the University has a robust gigabyte capable, 10/100-switched Ethernet network. It rivals all such university networks in the United States and the world. Through this, each student has access to an e-mail account and access to the Internet.

The notebook computers promote "congregate learning," in that students work in groups anywhere on campus and are no longer "tethered" to central computing laboratories. Students use the notebook computers to communicate to faculty and other students at any time and from any place on campus.

The Brooklyn and Long Island campuses each offer a Student Notebook Help Desk staffed by professional systems experts to provide support to all students with notebook computers.

At the start of the 2001-2002 academic year, undergraduates will be able to create their own Web page, called "My Poly," to examine their personal course information, student records, financial aid details and anything else they wish.

Students may use the computers in the University's central computer labs and various specialized labs, or they may dial in from home. Students living in residence halls on the Long Island campus have individual Ethernet connections to the University's networks. Students living in the Donald F. and Mildred Topp Othmer Residence Hall on the Brooklyn campus will have top-of-the-line voice, data and cable connections when the hall opens in fall 2002.

Polytechnic's Web site at www.poly.edu contains descriptions and Web pages for individual courses, academic departments, research centers, student activities and other features. Student may link their individual Web sites to Polytechnic's site.

The Brooklyn and Long Island campuses have central computer labs consisting of a collection of top-end personal computers running the Windows NT operating system. In addition, the central labs also have SUN SpareCenter servers running the Solaris (UNIX) operating system, giving students exposure to the most widely-used computing environments. Both campuses also have UNIX X-terminals for direct connection to the UNIX servers. All computers are networked, allowing students to take full advantage of a heterogeneous computer environment.

The software provided in the central computing labs include: Accolade, Adobe Acrobat, Adobe Illustrator, Adobe PageMaker, AutoCAD, Borland C++ Builder, Circuitmaker, Microsoft Front Page, Microsoft Office 2000, Microsoft Visual, Microsoft Windows 2000, Netscape Navigator, Object Ada, Primavera Project Planner and SPSS.

Students are encouraged to interact with their instructors either in person, through e-mail or, in some cases, through video conferencing. This allows students to have questions answered at almost any time from any location.

Several departments and laboratories have their own sub networks, which 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 Lab and the Freshman Engineering Labs.

The student chapters of the Association for Computing Machinery (ACM) provide support for students with questions as a volunteer service consistent with their mission.

Access to the computer network is available extensively during the week and weekends in the central labs and at all hours through dial-in or residential connections.

Students are also encouraged to take advantage of the many employment opportunities in the student notebook computer Help Desks and computing laboratories at Polytechnic. These jobs will help them with class work and future employment.

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 human and societal needs 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 mate-

rial 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

THE FAMILY EDUCATIONAL RIGHTS AND PRIVACY ACT (THE BUCKLEY AMENDMENT)

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

Specifically, these include students' right to:

- Inspect and review their education records
- Request the amendment of such records to ensure that they are not inaccurate, misleading or otherwise in violation of the student's privacy or other rights
- Consent to disclosure of personally identifiable information contained in their education records to the extent that Polytechnic's disclosure policy and directory information permits
- Obtain a copy of Polytechnic's policy on meeting the requirements of FERPA, available through the Office of the Registrar
- File with the U.S. Department of Education a complaint concerning alleged failure by the University to comply with FERPA

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

Polytechnic reserves the right to disclose the following information related to a student, which is considered directory information: the student's (1) name, (2) class year, (3) date/place of birth, (4) major field of study, (5) participation in officially recognized activities and sports, including weight and height of members of athletic teams, (6) dates of attendance at Polytechnic, (7) degrees and awards received, (8) most recent previous educa-

tional institution attended and (9) home and local addresses and telephone numbers, as well as any other similar information (e.g., the title of the student's master's project or doctoral dissertation, distinguished academic performance). Currently registered students who wish to withhold directory information may do so by following the directions in the Regulations on Privacy Rights for Students brochure available from the Office of the Registrar.

TRANSCRIPTS

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

Unless Polytechnic's disclosure policy permits otherwise, official transcripts of the scholastic record will be issued only upon the submission of a written request or upon the submission of a signed release from the student. Official transcripts will be sent directly to a school or other properly authorized parties. In no case can students receive official copies of their own transcripts, unless specifically authorized by the Registrar. Such exceptions are strictly monitored and are rarely given.

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

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 below.

SELECTION OF A MAJOR

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 Department of Introductory Design and Science.

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 minimize 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. The name of the minor will appear on students' transcripts if the approved 15 credits in the minor field have been completed with at least a 2.0 GPA. 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 elective 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 HU 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 1012 Calculus IA and MA 1022 Calculus IB in the first freshman semester. They may also be placed in one of the following courses when the test indicates a need for strengthening students' mathematical background:

MA 0902 Introduction to Precalculus	2 credits
MA 0912 Precalculus IA	2 credits
MA 0922 Precalculus IB	2 credits

These courses form a sequence and do not count toward degree requirements. Students must complete the sequence before starting the calculus program. Thus, students placed in MA 0902 must complete all three courses; students placed in MA 0912 must complete both precalculus courses; and students placed in MA 0922 must complete that course before entering the required calculus sequence.

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 deter-

mination 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, a writing learning center is located at the Brooklyn campus, 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 beginning 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 complete 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 insure that every engineering student is exposed to an appropriate mix of general preparatory courses in the liberal arts, mathematics and the basic sciences. It is also intended to 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 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 1 electives in two different disciplines and (2) one Level 2 elective. A Level 1 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: LA Liberal Arts, LW Law and TC Technical Communications.

(2) Mathematics Core

Every engineering student must take a minimum of 16 credits of study in mathematics.

The following courses are required of all engineering students:

MA 1012 Calculus IA	2 credits
MA 1022 Calculus IB	2 credits
MA 1112 Calculus IIA	2 credits
MA 1122 Calculus IIB	2 credits

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.

MA 2112 Multivariable Calculus I	2 credits
MA 2122 Multivariable Calculus II	2 credits
MA 2012 Elements of Linear Algebra I	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 0922 Precalculus IB must successfully complete this course before beginning the required sequence described above. Students placed in MA 0912 Precalculus IA must complete MA 0922 before beginning the required sequence. Likewise, some students may be placed into MA 902 Foundations of Algebra prior to taking MA 0912 and MA 0922.

(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 programs 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 part of the core 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 the following courses:

EG 1004 Introduction to Engineering	4 credits
CS 1114 Programming Methodology	4 credits
* Senior Design Project	4 credits

* Actual course code depends on department.

Transfer students 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.

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.

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. After the list is approved by the major academic department, it is mailed to students by the Registrar. Checklists are prepared for full-time students after they complete 80 credits. A revised checklist is issued to students who do not complete their degree program within a reasonable period after the initial checklist is mailed.

HONORS

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 toward 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 advisers.

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 all departmental offices.

APPLICATION PROCESS FOR THE BACHELOR OF SCIENCE

Students must file a formal application for the award of the degree Bachelor of Science from Polytechnic. Filing dates for each semester are published in the Schedule of Classes. Students who do not file by the published deadline dates become candidates for the next graduating class.

Applications for BS degrees 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.

Filing fees for diplomas are payable at the time of filing in the Office of Student Accounts. If the award of a degree is delayed, diploma fees are not charged again. By vote of the faculty, degrees are not awarded to members of the University teaching staff who hold the rank of assistant professor or higher.

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 Admissions and an adviser from the student's major department to determine the acceptability of individual substitutions and general acceptance of credits from their former institution(s). Much of this can be accomplished during the application process if 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

To provide students with alternative pathways to a BS degree in engineering and to facilitate the transfer process, Polytechnic has developed cooperative programs with other liberal arts and two-year institutions. Students completing approved programs at these institutions with sound academic

achievement are guaranteed admission to the University. Students interested in learning more about the cooperative programs should contact the Office of Admissions.

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

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 International Student Adviser prior to the last day of late registration each semester so that courses can be added to students' schedules if necessary.

Students in F-I and J-I status must also obtain written permission from the International Student Adviser to withdraw from classes, if the withdrawal will result in less than a full course load, or to take a leave of absence. The process of withdrawing or taking an official 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 Naturalization Service.

Failure to comply with the full course of study rule violates the non-immigrant student status and makes a student ineligible for any of the benefits of that status. According to the INS, 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**

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

** Only used in SL 1010 and SL 1020.

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

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.

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 or U for the semester, and are otherwise in good academic standing, are commended by the Office of Academic Affairs and placed on the Dean's List. This 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. Nondegree credit courses EN 1080 or EN 1090 may count toward the 12-credit requirement 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 Office of Academic Affairs.

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 students follow those for full-time students.

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

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
6	1.88
7	1.95
8	2.00
9	2.00
10	2.00

The Office of Academic Affairs 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 GPAs approach 2.0 are placed on academic warning. Letters are sent to these students warning them of potential problems, urging them to make use of the support services available to them, encouraging them to take whatever measures are necessary to maintain good standing and inviting them to meet with 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 suc-

cessful 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 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 Committee of Standing, comprising the Office of Academic Affairs 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 *Schedule of Classes* 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 *Schedule of Classes*.

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.

GRADUATE INTERNSHIPS

It is a University policy that MS students have an internship experience prior to receiving their degree. MS students should see their departmental adviser for the specific conditions that may be used to satisfy or waive this requirement.

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 1½ 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 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. 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 pro-

gram when they begin graduate study at Polytechnic. Detailed descriptions of the certificate programs are available from the responsible departments.

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. The following graduate advanced certificate programs are currently available:

- Achieving World Class Quality
- Bioinstrumentation
- Biomedical Materials
- Computer Engineering
- Construction Management
- Environment-Behavior Studies
- Executive Construction Management
- Financial Engineering
- Financial Technology Management
- Hazardous Waste Management
- Human Resource Management
- Image Processing
- Industrial Engineering
- Information Management
- Manufacturing Engineering and Production Science
- Manufacturing Excellence by Design: Holistic Approach
- Operations Management
- Organizational Behavior
- Risk Management
- Software Engineering
- Technical Communications
- Technology Management
- Telecommunication Network Management
- Telecommunications Management
- Traffic Engineering
- Transportation Management and Economics
- Transportation Planning
- Wireless Communications

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 Credit

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 fulfill the 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 Credit

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.*

Full-Time Equivalency for Graduate International Students

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 International Student Adviser 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 also obtain written permission from the International Student Adviser to withdraw from classes, if the withdrawal will result in less than a full course load, or to take a leave of absence. The process of withdrawing or taking an official 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 Naturalization Service.

Failure to comply with the full course of study rule violates the non-immigrant student status and makes a student ineligible for any of the benefits of that status including Optional Practical Training. According to the INS, 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 until they are completed, at which time 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 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 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.

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. A written policy on graduate probation and disqualification is available from the Office of Academic Affairs.

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

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

N>36. GPA>3.00 required (check every 6 credits)

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 student with a written statement of the academic performance required for the next academic year or semester to retain permission to register in future semesters. The statement will be kept on file in both the Office of 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 *Schedule of Classes* 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 *Schedule of Classes*.

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. Filing dates for each semester are published in the *Schedule of Classes*. Students who do not file by the published deadline dates become candidates for the next graduating class.

Applications for the MS degree 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.

Filing fees for diplomas are payable at the time of filing in the Office of Student Accounts. If the award of a degree is delayed, diploma fees are not charged again. By vote of the faculty, degrees are not awarded to members of the University teaching staff who hold the rank of assistant professor or higher.

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. 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 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.

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 otherwise, its basis as a Polytechnic University dissertation.

CAMPUS LIFE AND SUPPORTING SERVICES

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 Overnight and the freshman seminar (SL 1010)
- Student activities
- Student leadership development
- Counseling, advising and student advocacy
- Health insurance coordination
- Disciplinary policy administration
- Services for students with disabilities
- New York State Immunization requirements

OFFICE OF ACADEMIC SUCCESS

The mission of the Office 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 Office of Academic Success and key offices overseen by the Office of Student Affairs.

The Office 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. Adviser training

and faculty workshops provide further support. The office oversees the following academic support services: Academic Advisement Center, the Learning Center, the Math Help Center, the Writing Center, Counseling Services, Office of Special Services and the Higher Education Opportunity Program (HEOP).

OFFICE OF SPECIAL SERVICES

The Office of Special Services provides counseling and tutoring of Polytechnic students. The office is a TRIO program funded by the United States Department of Education. Therefore, some students requesting assistance must first meet eligibility guidelines. All tutorial, educational and support services are provided free of charge.

Personal counseling is available to assist students in managing the challenges of university life as well as common difficulties such as depression, anxiety and family and relationship problems. 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.

An individualized tutoring program is available to students. The office staff assigns qualified upperclassmen to tutor students one-on-one in physics, calculus, 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.

ACADEMIC ADVISEMENT CENTER

The mission of the Academic Advisement Center is to provide centralized advising for all incoming, matriculated freshman and 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.

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 their respective academic offices. 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.

THE LEARNING CENTER

The Learning Center offers assistance to students who are having difficulty in freshman- and sophomore-level courses in chemistry, physics, calculus and computer science. Tutoring is offered on a small-group basis by a staff of carefully selected and trained upperclassmen who are skilled in their subjects. A schedule is devised each semester to make small-group tutoring available to as many students as possible. Students are encouraged to sign up for groups early in the semester and are expected to attend sessions weekly. In addition, the office schedules some drop-in sessions and exam review sessions.

THE MATH HELP CENTER

Help in mathematics is offered on a flexible basis to support the development of mathematical problem-solving skills for freshman and sophomore level MA courses. This service helps students make the transition from a high school math education to the rigorous mathematics curriculum necessary for technical education at the university level. The center contributes to student success in math courses, and success with mathematics and logic as applied to engineering, computer science and other technical fields.

THE WRITING CENTER

The Writing Center provides individual and small-group consultation in writing and speaking for undergraduate and graduate students. This support is available for any writing or speaking assignment, whether in humanities, social sciences, EG 1004 Introduction to Engineering and Design or any scientific or technical subject, from beginning levels through doctoral dissertations. Help is also available for writing letter, résumés and other career-related documents. Both native English speakers and multilingual speakers are helped in the Writing Center, with conversation and pronunciation practice offered for multilingual speakers.

OFFICE OF 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 their abilities and interests
- Being provided experiences and services that give opportunities to apply their skills and academic background in paid and nonpaid work assignments
- Deciding whether to pursue graduate study or full-time employment

- Making a successful transition from the academic setting to the business, government and industrial sectors

Students at every academic level are encouraged to speak with 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 the more than 200 companies that recruit on campus annually. These companies conduct more than 1,500 interviews yearly, resulting in employment for many of our graduates. The placement rate for Polytechnic students who graduated in 2000 was 96 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 on a limited basis.

COOPERATIVE EDUCATION

Beginning in the sophomore year, students may participate in the Cooperative Education Program. Students whose academic programs permit may take a semester off from classes and work full time with a co-op employer. Students may also apply for part-time positions with local employers. Co-op gives students the advantage of gaining needed job experience before graduation while exploring their career goals. This experience contributes to a student's ability to make career decisions, motivates academic performance and provides a competitive advantage in the workplace. Please see "Cooperative Education Program" in Part 4 of this catalog for more details.

COUNSELING SERVICES

College students face a range of situational or personal roadblocks that may interfere with their ability to succeed academically. The University is committed to assist students in addressing these concerns. Free confidential counseling is available through the Office of Special Services. Typical areas of concern include study habits, adjustment problems, stress management, relationship difficulties, depression and anxiety.

If deemed necessary, referrals to off-site (low cost) services are made.

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 overnight orientation program in the fall, on-campus new student orientation days in the fall and spring semesters, programs for parents of freshmen and other social activities in addition to SL 1010 Freshman Seminar (see following section).

These orientation events provide a vital link for securing a strong relationship with the Polytechnic community. For example, in August of every year, the New Student Overnight, which takes place at an off-campus facility, brings together Polytechnic faculty, administrators, staff, alumni, upper-class students and new students. This unique interaction allows students to become familiar with faces in the Polytechnic community before they begin classes. The event is offered at no additional cost and is open to both undergraduate transfer students and freshmen.

FRESHMAN SEMINAR (SL 1010)

The Freshman Seminar (SL 1010[®]) is required for all entering first-year college students with fewer than six transfer credits. It is an extended orientation to the academic and social challenges of higher education and a preparation for the critical choices and decisions college students must make.

[®] SL 1010 is a zero-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
- Health and wellness (including stress management and alcohol and drug issues)

OFFICE OF ACADEMIC AFFAIRS

The Office of Academic Affairs directs the review of graduate students' progress each semester to determine academic standing. The office makes decisions regarding probation and sends notifications to the students and their respective academic departments. Graduate students are directed to meet regularly with their advisers to discuss academic progress and address questions concerning their academic standing.

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 mat-

ters. A student's adviser must sign all registration, program adjustment and course withdrawal forms.

GRADUATE ADVISERS

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

INTERNATIONAL STUDENTS AND SCHOLARS

Graduate and undergraduate international students are from more than 25 countries and make up 9 percent of the student body. They are an integral part of the Polytechnic community. All new international students and visiting scholars are required to report with immigration documents, including I-20's, IAP-66's and passports, to the Office of International Students and Scholars 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 regarding immigration compliance, travel, employment, acculturation, housing, health insurance and special events. International students may contact the office in person on the Brooklyn campus. Students on the Brooklyn, Long Island, Westchester and Manhattan campuses may contact the office by telephone, and are encouraged to attend on-site counseling offered at designated times during the academic year.

For additional information regarding admissions, please consult those sections dealing with undergraduate and graduate admissions.

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 nec-

essary 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.

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 Student Development.

ALCOHOL AND DRUGS

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

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

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.

ACCIDENT AND SICKNESS INSURANCE

Currently, all full-time students (graduate and undergraduate) are covered by accident insurance, at no additional charge. Complete health insurance coverage is mandatory for all students and may be provided through a private policy or the University's insurance program.

Information on the Polytechnic accident insurance (free for all full-time students) and sickness insurance (additional fee) policies is sent annually to full-time students. To receive these materials or further information, contact the Office of Student Development. Spouses and dependents of full-time students are eligible for insurance coverage.

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

GUIDELINES ON STUDENT RELIGIOUS OBSERVANCES

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

- 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 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.

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

For a 2000 cohort study of first-time, full-time students, the fall 1996 entering class had a four-year graduation rate of 32 percent, while 46 percent of the entering class of fall 1995 graduated within five years and 58 percent of the entering class of fall 1994 graduated within six years.

ATHLETICS

For information on intercollegiate and intramural athletics, please consult the section titled "Physical Education and Athletics," in Part 4 of this catalog.

Recreational activities are offered on the Long Island campus in the gymnasium and on the Brooklyn campus in Wunsch Hall and at the Brooklyn Friends Gym, located one block from campus. Contact the Office of Physical Education and Athletics for more information.

In fall 2002, the Brooklyn campus will open its new athletic facility, which will include a gymnasium, fitness center, locker rooms and athletic departmental offices.

CO-CURRICULAR STUDENT ACTIVITIES

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

ORGANIZATIONS AND ASSOCIATIONS

There are more than 50 student organizations, honors societies and fraternities 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.

STUDENT GOVERNMENT

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

PROFESSIONAL AND DEPARTMENTAL SOCIETIES

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

Participating Societies

- American Chemical Society
- American Institute of Aeronautics and Astronautics
- American Institute of Chemical Engineers
- American Society of Civil Engineers
- American Society of Mechanical Engineers
- Association of Computing Machinery
- Institute of Electrical and Electronics Engineers

National Society of Black Engineers
National Society of Professional Engineers
Society for Human Resource Management
Society of Automotive Engineers
Society of Hispanic Professional Engineers
Society of Physics Students
Society of Women Engineers

HONOR SOCIETIES

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

Participating Societies

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

FRATERNITIES AND SORORITY

Polytechnic has four social and service fraternities and one social sorority. One of them, Lambda Chi Alpha, owns property in the Brooklyn area and offers live-in accommodations. The fraternities and sorority 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.

Fraternities

Alpha Phi Delta (social)
Alpha Phi Omega (service)
Lambda Chi Alpha (social)
Omega Phi Alpha (social)
Tau Delta Phi (social)

Sorority

Sigma Phi Lambda (social)

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.

Social, Cultural, Religious and Other Organizations

Asian Student Association
Association of Latin American Students
Biomedical Engineering Society
Chess Club
Chinese Student Society
Chinese Students and Scholars Association
Construction Management Association
Demokritos (Greek Club)
Financial Engineering Association
Haitian Student Association
Hong Kong Student Association
Indian Pakistani Organization
Jewish Student Union
Korean Student Association
Malaysian Student Association
Muslim Student Association
Polytechnic Anime Society
Polytechnic Electronics & Robotics Club
Polytechnic Gamers Association
Polytechnic Interservice Christian Fellowship
Polytechnic Italian Cultural Club
Programming Advisory Board
Resident Hall Association
Russian Student Club
Society of Human Resource Management
South Asian Student Association
Taiwanese Culture Club
Vietnamese Student Association
Weightlifting Club

PUBLICATIONS

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

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 matriculated, full-time, undergraduate and graduate students. It is not appropriate for married students seeking housing for their families. Inquiries about campus housing should be made to the Office of Student Affairs at 718/260-3137.

CAMPUS HOUSING AT THE LONG ISLAND CAMPUS

There are three residence halls on the Long Island campus, accommodating approximately 145 students. West Hall primarily houses freshmen, in two distinct areas (by gender), with two persons per room. North Hall primarily houses sophomores, also with two students per room. East Hall houses others in suites accommodating four to five persons.

All residence halls have laundry facilities and a common area. Students participate in a meal plan; small refrigerators for convenience items are allowed in each room; the common area has a microwave. The cafeteria is in the main building.

All residence halls have in each room or suite cable TV, campus phones and fiber optic connections to the computer network, with basic service provided at no additional cost.

CAMPUS HOUSING SERVICE AT THE BROOKLYN CAMPUS

At the Brooklyn campus, housing is offered off campus to students in cooperation with the **Richard L. Conolly Residence Hall** at Long Island University. This facility has trained professional and student staff, who work and live in the residence halls.

Richard L. Conolly Hall is five blocks, and a 10-minute walk, from Polytechnic. It houses undergraduate students; however, graduate students may choose to live at Conolly Hall as well. First-time residents are usually placed in standard double occupancy rooms. A standard 12' x 20' room has two wardrobes, chests of drawers, desks, and beds. Conolly Hall, which houses up to 600 students, is open year-round. All rooms, and most floors, are single-gender. Common bathroom and shower facilities are located on each floor. Where floors are coed, separate facilities are provided. The meal plan is mandatory. Other facilities within the residence hall include a personal computer laboratory equipped with IBM personal computers and a multipurpose game room with pool table, vending machines and television. Dining room and coin-operated laundry facilities are conveniently located on the premises.

In fall 2002, the first residence hall on the Brooklyn campus opens. **The Donald F. and Mildred Topp Othmer Residence Hall** will be an 18-story building, housing 400 students in 100 four-student suites with kitchenettes and data, voice and cable television ports for every student. The building will include student lounges, study rooms, laundry facilities, health offices and storage space. A professional housing staff, made up of a full-time director and an assistant director, graduate student resident assistants and security personnel, will supervise the students and building 24 hours a day.

CAMPUS HOUSING REQUIREMENTS

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

OFF-CAMPUS HOUSING OPPORTUNITIES

Students interested in off-campus housing may take advantage of announcements made available through the off-campus housing postings on bulletin boards at each campus. An off-campus housing fact sheet is available for the Brooklyn campus.

For more information, contact the Office of Student Affairs at 718/260-3137.

UNIVERSITY CODE OF CONDUCT

The University *Code of Conduct* is distributed regularly to all students by the Office of Student Development. 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.

To obtain a copy of the *Code of Conduct*, contact the Office of Student Development at 718/260-3800.

ADMISSIONS

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

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 must anticipate the need to take additional courses for which graduate credit may not be given. (See "Conditional Status.")

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

Graduate admission information can be obtained from the Office of Graduate Admissions, Polytechnic University, Six MetroTech Center, Brooklyn, New York 11201, 718/260-3200 or online at www.poly.edu/admissions.

ADMISSIONS PROCEDURES

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

EXAMINATIONS

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

Information about GRE and GMAT may be obtained from The Educational Testing Service, 20 Nassau Street, Princeton, New Jersey 08541.

INTERNATIONAL APPLICANTS

An international student must complete an application for admission by May 1 (fall admission), October 15 (spring admission) or March 1 (summer admission) to be reviewed for the term requested. 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 required of all international applicants who have earned a bachelor's degree from an institution in a non-English speaking country and/or speak English as a second language. The Test of Spoken English (TSE) is required of all teaching fellowship applicants from non-English speaking countries.

Certification of ability to meet financial obligations is also required.

STATUS

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

Regular Status

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

Conditional Status

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

Provisional Status

A graduate degree applicant whose file is lacking documents necessary for academic evaluation may be permitted to register for one semester with provisional status. The applicant must provide all required admission documents to the Office of Graduate Admissions before the sixth week of the semester. If the applicant is not accepted for admission, the semester can be completed or a withdrawal with full refund may be requested. Subsequent registration will not be permitted.

Special Status

An individual requesting permission to register for one or two courses in a specific semester is assigned special admission status. A formal application for admission may or may not have been filed with the Office of Graduate Admissions. Included in this status are individuals who want to take courses for professional advancement

or personal development, but who do not want to earn a degree; and part-time degree applicants with incomplete admission files. A maximum of 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 Office of Graduate Admissions.

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 Office of Graduate Admissions.

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: 718/260-3100
Fax: 718/260-3446
E-mail: admitme@poly.edu
Web: www.poly.edu/admissions

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 (SAT) or the American College Testing Program (ACT).

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

Full-time undergraduate study

November 1 – for the spring semester
February 1 – for the fall semester

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

The preceding timetable does not apply to international applicants. Because of the extra time required to process applications from abroad, consideration will not be given to 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 \$250 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 after May 1 for the summer or fall semester, nor after January 1 for the spring semester.

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

THE EARLY ADMISSION PLAN

On occasion, Polytechnic offers early admission to outstanding high school juniors. Programs can be arranged so that these students simultaneously satisfy high school requirements while completing their 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 (SAT). The American College Testing (ACT) Program may substitute the SAT. 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
Foreign Language	2
Science	4
<i>(Chemistry is required and physics is strongly recommended)</i>	
Mathematics	4
<i>(Sequential I, II, III, precalculus, calculus)</i>	
Social Studies	3
Electives	2

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

Interviews and Campus Tours

Prospective students are strongly encouraged to visit the campus. Arrangements can be made by calling the Office of Admissions at 718/260-3100. If arrangements are made in advance, prospective students are welcome to have an interview with a member of the admissions staff during their visit to Polytechnic.

Freshman Admission with Advanced Standing

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

Specific requirements for administering college credit, for 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 remedial 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 who have not completed two years of college work should submit official transcripts of previous college and high school grades, and SAT I or ACT scores. Students who have completed two or more years of college need only submit official college transcripts.

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

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

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 credits 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 apply annually to NYSHESC using the TAP Student Payment Application. Applications are available in the Office of Financial Aid and must be submitted prior to the May 1 deadline during the award year. TAP recipients will receive an award certificate from NYSHESC.

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) in March for the upcoming academic year.

There are four methods for completing the FAFSA as follows:

- Complete the FAFSA via the Internet by using "FAFSA on the Web" at www.fafsa.ed.gov.

- Complete the FAFSA electronically by using "FAFSA Express" software, which may be downloaded from the U.S. Department of Education at www.ed.gov/gov/offices/OSFAP/students/apply/fexpress.html.
- Complete the paper Renewal FAFSA, which is mailed directly to all students who applied for federal aid in the previous year.
- 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 "FAFSA on the Web" and "FAFSA Express," students must download the signature page, sign and submit to the U.S. Department of Education.
- 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 Employment determines eligibility. The Office of Career Services arranges the work schedules.

At Polytechnic, the average Federal work-study award is \$2,000 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 applying for financial aid at Polytechnic (including the Stafford Loan) are required to apply for a Federal Pell Grant. 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). 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; the standards are listed in the "Academic Policies" section of this catalog and are available in the Office of Financial Aid. All TAP recipients must achieve a 2.0 cumulative GPA after the completion of four full-time semesters of study. Students may apply for a one-time waiver of academic progress requirements; however, waivers are granted only under extraordinary circumstances. Contact the Office of Financial Aid 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-mandated 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 2.5 or 3.0 cumulative GPA (depending on the award) and apply for Pell and TAP.

Polytechnic awards the following scholarships:

Board of Trustees Scholarships

Awarded to academically superior freshmen. Scholarship amounts are equal to full tuition, less any outside aid for which students are eligible. Scholars must maintain a 3.0 cumulative GPA and apply for Pell and TAP. This award does not cover graduate study.

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 their outstanding graduates for a scholarship of \$10,000 per year. A Scholarship Committee selects recipients from among nominees. Scholars must maintain a 2.5 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 3.0 or 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 2.5 cumulative GPA, enroll full-time and apply for Pell and TAP. No separate application is required.

Polytechnic Grants

Awarded to disadvantaged students on a need basis. Students apply directly to the Office of Financial Aid by completing a FAFSA.

National Society of Professional Engineers Scholarship (NSPE)

Awarded to academically superior freshmen majoring in engineering. Awards are determined by NSPE and range up to \$1,500. Scholars must maintain a 2.5 cumulative GPA.

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
Michael Beltran Scholarship
Orrin Dodge Berry Scholarship
Eugene Blank Scholarship
Bleeker/Hinden Scholarship
Board of Trustees Scholarship
Joseph Bonmarito Scholarship
R. Brown Scholarship
Joseph Bucich Scholarship
Dr. George Bugliarello Scholarship
Salvatore E. Cannizzaro Scholarship
L. F. Case Foundation Scholarship
David and Cecilia Chang Scholarship
J. B. Chittenden Scholarship
The Claessens Family Scholarship
Arthur Clapp Scholarship
Philip Clark Scholarship
Class of 1942 Scholarship
Class of 1944 Scholarship
Samuel and Grace B. Cohen Scholarship
Davis/Durborow/Brierly Scholarship Fund
DeWitt Scholarship
Willard H. Dickinson Scholarship
Peter Dollard Scholarship
Aaron and Simcha Duhitzky Scholarship
W. E. Duryea Scholarship
A. S. Dwight Scholarship
Eirich/Morawetz Scholarship
Burton Erickson Scholarship
Bernard Farkas Scholarship
I. W. Fay Scholarship
J. Robert Fisher Scholarship
Harold and Martha Forstrom Scholarship
Sidney Friend Scholarship
Geiger-Fialkov Scholarship
Roger Gilmont Scholarship
Dr. Anthony B. Giordano Scholarship
Gordon Gould Scholarship
James D. Graham Scholarship
Ying Chavas Greene Scholarship
Francis and Mildred Hallenbeck Foundation Scholarship
William Randolph Hearst Scholarship
Alfred Helwig Scholarship
Herbert Henkel Scholarship
HTI Scholarship
F. M. Jabara Scholarship
Jephson Educational Trust Scholarship
Dr. Peter Kabasakalian Scholarship
Susan Kamen Scholarship
Jacob Kaplan Scholarship
Ade Howe Kend Scholarship
Nathan Kleinman Scholarship
Ping Ku Scholarship
Eugene R. Kulka Scholarship
John F. Kunc Scholarship

Dr. Irving Kuntz Scholarship
Dorothy Lemelson Scholarship
Litton Industries Scholarship
Lockheed Martin Scholarship
Helen T. Lowe Scholarship
Lyons Scholarship
Maggio Scholarship
P. R. Mallory Memorial Scholarship
Raymond Mauro Scholarship
Steven J. Meoli Memorial Scholarship
Dr. Herbert Morawetz Scholarship
Colonel Frank Mott Scholarship
Bonnie Nagler Scholarship
NEC Scholarship (in Dr. Sekimoto's honor)
William Nichols Scholarship
Nippon Electric Scholarship
Stanley Nisenson Memorial Scholarship
Nordheimer Scholarship
Theodore Nowak Scholarship
NSC-Eddie Mitchell Scholarship
NSS-Hughes Aircraft Co. Scholarship
Dr. John C. Olsen 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
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
Richard and Emily Sbaschnig Scholarship
Dr. John P. Schaefer Scholarship
Edward C. Schmidt Scholarship
Paul J. Schwanenflugel Scholarship
Mitsuzo Shida Scholarship
Silleck Family Scholarship
Skeist Scholarship
Frank R. and Emily E. Stammer Scholarship
Michael Stock Scholarship
William Stolze Scholarship
Solon Summerfield Foundation Scholarship
Wai Nam Tam Scholarship
Arlene and Irving Tasblich Scholarship
Arnold Thompson Scholarship
Robert Tsao Endowment Fellowship
USX Scholarship

FINANCIAL AID

Kenneth G. Van Wynen Scholarship
Dr. Ernst Weber Scholarship
Ernst and Sonya Weber Scholarship
Donald N. and Susan C. Weisstuch
Scholarship
Warren E. Winsche Memorial Scholarship
William Wishnick Scholarship
WSTA Scholarship
Howard J. and Audrey R. Wulfken
Scholarship
Edward H. Zucker Scholarship

OTHER OPPORTUNITIES

ROTC Scholarships

Army ROTC offers four-, three-, and two-year scholarships. The four-year scholarships are awarded on a worldwide competitive basis to U.S. citizens entering college as freshmen. The three- and two-year scholarships are awarded and aligned with an ROTC program. Students who attend basic camp for the two-year program may also compete for two-year scholarships. Scholarships pay for tuition, textbooks and lab fees, plus a living allowance of up to \$1,000 for each year of the scholarship.

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

Veterans Administration (VA) Educational Benefits

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.

Consult Part 4 of this catalog and 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

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 (NYSHE-ESC), 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 NYSHE-ESC for final processing. The loan amount is deducted directly from the tuition bill. NYSHE-ESC also deducts a 3 percent processing fee. All funds are sent directly to Polytechnic via electronic funds trans-

fer 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).

Edythe and Albert DeGaeta Scholars Loan Program

The Edythe and Albert DeGaeta Scholars Loan Program was established through a generous donation from Polytechnic alumnus Albert DeGaeta. The program assists undergraduate students based on financial need and academic standing. Scholars must maintain a 2.5 cumulative GPA, with the maximum award of \$4,000 per academic year. The current interest rate is 4.5 percent

with repayment beginning six months after graduation or when the student withdraws from school.

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 four types of payment plans: semester, monthly, deferred and third party.

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 finance charge accessed at the beginning of the plan on an annual basis. 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 finance charge accessed 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 scholarships and grants, combined with Pell Grant and TAP awards, 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 a 2.5 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 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.

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. For complete details about registration dates and procedures and course schedules, see the *Schedule of Classes* published prior to each registration period and available from the Office of the Registrar.

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 written 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 registrar prior to each registration.

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

Incoming freshmen are required to take Polytechnic placement exams in mathematics and English. These exams are free and 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. Graduate students, particularly those who work, are encouraged to take advantage of regular registration by mail or fax. Payment of tuition and fees, or arrangement for payment, is due to the Office of Student Accounts no later than the deadline date announced in the *Schedule of Classes*.

Late Registration: this usually takes place during the week preceding the start of classes. A late fee is assessed to all continuing students. There is no late registration for continuing undergraduate students in the fall registration cycle. All undergraduates must register during regular registration. Information is mailed to each continuing student who did not register during the regular registration periods for fall and spring. 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.

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

STUDENT IDENTIFICATION

All students are required to carry and maintain at all times photo-identification cards issued by the Facilities Department. The photo-IDs must be presented at each registration for validation. 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.

REFUNDS

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

TUITION AND FEES

Up-to-date and detailed information on tuition and fees as well as announcements of cost changes can be obtained from the *Schedule of Classes* available before the start of each semester. The schedule is an official supplement to this catalog. Tuition and fees are paid by term or all at once for the entire academic year.

TUITION COSTS

The following costs are in effect at the time of publication, beginning with the fall 2001 term.

Undergraduate students

Full-time (12–18.5 credits*)	
Each semester	\$11,140
Part-time (0.5–11.5 credits)	
Each credit/credit hour	\$708
Zero credit remedial courses	\$2,124

Graduate students

Each unit	\$765
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*All credits/units in excess of 18.5 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 libraries and the facilities of the Office of Student Life.

OTHER CHARGES AND FEES

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

Full-time	
Graduate/Undergraduate	\$330
Part-time	
Undergraduate	\$225
Graduate	\$150

Application Fee

Undergraduate	\$40
Graduate	\$45

Acceptance Deposit**

\$250

Alumni Audit Fee (per course)

\$600

Deferred Payment Fee

\$150

Payment Plan Enrollment Fee

\$75

Credit by Examination Fee (undergraduate courses)
per credit

\$75

Doctoral Dissertation

Microfilm Fee

\$75

Seminar Fees

Late Registration Fee

\$50

Validation Credit (graduate courses)
per unit

\$75

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

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

Other fees include the returned check fee, late payment penalty fee and, for transfer students, possible charges for supplies or kits. Details on these charges can be found in the *Schedule of Classes*.

All fees are nonrefundable.

HOUSING

Housing charges vary according to arrangements at Brooklyn and Long Island. For details, consult the Office of Student Development.

PAYMENT OF TUITION AND FEES

Each semester, tuition and fee payments are due in full from all students at the time of registration. * Payment in full refers to various methods, used alone or in combination, including cash, check, money order or credit card (Visa, 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, 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 *Schedule of Classes*, usually about one month prior to the start of classes.

PAYMENT OPTIONS

The University provides monthly, semesterly and yearly payment options. The monthly tuition payment plan is available 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 in the *Schedule of Classes* and available from the Office of Student Accounts.

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 finance charge assessed at the beginning of the plan on an annual basis. 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 finance charge 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.

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.*

Refund Appeals

Appeals for an exception to the refund schedule must be submitted in writing to the Office of the Registrar, 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 summer 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.

PLACEMENT STATISTICS

PLACEMENT RATE

CLASS OF 2000: 96%

AEROSPACE ENGINEERING

Average starting salary: \$48,000

Major Employers: Atlas Air, Electric Boat, ExxonMobil Corp., Gibbs & Cox, Lizardos Engineering, Northrup Grumman, Symbol Technologies, Inc.

CHEMICAL ENGINEERING

Average starting salary: \$54,125

Major Employers: Domino Sugar Corp., ExxonMobil Corp., Petro-Chem Development Co., Picatinny Arsenal, U.S. Patent and Trademark Office, Xerox Corp.

CIVIL ENGINEERING

Average starting salary: \$43,816

Major Employers: Bovis, Con Edison, ExxonMobil Corp., Frederic R. Harris, Inc., Port Authority of NY & NJ, Raytheon Systems Company, Turner Construction, Tyco Submarine Systems Ltd., Syska and Hennessy, Verizon Communications

COMPUTER ENGINEERING

Average starting salary: \$54,000

Major Employers: AT&T Labs, Cabletron Systems, Chase Manhattan Bank, Computer Associates, Comrise Technology, Inc., Converse Information Systems, Eastman Software, Ericsson Messaging Systems, Inc., Fujitsu Network Communications, Gibbs & Cox, Hamilton Standard, IBM, Lehman Brothers, Lucent Technologies, Merrill Lynch, MIT Lincoln Laboratory, NCR Corporation, Paine Webber, Inc., Pitney Bowes, Qwest Internet Solutions, Raytheon Systems Company, Sapient Corp., Software Spectrum, Verizon Communications

COMPUTER SCIENCE

Average starting salary: \$49,000

Major Employers: CommTech Corp., Computer Associates, Deutsche Bank, Eastman Software, Federal Reserve Bank of N.Y., Goldman Sachs, Hamilton Standard, KeySpan Energy, Lehman Brothers, Lucent Technologies, Merrill Lynch, NCR, Paradyne Corp., Peripherals Corporation, Photocircuits, Prudential Securities, Qwest Internet Solutions, Raytheon Systems & Company, Salomon Smith Barney, Sears, Roebuck & Company, SIAC, Standard Microsystems Corp., Sun Microsystems, Symbol Technologies, Inc., Telcordia Technologies, Telephonics, Tyco Submarine Systems Ltd., U.S. Patent and Trademark Office

ELECTRICAL ENGINEERING

Average starting salary: \$47,846

Major Employers: AIL Systems, AT&T Labs, Verizon Communications, Cabletron Systems, Citibank, CommTech Corp., Comrise Technology, Inc., Con Edison, Eastman Software, Ericsson Messaging Systems, Inc., ExxonMobil Corp., Fujitsu Network Communications, Gibbs & Cox, Goldman Sachs, Hamilton Standard, IBM, KeySpan Energy, Lehman Bros., Inc., Massachusetts Electric Co., Merrill Lynch, MIT Lincoln Laboratory, Northrop Grumman, Photocircuits, Pitney Bowes, Port Authority of NY & NJ, Raytheon Systems Company, Sapient Corp., Software Spectrum, Standard Microsystems, Sun Microsystems Corp., Telcordia Technologies, Telephonics, theglobe.com, Thomson Industries, Tyco Submarine Systems, Ltd., Underwriters Lab., Inc.

MECHANICAL ENGINEERING

Average starting salary: \$41,375

Major Employers: Atlas Air, Verizon Communications, Con Edison, Estée Lauder, ExxonMobil Corp., Frederic R. Harris, Inc., Gibbs & Cox, Jaros, Baum & Bolles, MTA, Nab Construction, Northrop Grumman, Petro-Chem Development Co., Port Authority of NY & NJ, Standard Microsystems Corp., Symbol Technologies, Inc., Syska & Hennessy, Thomson Industries, Torrington Company, Trane Company, Turner Construction

STATISTICS ON ENROLLMENT AND THE STUDENT BODY

ENROLLMENT 2000–2001

FALL 2000

	Undergraduate			Graduate			Total
	FT	PT	TOT	FT	PT	TOT	
Brooklyn	1369	123	1492	415	522	937	2429
Long Island	272	11	283	9	162	171	454
Westchester	—	—	—	73	103	176	176
Total	1641	134	1775	497	787	1284	3059

STUDENT BODY

FALL 2000

	Undergraduate		Graduate	
	Men	Women	Men	Women
Brooklyn	1184	308	719	218
Long Island	245	38	147	24
Westchester	—	—	130	46

PERSISTENCE AND COMPLETION INFORMATION

First-time, full-time undergraduate students
continuing at the University, 1999–2000

University-wide: 79%

ENROLLMENT BY RACIAL/ETHNIC STATUS (USING STANDARD FEDERAL CLASSIFICATIONS)

	Undergraduate Students	Graduate Students
Asian, Pacific Islander	39%	12%
Caucasian	29%	15%
Black, Non-Hispanic	10%	3%
Hispanic	6%	1%
Native American	0.2%	0%
International	5%	14%
Unknown	11%	55%

International students come from more than 25 countries.

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, an MS in Management is 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
Biomedical Engineering	—	MS ⁶	MS ⁶			
Chemical Engineering	0906	BS, MS, PhD	MS			
Chemistry	1905	BS, MS, PhD ⁵		MS		
Civil Engineering	0908	BS, MS, PhD	MS	MS		
Computer Engineering	0999	BS, MS	MS	MS		
Computer Science	0701	BS, MS, PhD	MS	MS		
Electrical Engineering	0909	BS, MS, PhD	MS	MS		
Electrophysics	0919	MS	MS			
Environment-Behavior Studies	2201	MS				
Environmental Engineering	0922	MS				
Environmental Science	1999	MS	MS			
Financial Engineering	0599				MS	
History of Science	2205	MS				
Industrial Engineering	0913	MS	MS	MS		
Informatics in Chemistry & Biology	—	MS ⁶	MS ⁶	MS ⁶		
Information Systems Engineering	0990	MS	MS	MS		
Interdisciplinary Studies in Engineering	0999	ME	ME	ME		
Liberal Studies	4903	BS				
Management	0506	MS	MS	MS		MS ⁴
Management of Technology	0599				MS ²	
Manufacturing Engineering	0913	MS	MS	MS		
Materials Chemistry	1905	PhD				
Materials Science	0915	MS		MS		
Mathematics	1701	BS, MS, PhD	MS			
Mechanical Engineering	0910	BS, MS, PhD	MS			
Organizational Behavior	0514	MS	MS	MS		
Physics	1902	BS				
Polymer Science & Engineering	0906	MS				
System Engineering	0901	MS	MS	MS		
Technical & Professional Communication	0602	BS, MS				
Technology & Information Management	—	BS ⁶				
Telecommunication Networks	0799	MS	MS	MS		
Telecommunications & Information Management	0599	MS ²	MS ²	MS ²	MS ²	
Transportation Management	0510	MS				
Transportation Planning & Engineering	0908	MS, PhD	MS			
Urban Systems Engineering & Management	0908	MS ⁶	MS ⁶			

1. Higher Education General Inventory System.

2. Executive format program.

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

4. Offered in Israel. 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.

ACADEMIC DEPARTMENTS AND DEGREES

DEPARTMENT OF CHEMICAL ENGINEERING, CHEMISTRY AND MATERIALS SCIENCE

BS Chemical Engineering
BS Chemistry
MS Biomedical Engineering¹
MS Chemical Engineering
MS Chemistry
MS Informatics in Chemistry and Biology¹
MS Polymer Science and Engineering
PhD Chemical Engineering
PhD Materials Chemistry
Advanced Certificates: Bioinstrumentation, Biomedical Materials

DEPARTMENT OF CIVIL ENGINEERING

BS Civil Engineering
MS Civil Engineering
MS Environmental Engineering
MS Environmental Science
MS Transportation Management
MS Transportation Planning and Engineering
MS Urban Systems Engineering and Management¹
PhD Civil Engineering
PhD Transportation Planning and Engineering
Advanced Certificates: Construction Management², Executive Construction Management (Exec21), Hazardous Waster 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 Networks³
PhD Computer Science
Advanced Certificate: Computer Engineering¹, 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 Networks³
PhD Electrical Engineering
Advanced Certificates: Computer Engineering¹, Image Processing¹, Telecommunication Network Management¹, Wireless Communications

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCE

BS Liberal Studies
BS Technical and Professional Communication
MS Environment–Behavior Studies
MS History of Science
MS Technical and Professional Communication
Advanced Certificate: Environment–Behavior Studies, Technical Communications

DEPARTMENT OF MANAGEMENT

BS Technology and Information Management¹
MS Financial Engineering
MS Management
MS Management of Technology
MS Organizational Behavior
MS Telecommunications and Information Management
Advanced Certificates: Construction Management², Financial Engineering, Financial Technology Management¹, 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. Pending approval by New York State.
2. Offered jointly by the Department of Management and Department of Civil Engineering
3. Offered jointly by the Department of Computer and Information Science and Department of Electrical and Computer Engineering.

PART 2

ACADEMIC DEPARTMENTS





DEPARTMENT OF CHEMICAL ENGINEERING, CHEMISTRY AND MATERIALS SCIENCE

Head: Kalle M. Levon

The increased complexity of materials and biomaterials in science, engineering and technology applications has increased the need for interdisciplinary approaches to synthesis, production and applications. Tasks ranging from synthesis of molecules to factory production of materials require increased numbers of chemists, chemical engineers and materials scientists. Employment opportunities include the biomedical sciences and pharmaceutical, cosmetics, food and plastics industries. Job growth rates in these related fields are among the highest in the technical professions.

To face the demands and challenges in modern industry, the Department of Chemical Engineering, Chemistry and Materials Science offers educational and research programs that focus on novel molecules, advanced materials properties and processes and high quality optimization. Undergraduate programs include chemical engineering and chemistry with an option in biomedical sciences. Master's programs are offered in chemical engineering, chemistry, biomedical engineering, informatics in chemistry and biology and polymer science and engineering. PhD programs are offered in chemical engineering and materials chemistry.

All programs relate strongly to Polytechnic's reputation in polymeric materials. The University was the first in the world to offer education in polymer science. The department works closely with the Herman F. Mark Polymer Research Institute, which coordinates industrial cooperations, advanced workshops and specific symposia.

The department's faculty comprises leading active researchers in their fields. Research activities are supported by both government and industrial cooperation. Annual meetings are held to optimize recruiting, mutual interactions and information exchange. The fundamental areas of research include molecular thermodynamics, molecular modelling and crystallization studies, which together form the essentials for overall understanding of structure formation. The faculty specializes in advanced characterization methods, using laboratories for surface analysis, scattering, HOP-chromatography, molecular modelling, X-ray scattering, spectroscopy, microscopy (AFM, STEM, STM and OM) and electrical and optical properties of materials. The wide variety of areas in research include chiral polymers, of importance to the pharmaceutical and information technology industries, and complex polymer fluids, which respond to external conditions like temperature, pressure and stress. Composite materials and polymer blends are used in research in which desired properties are tailor-made for various structural applications. The study of electrical and optical properties of materials has brought the fundamental science closer to applications of electro-active materials. Research in biomedical materials also plays an important part in efforts to create elastic biodegradable materials, encapsulated medicine and new drug-release technology. A number of interdisciplinary research projects involve mechanical and electrical engineering and computer science faculty.

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 Department of Chemical Engineering, Chemistry and Materials Science is to develop graduates capable of contributing to the advancement of chemical engineering, chemistry and biology. 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

- Chemical Engineering
- Chemistry (Concentration in Biomedical Science available)

Master of Science

- Biomedical Engineering*
- Chemical Engineering
- Chemistry
- Informatics in Chemistry and Biology*
- Polymer Science and Engineering

Doctor of Philosophy

- Chemical Engineering
- Materials Chemistry

Advanced Certificates

- Bioinstrumentation*
- Biomedical Materials*

* Pending New York State approval.

UNDERGRADUATE PROGRAMS

The undergraduate program in chemical engineering provides a sound foundation in science and the engineering sciences and builds on this a strong and integrated set of courses in chemical engineering. Thorough instruction is given in chemistry, physics, mathematics and 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 Engineering and is accredited by the Accreditation Board for Engineering and Technology (ABET). The chemical engineering 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 industry or to enter graduate school for advanced study in chemical engineering or other fields.

For students majoring in chemistry, the department provides curricula that go beyond the professional training requirements of the American Chemical Society. The courses prepare students for graduate studies or work in industry. The American Chemical Society certifies Polytechnic's BS in Chemistry; graduates are immediately eligible for ACS membership.

The Biomedical Sciences Option of the BS in Chemistry provides significant exposure to both chemical and biological sciences. Students select their curriculum to prepare them for careers in medicine, dentistry, osteopathy, veterinary, podiatry, optometry or biotechnology and bioengineering.

GRADUATE PROGRAMS

Graduate programs in chemical engineering introduce students to advanced designs, research and development. The department offers programs leading to an MS and PhD in Chemical Engineering and to an MS in Polymer Science and Engineering.

The MS program in chemistry and the PhD program 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 program in Informatics in Chemistry and Biology 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.

OFFICES

Brooklyn Campus

Rogers Hall, Room 801

Tel: 718/260-3470

Fax: 718/260-3125

E-mail: zpatters@poly.edu

Web: <http://chem.poly.edu>

Long Island Campus

Main Bldg., Room 126

Tel: 631/755-4444

Fax: 631/755-4404

E-mail: zpatters@poly.edu

Web: <http://chem.poly.edu>

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 scatter-
ings, nonlinear optics 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 genera-
tion of polymeric structures,
bioresorbable polymers*

Kalle M. Levon, Professor of
Chemistry, Department Head, Director
of Polymer Research Institute
DrAgr, University of Tokyo (Japan)
*Phase separation in polymer blends and
solutions, conducting polymers*

Jovan Mijovic, Professor of Chemical
Engineering
PhD, University of Wisconsin at
Madison
*Relaxation dynamics in complex sys-
tems, modeling of processing of poly-
mers, in-situ monitoring of processes,
structural relaxation in the glassy state*

Shirley M. Motzkin, Professor of
Biology
PhD, New York University
*Development mechanisms, teratology
and skeletal development, radiation
effects*

Abraham Ulman, Alstadt-Lord-Mark Professor of Chemistry
PhD, The Weizmann Institute (Israel)
Self-assembled monolayers and surface engineering, wetting and adhesion, surface initiated polymerization and polymer brushes, nanoparticles and nanotechnology, advanced materials

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

Jordanka Zlatanova, Professor of Biology
PhD, DrSc, Bulgarian Academy of Sciences, Sofia
Chromatin structure and function, atomic force microscope, optical tweezers

ASSOCIATE PROFESSORS

Mary K. Cowman, Associate Professor of Biochemistry
PhD, Case Western Reserve University
Molecular biomechanics of connective tissue polysaccharides. Solution conformation and interactions of hyaluronan, novel methods for structure characterization, connective tissue organization and function

Leonard I. Stiel, Associate Professor of Chemical Engineering
PhD, Northwestern University
Thermodynamic properties of mixtures, properties of polar fluids

Iwao Teraoka, Associate Professor of Polymer Chemistry
PhD, University of Tokyo (Japan)
Polymer solution dynamics, fractionation of polymers

Nancy M. Tooney, Associate Professor of Biochemistry, Associate Dean of Engineering and Applied Sciences
PhD, Brandeis University
Structure and function of proteins and other biopolymers, blood clotting system, fibronectin structure and function, environmental chemistry

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

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

ASSISTANT PROFESSOR

Yitzhak Shnidman, Assistant Professor of Chemistry
PhD, The Weizmann Institute (Israel)
Modeling structure and dynamics in multiphase fluid, solid, colloid and polymer systems, focusing on interfacial phenomena, such as wetting, adsorption, adhesion and nucleation

RESEARCH FACULTY

Akihiro Abe, Research Professor of Chemistry
PhD, Polytechnic University
Physical chemistry of polymers, statistical mechanics of chain molecules

Alexander F. Izmailov, Research Assistant Professor of Chemical Engineering
PhD, Lebedev Physical Institute of Chemical Physics (Russia)
Supersaturated solutions, mathematical modeling

T. K. Kwei, Research Professor of Polymer Chemistry
PhD, Polytechnic University
Polymer-polymer miscibility, segmented polyurethanes and unsaturated polyesters, phase relationships in polymer blends, interactions in composites

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

Shiro Matsuoka, Research Professor for Polymer Research Institute
PhD, Princeton University
Polymer physics, viscoelasticity, ultimate mechanical properties

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

Sergio Petrucci, Research Professor of Physical Chemistry
PhD, University of Rome (Italy)
Relaxation kinetics, ligand substitution in nonaqueous media, microwave and diffusional rotational relaxation

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

Edith Turi, Research Professor for Polymer Research Institute
PhD, Technical University of Budapest (Hungary)
Thermal analysis of polymeric systems

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

Paul F. Bruins, Professor Emeritus of Chemical Engineering
PhD, Iowa State University
HonDSc, Polytechnic University

Frederick Eirich, Distinguished Professor Emeritus of Polymer Chemistry
PhD, University of Vienna (Austria)

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

W. Fred Schurig, Professor Emeritus of Chemical Engineering
MChE, Polytechnic University

DEPARTMENT OF CIVIL ENGINEERING

Head: Fletcher H. Griffis

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 subdisciplines.

THE DEPARTMENT

Through its research programs, the Department of Civil Engineering strives to be at the forefront in urban infrastructure, with emphasis on the use of information technology in transportation systems, construction management, environmental analysis and the management of urban utilities (water, electric power, gas) networks.

Through its educational programs, graduates will be well rounded in state-of-the-art techniques and will develop the skills needed to become leaders in a complex profession. Among these skills are the ability to communicate effectively in written and verbal form, and the ability to understand the context of civil engineering projects in a complex society.

To enhance the value of the undergraduate education, the department plans to initiate a co-op program with industry as a means to attract the best and brightest students into the civil engineering profession.

The department has a distinguished faculty actively involved in both teaching and research. While some laboratories are supervised by graduate students, virtually all courses are taught by members of the full-time or adjunct faculty. Many faculty members conduct research addressing infrastructure issues of the New York City region.

CIVIL ENGINEERING PROFESSION

Civil engineers are responsible for the 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.

DEGREE PROGRAMS

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 subdisciplines, as well as to pursue general graduate work across several different areas.

The Department offers the following degree and certificate programs.

Bachelor of Science

- Civil Engineering

Master of Science

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

Doctor of Philosophy

- Civil Engineering
- Transportation Planning and Engineering

Advanced Certificates

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

**Pending New York State approval.*

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

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

OFFICES

Brooklyn Campus

Rogers Hall, Room 517
Tel: 718/260-3220
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E-mail: cee@poly.edu
Web: www.poly.edu/cee

Long Island Campus

Main Bldg., Room 126
Tel.: 631/755 4444
Fax: 631/755 4404
E-mail: cee@poly.edu
Web site: www.poly.edu/ccc

FACULTY**PROFESSORS**

George Bugliarello, University Professor, Chancellor
ScD, Massachusetts Institute of Technology
Fluid mechanics, urban development, megacities, knowledge parks, infrastructure, science and technology policy

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

Fletcher H. Griffiths, PE, Professor of Civil Engineering, Department Head, 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, Special Assistant to Dean for Academic Assessment
PhD, Polytechnic University
Highway capacity and level of service analysis, traffic control and operations, public transportation operations, transportation economics, engineering pedagogy

Dipak Roy, PE, Professor of Environmental Engineering
PhD, University of Illinois
Hazardous waste management, in-situ remediation, bioremediation, soil flushing, biological processes for waste treatment, disinfection

ASSOCIATE PROFESSORS

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

Feng-Bao Lin, PE, Associate Professor of Civil Engineering
PhD, Northwestern University
Non-linear finite element methods, boundary element methods, structural dynamics, nondestructive testing of structures, constitutive modeling, fracture mechanics, plasticity theory, damage modeling, optical tomography, seismic analysis of high-rise buildings, reinforced and prestressed concrete structures

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

ASSISTANT PROFESSORS

Symeon Christodoulou, Assistant Professor of Civil Engineering
PhD, Columbia University
Decision support systems, project schedule and cost control systems, three-dimensional computer models and the fully integrated and automated project process, information management and system integration, artificial neural networks, bid strategies

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

Eakalak Khan, Assistant Professor of Environmental Engineering
PhD, University of California at Los Angeles
Waste and wastewater quality, especially on biodegradability level, biological process development for water, waste, and wastewater treatment, removal of hazardous chemicals/metals from water and wastewater

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

Hualiang Teng, Assistant Professor of Transportation Engineering
PhD, Purdue University
Intelligent transportation systems, demand modeling, network analysis, traffic engineering, freight transportation 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 Anifitos, PE, Adjunct Lecturer in Civil Engineering
PhD, Polytechnic University

Exec 21 Program

William Goldstein, Adjunct Lecturer of Civil Engineering
Vice-President, O'Brien Kreitzberg

Ralph Locurcio, PE, Adjunct Lecturer in Civil Engineering
Senior Vice-President, STV Group

Alfred T. McNeill, PE, Adjunct Lecturer in Civil Engineering
Former Chairman and CEO, Turner Construction

Robert Ruben, PE, Esq., Adjunct Lecturer in Civil Engineering
Partner, Postner and Ruben

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

Environmental and Water Resource Engineering

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

Michael J. Sakala, PE, Adjunct Assistant Professor of Environmental Engineering
MS, Polytechnic University

John J. Tancredi, Adjunct Professor of Environmental Engineering
PhD, Polytechnic University

Structural and Geotechnical Engineering

Donald Bruce, CEng, Adjunct Lecturer in Civil Engineering
PhD, University of Aberdeen (Scotland)
Senior Research Adviser, Urban Utilities Center

Dong Keun Chang, PE, Adjunct Lecturer in Civil Engineering
PhD, Columbia University
Mueser Rutledge Consulting Engineers

Ben Golshar, PE, Adjunct Lecturer in Civil Engineering
MS, City University of New York
Project Manager, Liro-Kassner Inc.

Edward E. Lockley, PE, Adjunct Lecturer in Civil Engineering
PhD, Polytechnic University
Consultant

J. Jong Lou, PE, Adjunct Associate 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

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

Kuros Sorbi, PE, Adjunct Lecturer in Civil Engineering
MS, Polytechnic University

Yung K. Wang, Adjunct Lecturer in Civil Engineering
PhD, Polytechnic University
Research Engineer, Advanced Technology Office, Brookhaven National Laboratories

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

Transportation and Highway Engineering

Capt. Fiaz Arain, Adjunct Lecturer in Transportation Engineering
PhD, Polytechnic University
U.S. Merchant Marine

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

Apanika Ntekim, Adjunct Lecturer in Civil Engineering
PhD, Polytechnic University

Vassilios Papayannoulis, Adjunct Lecturer in Transportation Engineering
PhD, Polytechnic University
Urbitran Associates

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. Mikochik, Professor Emeritus
MS, Rutgers University

Robert C. Veit, Professor Emeritus
MSE, Polytechnic University

Ping-Chun Wang, PE, Emeritus Professor
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, current job growth 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 foci are in distributed systems, media systems and software engineering. 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.

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 under-

graduate 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

Advanced Certificates

- Computer Engineering*
- 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.

UNDERGRADUATE PROGRAMS COMPUTER SCIENCE

The undergraduate program in computer science is accredited by the Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB), a specialized accrediting body recognized by the Council on Postsecondary Accreditation (COPA) and the U.S. Department of Education. The 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 department'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.

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FACULTY

PROFESSORS

Phyllis G. Frankl, Professor of Computer Science
PhD, New York University
Software testing and analysis

Ivan T. Frisch, Professor of Electrical Engineering and Computer Science, Executive Vice President and Provost
PhD, Columbia University, Director of Long Island Graduate School for Professional Studies
Information systems, computer networks and network control

K. Ming Leung, Professor of Physics and Computer Science
PhD, University of Wisconsin
Computer programming, computer simulation

Richard Van Slyke, Professor of Electrical Engineering and Computer Science
PhD, University of California at Berkeley
Combinatorial optimization, information network design, algorithms

ASSOCIATE PROFESSORS

Boris Aronov, Associate Professor of Computer Science
PhD, New York University
Algorithms, computational and combinatorial geometry

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

Nasir Memon, Associate Professor of Computer Science
PhD, University of Nebraska
Pulse compression, computer security, image processing

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

Yi-Jen Chiang, Assistant Professor of Computer Science
PhD, Brown University
Computer graphics, computer algorithms

Gleb Naumovich, Assistant Professor of Computer Science
PhD, University of Massachusetts at Amherst
Static analysis of concurrent software, software engineering, programming languages

Torsten Suel, Assistant Professor in Computer Science
PhD, University of Texas
Database, parallel computation, algorithms

INDUSTRY FACULTY

Alan R. Davis, Industry Associate Professor of Computer Science
PhD, Polytechnic University
Programming systems, algorithms, education technology

David R. Doucette, Industry Professor of Computer Science, Associate Dean of Long Island Campus
PhD, Polytechnic Institute of Brooklyn
Systems integration, software engineering, operating systems

Robert J. Flynn, Industry Professor of Computer Science
PhD, Polytechnic University
Computer architecture, operating systems

Linda Anne Grieco, Industry Associate
Professor of Computer Science
PhD, Rutgers University
Programming and computer software

Haldun Hadimioglu, Industry
Associate Professor of Electrical
Engineering and Computer Science
PhD, Polytechnic University
*Computer architecture, high-
performance systems*

Barry Jones, Industry Associate
Professor of Electrical Engineering and
Computer Science
MS, Marist College
*Electromechanical systems, real-time
computer 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

Maurice Karnaugh, Research Professor
of Computer Science
PhD, Yale University

Gad M. Landau, Research Professor of
Computer Science
PhD, Tel-Aviv University (Israel)
*Algorithms, string matching, computa-
tional biology, pattern recognition,
communication networks*

LECTURERS

Ronald E. Fedderson, Lecturer of
Computer Science
MS, Polytechnic University

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

Hamid Ahmadi, Adjunct Professor of
Computer Science
PhD, Columbia University

Thomas P. Cahill, Adjunct Professor of
Computer Science
MS, Polytechnic University

Elliote R. Haruld, Adjunct Lecturer of
Computer Science
MS, New Jersey Institute of Technology

Mark Hoffman, Adjunct Professor of
Computer Science
PhD, Polytechnic University

Edward Lancevich, Adjunct Professor
of Computer Science
PhD, Polytechnic University

Clifford Marshall, Adjunct Professor of
Computer Science
PhD, Columbia University

Jorge Negron, Adjunct Lecturer of
Computer Science
BS, Polytechnic University

Charles Palmer, Adjunct Professor of
Computer Science
PhD, Polytechnic 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

Edward J. Smith, Professor Emeritus of
Electrical Engineering
DEE, Polytechnic University

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Head: David J. Goodman

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 electrotechnology 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. One cluster of highly visible research projects happening during 2001 to 2003 focuses on technology to realize the promise of a Wireless Internet.

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

Master of Science

- Computer Engineering**
- Electrical Engineering
- Electrophysics
- System Engineering
- Telecommunication Networks**

Master of Engineering

- Interdisciplinary Studies in Engineering (Wireless Innovation***)

Doctor of Philosophy

- Electrical Engineering

Advanced Certificates

- Computer Engineering**
- Image Processing***
- Telecommunication Network Management****
- Wireless Communications

**Accredited by the Accreditation Board for Engineering and Technology (ABET).*

***Offered in conjunction with the Department of Computer and Information Science.*

****Offered in conjunction with the Department of Management and the Department of Computer and Information Science.*

*****Pending New York State approval.*

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 PROGRAMS

BS/MS Honors Program: 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 activity 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 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 ATM, Broadband ISDN, network bridging, digital filtering, software design and reliability, packet-switched network design tools, real-time systems, traffic planning and capacity engineering, UNIX networks design work bench, wireless and image communications and image compression and pattern recognition.

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Web: www.ece.poly.edu

FACULTY

PROFESSORS

Henry L. Bertoni, Professor of Electrical and Computer Engineering, Director of Weber Wireless Research Institute
PhD, Polytechnic University
Wireless, electromagnetics

Robert R. Boorstyn, Professor of Electrical and Computer Engineering
PhD, Polytechnic University
Communication networks

Frank A. Cassara, Professor of Electrical and Computer Engineering
PhD, Polytechnic University
Electronic circuits, wireless communication systems

David C. Chang, Professor of Electrical and Computer Engineering, University President
PhD, Harvard University
Electromagnetics, microwave integrated circuits

H. Jonathan Chao, Professor of Electrical and Computer Engineering
PhD, Ohio State University
Design of VLSI chips for telecommunications

Ivan T. Frisch, Professor of Electrical Engineering and Computer Science, Executive Vice President and Provost, Director of Long Island Graduate Center
PhD, Columbia University
Information systems, computer networks, network control

David J. Goodman, Professor of Electrical and Computer Engineering, Department Head
PhD, Imperial College, University of London (England)
Communications systems

Farshad Khorrani, 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
Magneto hydrodynamics

I-Tai Lu, Professor of Electrical and Computer Engineering
PhD. Polytechnic University
Electromagnetics, acoustics, wireless communication

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 at 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

Nirod K. Das, Associate Professor of Electrical and Computer Engineering
PhD. University of Massachusetts
Electromagnetics, antennas, microwave integrated circuits

Ramesh Karri, Associate Professor of Electrical and Computer Engineering
PhD. University of California at San Diego
VLSI, CAD, computer engineering

Shivendra S. Panwar, Associate Professor of Electrical and Computer Engineering. Director of Center for Advanced Technology in Telecommunications
PhD. University of Massachusetts
Communication networks

Malathi Veeraraghavan, Associate Professor of Electrical and Computer Engineering
PhD. Duke University
Wireless protocols, networks, telecommunications

Peter Voltz, Associate Professor of Electrical and Computer Engineering
PhD. Polytechnic University
Communications and signal processing

ASSISTANT PROFESSORS

Dariusz Czarkowski, Assistant Professor of Electrical and Computer Engineering
PhD. University of Florida
Power electronics, power quality

Elza Erkip, Assistant Professor of Electrical and Computer Engineering
PhD. Stanford University
Wireless communication, communication theory, information theory

Zhong-Ping Jiang, Assistant Professor of Electrical and Computer Engineering
PhD. École des Mines de Paris (France)
Control systems

Ivan W. Selesnick, Assistant Professor of Electrical and Computer Engineering
PhD. Rice University
Signal processing

RESEARCH FACULTY

Philip Balaban, Research Professor of Electrical and Computer Engineering
PhD. Rice University

Andreas H. Hielscher, Research Professor of Electrical and Computer Engineering
PhD. Rich University

INDUSTRY FACULTY

Mokhtar Boukli-Hacene, Industry Associate Professor of Electrical and Computer Engineering
PhD. Polytechnic University
Communication systems, fiber optics

ADJUNCT FACULTY

Tushar Bhattacharjee, Adjunct Lecturer
PhD. Jadavpur University (India)

Charles Bolen, Adjunct Lecturer
MS. Polytechnic University

Robert Cahn, Adjunct Lecturer
PhD. Yale University

Matthew Campisi, Adjunct Lecturer
MS. Polytechnic University

X. K. Chen, Adjunct Assistant Professor
PhD. Polytechnic University

Robert DiFazio, Adjunct Lecturer
PhD. Polytechnic University

Robert Gordon, Adjunct Lecturer
PhD. Polytechnic University

Sidney Hantler, Adjunct Lecturer
PhD. University of Michigan

Howard Hausman, Adjunct Lecturer
MS. Polytechnic University

Michael Henderson, Adjunct Lecturer
MS. Rensselaer Polytechnic Institute

Jun Hong, Adjunct Lecturer
PhD. Polytechnic University

Parviz Kermani, Adjunct Lecturer
PhD. University of California at Los Angeles

Michael Knox, Adjunct Lecturer
MS. Polytechnic University

Ben Spherling, Adjunct Lecturer
PhD. Leningrad Polytechnic University

George Sullivan, Adjunct Lecturer
MS. Polytechnic University

Fred Winter, Adjunct Lecturer
PhD. Polytechnic University

Zhenqxue Zhao, Adjunct Lecturer
PhD. Polytechnic University

FACULTY EMERITI

Leonard Bergstein, 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

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 Marcovitz, 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

Athanasios Papoulis, University Professor Emeritus
PhD, University of Pennsylvania

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

Edward J. Smith, Professor Emeritus of Electrical Engineering and Computer Science
DEE, Polytechnic 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

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 whereby students can expand their understanding of the society and culture in which they live and 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. Such persons 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 persons 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 who are majors in other departments. Today's engineers and scientists must have 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, second professional concentrations in Education, Information Design and Administration, International and Global Studies and Technical and Professional Communications)
- Technical and Professional Communication

Master of Science

- Environment-Behavior Studies
- History of Science
- Technical and Professional Communication

Advanced Certificate

- Environment-Behavior Studies
- Technical Communications

All majors and minors are available at the Brooklyn campus. For availability at the Farmingdale campus, check with the departmental office.

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Web: www.poly.edu/huss

UNDERGRADUATE PROGRAMS

Students working toward the degree Bachelor of Science take a core curriculum in contemporary liberal arts, together with their chosen course concentrations. The core curriculum was conceived to meet the increasing need for specialists in the social sciences, technical writing and the humanities who are also familiar with computers, the physical sciences and engineering and mathematics. The degree is interdisciplinary, with emphasis on developing integrated historical, economic, behavioral and cultural perspectives on human society. The graduate and undergraduate programs exploit the advantages and strengths of a technological university and thus are particularly beneficial to students who combine strong interests in the social sciences, humanities or journalism and technical writing with interests in science and technology.

THE WRITING PLACEMENT EXAM

As freshmen, all students admitted to Polytechnic University are placed at appropriate levels in the freshman English sequence. On the basis of an English composition placement test evaluated by the department, most students are placed in one of the standard freshman courses (EN 1014 or EN 1034), some may be exempted and placed in EN 1204, the second required course of the sequence, others may first be required to take one or more semesters of an introductory course in English (EN 1080 or EN 1090) with a reduced course load (a maximum of 14 credits).

RESEARCH CENTERS

The department houses the Center for the History and Philosophy of Technology and Science Studies. The center 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.

INSTRUCTIONAL LAB

The Technical and Professional Communications Computer Lab is reserved for students in the graduate and undergraduate Technical and Professional Communications programs and undergraduates in the Liberal Studies program. This lab includes Macintosh computers, color printers, scanners and software for graphic design and Web page authorship.

FACULTY

PROFESSORS

Wolhee Choe, Professor of English
PhD, City University of New York
Nineteenth-century English literature, literary theory

Anne Eisenberg, Professor of Humanities and Communications
PhD, New York University
Science writing

David Mermelstein, Professor of Economics
PhD, Columbia University
Political economy, macroeconomic policy, money and banking

ASSOCIATE PROFESSORS

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

F. David Mulcahy, Associate Professor of Anthropology
PhD, University of Massachusetts
China, Spain, language and culture

Lowell L. Scheiner, Associate Professor of Humanities and Communications
MS, Columbia University Graduate School of Journalism
MA, Columbia University
Technical writing, journalism

Romualdas Sviedrys, Associate Professor of History of Technology
PhD, Johns Hopkins University
Technology forecasting and technology assessment, history of technology and science since 1750, technology transfer to developing countries

Richard E. Wener, Associate Professor of Psychology
PhD, University of Illinois at Chicago
Environmental psychology, crowding, assessment of the built environment

ASSISTANT PROFESSORS

Alexi Assmus, Assistant Professor of History of Science and Technology
PhD, Harvard University
U.S. science and technology, history of modern physics, technology policy and assessment

Jonathan Bain, Assistant Professor of Philosophy of Science
PhD, University of Pittsburgh
Quantum theory, philosophy of space and time

Joline L. Blais, Assistant Professor of Technical and Professional Communication
PhD, University of Pennsylvania
Fiction, digital media

Francine L. Dolins, Assistant Professor of Psychology
PhD, University of Stirling (Scotland)
Non-human primate cognition

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

Jonathan Soffer, Assistant Professor of History
PhD, Columbia University
American history, pre-law adviser

INDUSTRY FACULTY

Noel N. Kriftcher, Industry Professor of Humanities, Director of David Packard Center for Technology and Educational Alliances
EdD, Hofstra University

Harold P. Sjurson, Industry Professor of Philosophy, Head of Department of Humanities and Social Sciences
PhD, New School for Social Research
History of philosophy, ethics, philosophy of science and technology

LECTURERS

Elizabeth Chesla, Lecturer of English, Coordinator of Technical and Professional Communications Program
MA, Columbia University
Composition, science fiction

Donald S. Phillips, Lecturer of Psychology
BS, Polytechnic University
Experimental and physiological psychology, physical anthropology, paleontology

Bethany Saltman, Lecturer of English
MFA, Brooklyn College
Literature, writing

INSTRUCTORS

Alph Edwards, Instructor of English
MA, Hunter College
Developmental writing

David Kaplan
Instructor of Philosophy
PhD, Fordham University
*20th-century continental, social-political,
philosophy of technology*

Lauren Kozol, Instructor of English
MA, City University of New York
Literature and the fine arts

James P. Lewis, Instructor of
Humanities
MA, State University of New York
at Stony Brook
Humanistic psychology

ADJUNCT FACULTY

Asya Blue, Adjunct Instructor of
Technical and Professional
Communication
BFA, Parsons School of Design

Lucielle Borelli, Adjunct Instructor of
Technical and Professional
Communication
MA, Fairleigh Dickinson University

Diana Bryant-Friedman, Adjunct
Instructor of English
MA, New York University

James Roderick Burns, Adjunct
Instructor of English
MA, State University of New York at
Stony Brook

Noel Caban, Adjunct Instructor of
Technical and Professional
Communication
BFA, State University of New York at
Buffalo

Deborah Cassetta, Adjunct Instructor
of History
MPhil, New York University

Allen Cobrin, Adjunct Instructor of
English
MA, Columbia University

Reva Ehrlich, Adjunct Assistant
Professor of Speech
Doctor of Arts, St. John's University

Susan Fowler, Adjunct Instructor of
Technical and Professional
Communication
BA, University of Hartford

Susan Fox, Adjunct Instructor of
Technical and Professional
Communication
MA, George Mason University

Frances Gambino, Adjunct Instructor
of Technical and Professional
Communication
MS, Rensselaer Polytechnic Institute
MBA, New York University

Sean Kaplan, Adjunct Instructor of
Philosophy
PhD, New School for Social Research

Julia Keefer, Adjunct Instructor of
Technical and Professional
Communication
PhD, New York University

Dianne Kohl, Adjunct Instructor of
English
MA, State University of New York at
Stony Brook

I. Leonard Leeb, Adjunct Associate
Professor of History
PhD, Columbia University

Barbara Lynch, Adjunct Instructor of
Speech
MA, Teachers College, Columbia
University

Valerie Mantz, Adjunct Instructor of
MA, Hunter College

Louis Menashe, Adjunct Professor of
History
PhD, New York University

Olga Nachimovsky, Adjunct Instructor
of Technical and Professional
Communication
BA, Yeshiva University

Alan M. Nadler, Adjunct Instructor of
English
MFA, Columbia University

Julie Price, Adjunct Instructor of
English
BA, St. John's University

Jillian Quinn, Adjunct Instructor of
English
MA, State University of New York at
Stony Brook

Colleen M. Sandford, Adjunct
Assistant Professor of English
PhD, University of Illinois

Scott Wilson, Adjunct Instructor of
Technical and Professional
Communication
BA, California State University at
Northridge

FACULTY EMERITI

Lester Bumas
John G. Cavanna
Duane DeVries
Marvin Gettleman
Helmut Gruber
Frederick C. Kreiling
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. The faculty 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.

OFFICE

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E-mail: dids@poly.edu
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

Thomas M. Pannaparayil, Industry Professor of Physics
PhD, Fordham University

Valery A. Sheverev, Industry Associate Professor of Physics, Director of Physics Laboratory Program
PhD, Saint-Petersburg State University (Russia)

LECTURER

S. John DiBartolo, Lecturer of Physics
PhD, University of Virginia

INSTRUCTORS

Partha P. Debroy, Instructor of Physics
PhD, Carnegie Mellon University

Charles P. Martucci, Instructor of Chemistry
PhD, Columbia University

David T. Mugglin, Instructor of Physics
PhD, Lehigh University

Jamahl W. Overstreet, Instructor of General Engineering
MS, Polytechnic University

Myron I. Pollack, Instructor of Chemistry
PhD, New York University

Onofrio N. Russo, Instructor of General Engineering
BS, Polytechnic University

Vladimir I. Tsifrinovich, Instructor of Physics
DSc, Academy of Science of the USSR

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

Janice Aber, Adjunct Professor of Chemistry
PhD, Polytechnic University

Victor Barinov, Adjunct Professor of Physics
PhD, Academy of Science of the Ukraine

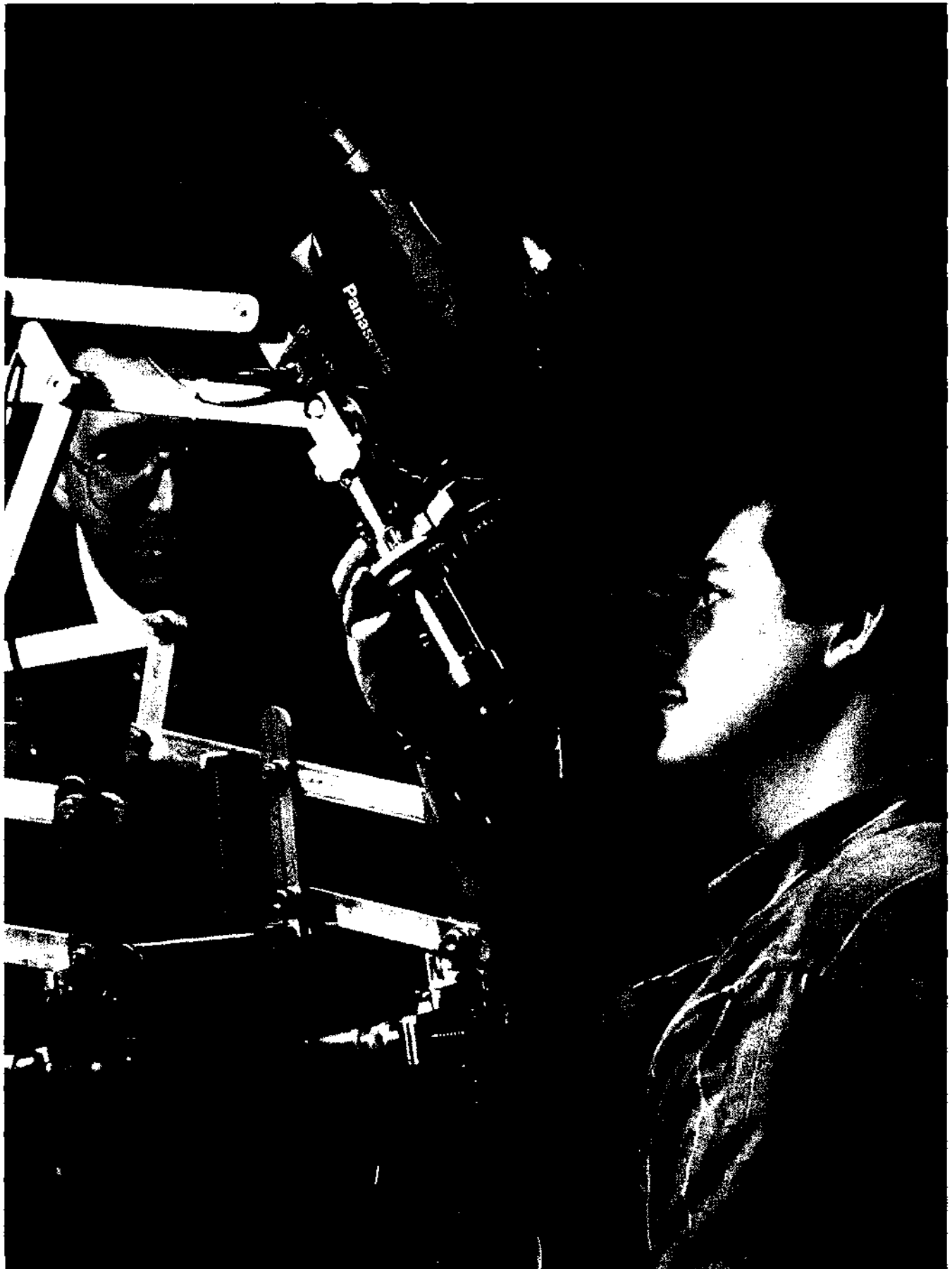
Samuel Derman, Adjunct Professor of Physics
PhD, New York University

Roman Kezerashvili, Adjunct Professor of Physics
DSc, Saint-Petersburg State University (Russia)

Yury London, Adjunct Professor of Physics
MS, Kharkov State University (Ukraine)

Donald Nicosia, Adjunct Lecturer of Physics
MS, Polytechnic University

Vladimir Ostrovsky, Adjunct Professor of Physics
DSc, Academy of Science of the Ukraine



DEPARTMENT OF MANAGEMENT

Chair: Mel Horwitch

GO BEYOND THE GENERIC MBA TO SUCCEED IN THE KNOWLEDGE ECONOMY

"Mastering broadly defined technology, innovation and information 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 electronic business and the Internet. 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, technology-driven manufacturing firms, electronic businesses and bio-medical/pharmaceuticals—the areas of greatest growth and opportunity in the emerging economy."

—Mel Horwitch, PhD
Chair, Department of Management

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 innovation, information and technology management and electronic business. 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

- Technology and Information 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**)

Advanced Certificates

- Construction Management***
- Financial Engineering
- Financial Technology Management
- Human Resource Management
- Information Management
- Operations Management
- Organizational Behavior
- Risk Management
- Technology Management
- Telecommunications Management

**Pending New York State approval.*

***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.*

RESEARCH AND DEVELOPMENT

The department has achieved its pre-eminent position with a continuous stream of high-quality and relevant research, development and pacesetter 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 now offers a Bachelor of Science in Technology and Information Management (T&IM). Undergraduates entering the University in September 2001 and later may choose this new program.

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 redesigned and modernized educational programs, all dealing in some fashion with the broad spectrum of innovation, technology and information management in the modern economy, including the Internet.

The department offers six graduate and professional degrees, two of which are earned in Executive Management Programs, i.e., meeting Friday mornings and Saturdays, or Thursday evenings and Saturdays on alternating weekends:

- 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)

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

The Doctor of Philosophy in Technology Management (PhD-TM) Program has been approved by the University faculty and will begin in September 2002 contingent upon approval by the New York State Education Department.

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-TM Program is designed for this increasingly significant set of scholarly and educational opportunities.

This degree program is designed for research-oriented students. Admission criteria will include academic record, professional experience, research potential, GMAT or GRE scores and references.

Visit www.phd-tim.poly.edu for more information.

FORTHCOMING MANAGEMENT DEGREE PROGRAMS

The following Management Program is imminent, pending faculty approval: Master of Science in Management of Technology, Global Executive Program: Technology in the New Global Organization (TANGO).

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 Association (and Club, FESC) is quite active in promoting a distinguished speaker series and in organizing career opportunity events.

INSTITUTE FOR TECHNOLOGY AND ENTERPRISE

The Department of Management's Institute for Technology and Enterprise (ITE) is a New York research and education hub for bridging management and innovation. Through a highly interactive portfolio of programs and research activities, the Institute nurtures and builds managerial knowledge based on the lessons of high-quality scholarship and pace-setting business practices. Essentially, it functions as a high-level research and development "engine" for the entire department and for relevant firms and fields at large.

Located in the heart of Manhattan's high technology and financial districts at the New York Information Technology Center, 55 Broad Street, ITE acts a "jump-gate" for companies and managers into Silicon Alley and innovative corporations throughout the region. It provides a starting point for forward-thinking firms embarking on much needed major managerial change or transformation based on modern, including digital-based, innovation.

Recent initiatives by ITE focused on such topics as electronic retailing, new media management, technology-enabled innovation in financial services, the Internet-triggered reconfiguration of the music and entertainment industry, and open source software—a possible new model for innovation, overall, wireless innovation, high-tech entrepreneurship and innovation-enabled transformation.

For further information or to participate in an upcoming program, please contact ITE by telephone: 212/547-7030, fax: 212/547-7029, e-mail: ite@poly.edu, Web: 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, Executive Director, CFT, at 718/260-3436, e-mail: fnovomes@poly.edu.

EXTENSION IN ISRAEL

The Department of Management offers its management programs at its extension in Rehovot, Israel, home of the prestigious Weizmann Institute of Science and many technology-based firms. The program is identical to the MSM evening curriculum in New York, with selected concentrations specifically designed for professionals and managers working in Israeli business and industry. The MSM program brings cutting-edge technology management approaches taught by Polytechnic professors together with Israeli faculty to address the advanced state of technology in Israel. A Master of Science in Organizational Behavior (OB) and the Bachelor of Science in Technology Management (TM) will be offered for the Israel extension pending faculty approval.

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@duke.poly.edu.

OFFICES

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E-mail: mgt-dept@poly.edu

Web: www.managementdept.poly.edu

Manhattan Location

MOT and TIM Executive Masters Programs

55 Broad Street, Suite 13B

New York, NY 10004

Tel: 212/547-7030 x207

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.

FACULTY

PROFESSORS

Mel Horwitch, Professor of Management, Department Chair, Director of Institute for Technology and Enterprise, Co-director of Executive Management Master's Programs DBA, Harvard University
Innovation, information technology, technology management, electronic business

Harold G. Kaufman, Professor of Management, Academic Director of Organizational Behavior Program, Academic Director of MSM Extension in Israel
PhD, New York University
Managing professional and technical workers, career management, obsolescence of knowledge and skills, research methods

ASSISTANT PROFESSORS

Yair Berson, Assistant Professor of Management
PhD, SUNY Binghamton
Organizational behavior, leadership of high technology firms, strategic leadership

Barry S. Blecherman, Assistant Professor of Management, Academic Director of MSM Program
PhD, Wharton School, University of Pennsylvania
Information economics and strategy, decision theory, business negotiations

Jonathan P. Linton, Assistant Professor of Management
PhD, York University
Process innovation, operations management, project management

Mihir Parikh, Assistant Professor of Management
PhD, Georgia State University
Information and knowledge management, management of information technologies (IT) and systems, impact of IT on organizations and industries, IT-enabled innovation, applications of IT in business decision making and education, electronic business

Bharat P. Rao, Assistant Professor of Management
PhD, University of Georgia
Strategic alliances, collaborative new product development, supply chain management, strategic management, electronic commerce

INDUSTRY FACULTY

Fredrick Novomestky, Industry Associate Professor of Management, Academic Director of Financial Engineering Program, Director of Center for Finance Technology
PhD, Polytechnic University
Multimedia object development, 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 Management Master's Programs
PhD, New York University
Strategic relationships between the technology organization and business units, intranet and Internet strategy, global technology strategy

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

Philip Angelillo, Adjunct Assistant Professor of Management
MS, Polytechnic University
Operations management, management of technology

Richard T. Archambault, Adjunct Associate Professor of Management
MBA, Fairleigh Dickinson University
Strategic planning, supply chain management, project management, business process re-engineering

Eknath Belbase, Adjunct Associate Professor of Financial Engineering
PhD, University of Pennsylvania
Structured financial products, quantitative financial modeling

Leonard Berkowitz, Adjunct Associate Professor of Management
MS, Massachusetts Institute of Technology
Intellectual property, patents, research and development

Paul Beiderman, Adjunct Associate Professor of Financial Engineering
PhD, New School University
Financial market regulation, industry economic analysis

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

Robert Cohen, Adjunct Associate Professor of Management
MBA, New York Institute of Technology
Management information systems, quality control and systems

Michael Cortegiano, Adjunct Associate Professor of Management
BS, Fairfield University
Accounting and finance

Anthony Davidson, Adjunct Associate Professor of Management
PhD. City University of London (England)
Management information systems, information technology, operations management, business policy and marketing

Ducarmel Dorceus, Adjunct Associate Professor of Financial Engineering
MA, New York University
Accounting of financial products

Philip Dorin, Adjunct Associate Professor of Management, Management Department Adviser for Long Island Campus
PhD. University of Connecticut
Human resource management, training and development

Philip Ferrara, Adjunct Associate Professor of Management
PhD. Hofstra University
Organizational staffing, job design

Frederick Ferront, Adjunct Associate Professor of Management
MBA, Rutgers University
Management information systems, operation management, online marketing applications

Martin Fischer, Adjunct Associate Professor of Management
MA, Columbia University, Teacher's College
Network management, electronic commerce, systems management

Roy Freedman, Adjunct Associate Professor of Financial Engineering
PhD. Polytechnic University
Evolutionary information technology, quantitative methods in finance, artificial intelligence

Robert R. Goodman, Adjunct Associate Professor of Management
MBA, Harvard University
Corporate and government management

Clyde Granger, Adjunct Associate Professor of Management
MBA, Dowling College
Total quality management

Sara Grant, Adjunct Associate Professor of Management
MA, Indiana University, MA, Columbia University
Organizational theory and design, human resource management, conflict management

Edward Greenbaum, Adjunct Associate Professor of Management
MS, Cornell University
Industrial and labor relations

Thomas Hutchinson, Adjunct Associate Professor of Financial Engineering
MA, McMaster University (Canada)
Investment banking, financial economics

Mark Kurman, Adjunct Associate Professor of Management
MA, Bowling Green State University
Human resource management, organizational development

Victor Makarov, Adjunct Associate Professor of Financial Engineering
PhD. USSR Academy of Sciences
Market risk measurement and management, quantitative methods in finance

Ingrid Marshall, CPA, Adjunct Associate Professor of Financial Engineering
MBA, St. John's University
Corporate financial accounting

Daniel A. Nathanson, Adjunct Associate Professor of Management
PhD, Wharton School, University of Pennsylvania
Entrepreneurship, venture capital, venture creation

Carl Nelson, Adjunct Associate Professor of Management
MIE, New York University
Operations management

Laurence O'Connell, Adjunct Associate Professor of Management
MBA, Fordham University
Construction and operation management

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

Joel Rudenstein, Adjunct Associate Professor of Management
MS, New York University
Entrepreneurship, venture capital, angel investing, venture creation

James Sagner, Adjunct Associate Professor of Financial Engineering
PhD, American University
Cash flow reengineering, financial institution management

Sven Sandow, Adjunct Associate Professor of Financial Engineering
PhD, Martin-Luther-Universität (Germany)
Mortgage-backed securities, fixed income portfolio strategies

Jayanthi Sankaran, Adjunct Associate Professor of Financial Engineering
PhD, Syracuse University
Equity valuation, financial statement analysis, risk management

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

Howard Stern, Adjunct Associate Professor of Financial Engineering
PhD, Massachusetts Institute of Technology
Structured financial products, quantitative financial remodeling

Arthur Szeglin, Adjunct Associate
Professor of Management
MS, Polytechnic University
Total quality 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*

Stanley Welland, Adjunct Associate
Professor of Management
PhD, New Jersey Institute of
Technology
*Financial systems design and manage-
ment, computer networking, financial
markets and global economics*

Stanley Willing, Adjunct Professor
of Management
EdD, New York University
*Labor relations, performance appraisal,
compensation management*

Gerald Wisz, Adjunct Associate
Professor of Financial Engineering and
Management
PhD, Johns Hopkins University
*Corporate financial strategy, quantita-
tive methods applied to finance and
operations research*

Anthony Zinsser, Adjunct Associate
Professor of Management
PhD, Stevens Institute of Technology
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, Professor
Emeritus of Management
ScD, Columbia University
*Management of innovation, technology
management, science and technology
policy*

ADVISORY BOARDS: CORPORATE AND ACADEMIC

The Department of Management main-
tains close and deep ties with a wide range
of firms in a host of knowledge- and
innovation-intensive sectors. The depart-
ment 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 dis-
cuss and review the department's learning
programs, research and plans for the future.
In this manner, the department stays
informed, meets the pragmatic and schol-
arly needs and critical challenges con-
fronting technology and innovation
executives and makes certain that its
courses and programs are state-of-the-art
and relevant.

CHAIR OF CORPORATE ADVISORY BOARD

George M. Lieberman
Chief Information Officer
Verus International Group Limited

OTHER CORPORATE ADVISORY BOARD MEMBERS

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Edward Fitzpatrick
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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 Knowledge Officer
Monitor Company

Michael Kleeman

Chief Technology Officer
Aerie Networks

Lewis Krulwich

Partner
PricewaterhouseCoopers LLP

Stephen Lake

CEO
Nextdoor.com

Stephen J. Newman

Program Director
Executive Development
LM Ericsson

Dennis O'Brien

Technical Program Manager
Telica

J. R. (Jay) Topper, Jr.

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Welland Associates

Randy Wiele

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**PROGRAM ADMINISTRATION
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Administrative Director
MOT-TIM Executive Masters Programs
BS, Union College

Bohdan Hoshovsky

Executive Assistant and Deputy
Webmaster
MS, Polytechnic University

Olga Juravitsky

PC/LAN Support

Janelle McAdams

Administrative Assistant
BA, Lycoming College

Cheryl Robinson

Administrative Assistant
BA, College of New Rochelle

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.

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.

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.

DEGREES OFFERED

Bachelor of Science

- Mathematics

Master of Science

- Mathematics

Doctor of Philosophy

- Mathematics

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FACULTY

PROFESSORS

Keith Ball, Professor of Mathematics
PhD, Cambridge University
Functional analysis, combinatorics, convexity

Burton Lieberman, Professor of Mathematics
PhD, New York University
Statistics, differential equations, sports science

Erwin Lutwak, Professor of Mathematics, Department Head
PhD, Polytechnic University
Geometric analysis

Edward Y. Miller, Professor of Mathematics
PhD, Harvard University
Differential topology

Lesley Sibner, Professor of Mathematics
PhD, New York University
Partial differential equations, global analysis

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

Erich Zauderer, Professor of Mathematics
PhD. New York University
Nonlinear wave propagation, partial differential equations, diffraction problems

Gaoyong Zhang, Professor of Mathematics
PhD. Temple University
Geometric analysis

ASSOCIATE PROFESSORS

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 PROFESSORS

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

LECTURER

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PhD. University of Texas at Austin
Commutative algebra

INSTRUCTORS

Wenxiong Chen, Instructor of Mathematics
PhD. Institute of Math, Academia Sinica (China)
Nonlinear partial differential equations, geometric analysis

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PhD. Northern Illinois University
Cohomology of infinite groups, CW-complexes and homological algebra

Jerome S. Epstein, Instructor of Mathematics
PhD. New York University
Mathematical physics

Abdelhamid Kadik, Instructor of Mathematics
PhD. Polytechnic University
Medical physics

Carolyn D. King, Instructor of Mathematics
MA, New York University
Mathematics education

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PhD. Columbia University
Pseudo-differential operators, mathematical physics

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Mathematical biology

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PhD. Tufts University
Probability theory, stochastic processes, statistics

Alina Stancu, Instructor of Mathematics
PhD. University of Rochester
Geometric analysis

Hanna A. Ulman, Instructor of Mathematics
MA, Tel-Aviv University (Israel)
Real analysis

Lindsey Van Wagenen, Instructor of Mathematics
PhD. Columbia University
Applied physics

ADJUNCT FACULTY

Emeric Deutsch, Adjunct Professor of Mathematics
PhD. Polytechnic University

Harvansh Manocha, Adjunct Professor of Mathematics
PhD. Panjab University

Matthew Messinger, Adjunct Instructor of Mathematics
MS. Polytechnic University

Sudhakara Mishra, Adjunct Professor of Mathematics
PhD. City University of New York

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MS, New York University

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EMERITI FACULTY

George Bachman
Heinrich Guggenheimer
Leon Herbach
Harry Hochstadt
Clifford W. Marshall
Andrew J. Terzuoli
Hermann Waldinger
Georges Weill

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.

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 degrees are accredited by the Engineering Accreditation Commission (AEC) of the Accreditation Board of Engineering and Technology (ABET). 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.

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)

Advanced Certificates

- Achieving World Class Quality
- Industrial Engineering
- Manufacturing Engineering and Production Science
- Manufacturing Excellence by Design: Holistic Approach

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FACULTY**PROFESSORS**

William R. McShane, Professor of Mechanical and Systems Engineering, Vice President and Dean of Engineering and Applied Sciences
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, ferroelectric thin films

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

Sunil Kumar, Associate Professor of Mechanical Engineering
PhD, University of California at Berkeley
Thermal fluid sciences, applied mathematics

M. Volkan Otugen, Associate Professor of Mechanical Engineering
PhD, Drexel University
Experimental and theoretical fluid mechanics, unsteady and turbulent flows, optical diagnostics, combustion aerodynamics

Richard S. Thorsen, Associate Professor of Mechanical Engineering, Vice President of 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

Vikram Kapila, Assistant 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.

Xiaodong Wang, Assistant Professor of Mechanical Engineering
PhD, Massachusetts Institute of Technology
Linear and nonlinear fluid-structure interaction analyses; mathematical theory of computational methods; vibration, nonlinear dynamics, and instability theory; applied numerical methods for solids, fluids, and heat (mass) transfer problems; and hybrid computation with molecular dynamics and continuum mechanics

INDUSTRY FACULTY

James Bentson, Industry Professor of Mechanical and Aerospace Engineering
PhD, Polytechnic University
Computational methods, electrophysics, simulation, vehicle dynamics

Charles W. Hoover Jr., Distinguished Industry Professor of Manufacturing Engineering
PhD, Yale University
Physical design, manufacturing processes, electronic device assembly

Blair R. Williams, Industry Professor of Mechanical Engineering, Director of Manufacturing and Industrial Engineering Programs
MBS, University of Chicago
Computer integrated manufacturing

ADJUNCT FACULTY

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MS, University of Michigan
Physical design

Joseph Borowicz
PhD, Polytechnic University
Finite elements, numerical methods

David Fleck
MAABS, Leadership Institute of Seattle
Building high performance teams

David Friedman
PhD, Georgia Institute of Technology
Manufacturing

Michael Greenstein
MBA, University of Louisville
Design for manufacturability

Jai Menon
PhD, Cornell University
Geometric modelling, CAD/CAM, computer graphics, virtual reality

Cal Oltrogge
PhD, New York University
Change management, work design, personnel research, retraining and resource balancing

Reuven Shapira
MS, University of Tel-Aviv (Israel)
Production planning and control, ISO9000, quality driven process management

David Soukup

MS, University of Tennessee
*Factory simulation, project planning
and control*

Arthur Szeglin

PhD, Hofstra University
Design

John Thomas

MBA, University of Rochester
*Production control and manufacturing
resources planning*

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
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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
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Jerome M. Klosner, PE, Professor
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PhD, Polytechnic University

Harold Margolin, Professor Emeritus
DEngSc, Yale University

Morris Morduchow, Professor
Emeritus
DAcE, Polytechnic University

Gino Moretti, Professor Emeritus
PhD, University of Turin (Italy)

Wheeler K. Mueller Jr., Professor
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PhD, University of Illinois

Sebastian V. Nardo, Professor
Emeritus
PhD, Polytechnic University

Huo-Hsi Pan, Professor Emeritus
PhD, University of California at
Berkeley

Sharad A. Patel, Professor Emeritus
PhD, Polytechnic University

Bernard W. Shaffer, 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 course 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.

BIOMEDICAL ENGINEERING PROGRAM

Academic Director: Richard A. Gross

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 anticipate 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 BS 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 written report. Alternatively, a student may substitute BE 871/872 or BE 873/874 with electives chosen from the list of elec-

tives 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 program 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 753 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 administered by Polytechnic with a strategic partnership with SUNY Downstate Medical Center. 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

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 home departments.

BE 601 Molecular Immunology 2%/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%/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%/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%/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, biomagnetic 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. Immunosensors, 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 bio-medical 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, rheo-

logical 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 compensation. 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
2%: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

Breton 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

**PARTICIPATING FACULTY FROM
POLYTECHNIC UNIVERSITY**

Stephen Arnold, Thomas Potts Professor
of Physics and University Professor

Mary K. Cowman, Associate Professor
of Biochemistry

Bruce A. Garetz, Professor of Physical
Chemistry

Mark M. Green, Professor of Organic
Chemistry

Richard A. Gross, Herman F. Mark
Professor of Polymer Science; Director
of NSF Center for Biocatalysis and
Bioprocessing of Macromolecules

Kalle Levon, Professor of Chemistry;
Head of Department of Chemical
Engineering, Chemistry and Materials
Science; Director of Polymer Research
Institute

Jovan Mijovic, Professor of Chemical
Engineering

Shirley M. Motzkin, Professor of
Biology

Yitzhak Shnidman, Assistant Professor
of Chemistry

Leonard I. Stiel, Associate Professor of
Chemical Engineering

Iwao Teraoka, Associate Professor of
Polymer Chemistry

Nancy M. Tooney, Associate Professor
of Biochemistry, Associate Dean of
Engineering and Applied Sciences

Abraham Ulman, Alstadt-Lord-Mark
Professor of Chemistry

Edward N. Ziegler, Associate Professor
of Chemical Engineering

Jordanka Zlatanova, Professor of
Biology

Walter P. Zurawsky, Associate
Professor of Chemical Engineering

CHEMICAL ENGINEERING PROGRAM

Chemical 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 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 engineers may choose from a very wide range of activities including research, process and product development, design and supervision of the construction and operation of industrial plants, technical sales and services, consulting, management and teaching. Opportunities in chemical engineering are virtually unlimited.

The foundations of chemical engineering are the sciences, with emphasis on chemistry, mathematics, physics and the engineering sciences (including thermodynamics, fluid mechanics, kinetics and heat and mass transfer). Chemical engineering courses include the analysis, design and control of equipment, operations and processes. Through this course of study, chemical engineering 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 engineering provides a solid foundation in science and the engineering sciences. An integrated set of chemical engineering courses is built upon this foundation. Thorough instruction is given in chemistry, physics, mathematics and engineering science, which are basic to the understanding of physical and chemical operations and processes. Courses in engineering science include engineering thermodynamics, reaction kinetics, process dynamics, fluid

mechanics, heat transfer and mass transfer.

The undergraduate program leads to a Bachelor of Science in Chemical Engineering and is accredited by the Accreditation Board for Engineering and Technology (ABET).

GOALS AND OBJECTIVES

The objectives of the BS degree in Chemical Engineering are to produce graduates who:

1. Are well grounded in the fundamentals of chemical engineering
2. Understand how to apply these fundamentals to the analysis and design of chemical processes
3. Understand the social, economic and ethical problems inherent in the practice of chemical engineering
4. Are committed to a lifetime of learning

With these attributes, graduates will be poised to become valuable members of the chemical engineering profession and society as a whole and they will be prepared to work in industry or government or pursue advanced degrees in chemical engineering or related fields. 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 engineering education and is incorporated into many of the chemical engineering 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 engineering curriculum provides a background that enables the graduate to select a professional career from an extremely broad spectrum of opportunities. Graduates are prepared to take

employment in a number of capacities in industry or to enter graduate school for advanced study in chemical engineering or other fields.

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 2.0 GPA must be maintained in chemical engineering courses CH 2214, CH 3314, CH 3324, CH 3214 and CH 3514; 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, Doctor of Philosophy in Chemical Engineering and Doctor of Philosophy in Chemical Engineering with a concentration in Polymer Science and Engineering available. The department also offers a program leading to a Master of Science in Polymer Science and Engineering, which is described in a separate section of this catalog. A degree in chemical engineering is generally required for admission to graduate study. An applicant who has earned a bachelor's degree from a foreign institution is required to submit Graduate Record Examination and TOEFL scores. 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 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.

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 631	Transport Phenomena I	3
CH 632	Transport Phenomena II	3
CH 773	Thermodynamics I	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, in January, and is taken after the first semester of graduate study. 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 (credits) of academic work past the bachelor's degree, including a minimum of 48 units of dissertation research. Although the student may elect to take more than 48 units of 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 three 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 15

Course No.	Course Title	Units
CH 631	Transport Phenomena I	3
CH 632	Transport Phenomena II	3
CH 773	Thermodynamics I	3
CH 774	Thermodynamics II	3
CH 781	Chemical Reactor Analysis & Design I	3
CH 991*	Departmental Seminar	0

* CH 991 Must be taken for 2 years.

2. Electives: six courses, of which at least two must be in chemical engineering subjects. 18

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

CONCENTRATION IN POLYMER SCIENCE AND ENGINEERING

The objective of the Polymer Science and Engineering program is to provide the students with a well-rounded advanced level education covering major areas of chem-

istry, physics and engineering of polymeric materials. Polytechnic has all of the elements necessary to conduct such a program, owing to its long tradition of excellence in the area of polymers. The philosophy followed in this program is to expose full-time and part-time students to all aspects of Polymer Science and Engineering and to enable them to (a) choose a new career path, (b) advance in the sub-specialty at a professional level and/or (c) continue in a PhD program.

The department also offers a graduate program leading to the degree PhD in Chemical Engineering with a concentration in Polymer Science and Engineering. An undergraduate degree in chemical engineering is usually required for admission to this program. Applicants with degrees in other fields may be admitted with undergraduate or graduate deficiencies upon the approval of a graduate adviser. Candidates for the PhD in Chemical Engineering with concentration in Polymer Science and Engineering are to plan their programs in accordance with the following list of requirements for full-time study:

1. Required Subjects 18

Course No.	Course Title	Units
CH 631	Transport Phenomena I	3
CH 632	Transport Phenomena II	3
CH 773	Thermodynamics I	3
CH 781	Chemical Reactor Analysis & Design	3
CH 921	Polymer Processing	3
CH 926	Engineering Properties of Polymers	3
CH 991/992*	Seminar in ChE	0

* CH 991/992 must be taken for two years.

2. Minor: three courses 9

A three-course minor must be chosen in polymer-related subjects from the following courses in the department: CM 771, CM 772, CM 781, CM 782, CM 783 and CM 785.

3. Electives: five courses 15

At least two electives must be chosen from the residual courses on the minor list and the following courses in chemical engineering: CH 862, CH 922, CH 928, CH 933, CH 940. The remaining three electives may be chosen from any graduate course in chemical engineering or chemistry, or from another science or engineering department with the approval of the graduate advisor in chemical engineering.

4. CH 989 PhD Thesis 48

Up to 12 units of Master's Thesis can be included here.

Total 90

Of the 14 courses, at least seven are on polymers.

UNDERGRADUATE COURSES

CH 2214 Chemical Process Analysis 4:0:0:4

Introduction to chemical processing and chemical engineering problem solving through material and energy balance calculations on non-reacting and reacting systems. Material and energy balances on closed and open systems, including systems with recycle and chemical reactions, are examined. *Prerequisite: adviser's approval.*

CH 3214 Chemical Reactor Engineering 4:0:0:4

Application of thermodynamics and chemical kinetics to the analysis and design of chemical reactors and reactor systems. Batch and continuous-flow, ideal reactors. Isothermal and non-isothermal reactor design. Catalysis and catalytic reactors. Mass transfer effects. Models for non-ideal reactors. *Prerequisite: CH 3314, 3514. Co-requisite: CH 3324.*

CH 3314 Transport Phenomena 4:0:0:4

Introduction to viscous fluid flow, heat transfer and mass transfer. Basic conservation equations and rate equations are developed, discussed and used to analyze systems of interest for chemical processing. *Prerequisite: MA 2132.*

CH 3324 Mass Transfer Operations 4:0:0:4

Introduces many aspects of mass transfer. Topics covered in this course 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: CH 3514 and CH 3314.*

CH 3514 Chemical Engineering Thermodynamics 4:0:0:4

Application of First and Second Law for real fluids with equations of state. Thermodynamic analysis of steady-state flow and cyclic processes. Thermodynamic properties of fluids. Ideal and non-ideal mixtures. Partial molar and excess properties of mixtures. Phase equilibrium calculations at low and elevated pressures by computer procedures. Chemical reaction equilibria. *Prerequisites: CM 2614 and CH 2214.*

CH 4114 Engineering Laboratory and Profession I 2:6:0:4

The laboratory portion of this course focuses on experimental studies of unit operations, transport processes and thermodynamics. Students must design and conduct experiments, interpret results and prepare engineering reports. The lecture portion of this course covers a range of laboratory, equipment and design issues. *Prerequisites: CH 3324 and CH 3314.*

CH 4124 Engineering Laboratory and Profession II 2:6:0:4

The laboratory portion of this course focuses on experimental studies of unit operations, transport processes and process control and chemical reactions. Students must design and conduct experiments, interpret results and prepare engineering reports. The lecture portion of this course covers a range of laboratory, equipment and design issues. *Prerequisites: CH 4114 and CH 4414.*

CH 4414 Process Dynamics and Control 4:0:0:4

Introduces chemical engineering students to process dynamics and process control. Dynamic models of 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. *Prerequisite: CH 3314.*

CH 4614 Chemical Process Design
4:0:0:4

Design of large chemical process systems, with special emphasis on more complex, integrated process schemes and systems. *Prerequisites: CH 4114, CH 3214 and CH 4414.*

CH 4714 Engineering Materials
4:0:0:4

Processing, structure, properties and applications of polymers, metals, alloys and composites as engineering materials. Fundamentals of processing-morphology-property correlations in materials. Basic concepts of viscoelasticity, fracture behavior and thermal and electrical properties of engineering materials. *Prerequisite: CH 3214.*

CH 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.*

CH 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.*

CH 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 631/632 Transport Phenomena I/II
each 2½:0:0:3

Fundamental concepts of momentum, energy and mass transport; transport in stationary and flow systems, steady-state and transient conditions. Elementary Cartesian vector and tensor analyses; conservation equations for general cases and in macroscopic form; rate expressions. Fluid dynamics, energy transfer and diffusion; turbulent transport; transport coefficients; analogies; dimensional analysis; boundary layers, high rates of mass transport. Applications to chemical engineering systems stressed. *CH 631 prerequisites: CH 3314 and CH 3324 or equivalent. CH 632 prerequisite: CH 631.*

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.

CH 773 Chemical Engineering Thermodynamics I
2½:0:0:3

Advanced treatment of chemical and phase equilibria, phase rules, Gibbs-Duhem equation, non-ideal solutions; stability of thermodynamic systems, osmotic pressures, surface tensions, thermodynamic equilibria in potential fields; introduction to irreversible thermodynamics. *Prerequisite: CH 3514 or equivalent.*

CH 774 Chemical Engineering Thermodynamics II
2½:0:0:3

Laws of thermodynamics, conditions for thermodynamic equilibria; use of equations of state and the principle of corresponding states to determine changes in thermodynamic properties for pure substances and mixtures. Chemical potentials, standard states, ideal solutions, introduction to chemical and phase equilibria. *Prerequisite: CH 3514 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: CH 3214.*

CH 821 Process Dynamics and Control
2½:0:0:3

Instrumentation and control of chemical processes from the viewpoint of systems engineering. Unsteady state behavior of chemical engineering systems. Analyses of closed-loop feedback systems for control of variables of chemical processes equipment. *Prerequisite: CH 4414 or equivalent.*

CH 921 Polymer Processing
2½:0:0:3

Applications of engineering principles to polymer processing. Non-Newtonian polymeric systems. Extrusion theory and applications. Discussions and problem-solving in injection molding, fiber spinning, film blowing and co-extrusion, as well as other polymer engineering processes. *Prerequisites: CH 3314 and CH 3324 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.*

PROJECTS, THESES AND SEMINARS**CH 902 Guided Studies in Chemical Engineering** 6 units, each 2 units

Selections, analyses, solutions, and presentations of engineering reports of problems in processes or equipment design, thermodynamic studies or correlations, or other fields of chemical engineering practices under supervision of staff member. Conferences scheduled. Master's degree candidates required to submit three unbound copies of typewritten reports to advisers one week before the last day of classes. *Prerequisite: degree status.*

CH 930 Guided Studies in Polymer Science and Engineering

6 units, each 2 units

Selections, analyses, solutions and presentations of comprehensive reports of problems involving polymeric materials, such as polymer synthesis, processing, evaluations and equipment design. Supervision by staff members. Conferences scheduled. Master's degree candidates required to submit three unbound copies of typewritten project reports to advisers one week before the last day of classes. *Prerequisite: degree status.*

CH 987 Thesis for Degree of Master of Science in Polymer Science and Engineering 9 units, each 3 units

Theses for the master's degree in polymer science and engineering should give results of original investigations of problems in the chemistry and chemical engineering of polymeric materials. Theses may involve experimental research, theoretical analyses, process design, or combinations thereof. Master's degree candidates required to submit four typewritten unbound thesis copies to advisers before or on the seventh Wednesday before commencement. *Prerequisite: degree status.*

CH 989 Dissertation for Degree of Doctor of Philosophy in Chemical Engineering with Concentration in Polymer Science and Engineering 30 units, each 3 units

See description for CH 999. A wide variety of problems may be selected from topics in polymer science and engineering.

CH 991/992 Departmental Seminars*No Credit*

Recent developments in chemical engineering, chemistry and materials science are presented through lectures given by engineers from industry, research and educational institutions and by staff members and qualified graduate students. Two semesters are required of all graduate students seeking degrees.

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

Theses for 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 typewritten unbound thesis copies to advisers before or on the seventh Wednesday prior to commencement. *Prerequisite: degree status.*

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

Dissertations must give results of independent investigations of problems in chemical engineering and may involve experimental and/or theoretical work. Theses must show ability to do creative work and that original contributions 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: degree status and a qualifying examination on quantitative aspects of chemical engineering.*

Typical Course of Study for the Bachelor of Science in Chemical Engineering

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
MA 1012	Calculus IA ¹ (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 ²	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
PH 1004	Introductory 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 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
CM 2214	Organic Chemistry I	3	3	0	4
HL 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 (½ semester)	4	0	0	2
CH 2214	Chemical Process Analysis	4	0	0	4
CM 2614	Physical Chemistry I	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

CM 3214	Industrial Organic Chemistry	3	6	0	4
CH 3514	Chem. Eng. Thermodynamics	4	0	0	4
CH 3314	Transport Phenomena	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					16

Spring Semester

CH 3324	Mass Transfer Operations	4	0	0	4
CH 3214	Chemical Reactor Eng.	4	0	0	4
	Sequence Elective I ⁴				4
	Technical Elective ⁵				4
					16

SENIOR YEAR

Fall Semester

CH 4114	Engineering Laboratory I	2	6	0	4
CH 4414	Process Dynamics & Control	4	0	0	4
	Sequence Elective II ⁴				4
	Technical Elective ⁵				4
					16

Spring Semester

CH 4124	Engineering Laboratory II	2	6	0	4
CH 4714	Engineering Materials	4	0	0	4
CH 4614	Chemical Process Design	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					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 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, HL, MU, PL, and PS. Two courses must be from Level II Elective courses in different disciplines and one from Level II Elective courses.

4. A list of approved Sequence Electives is available from the department.

5. Technical Electives must be engineering courses unless the Sequence Electives are in engineering; then the Technical Electives may be non-engineering technical courses.

CHEMISTRY PROGRAM

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 Department of Chemical Engineering, Chemistry and Materials Science 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 Chemistry, a Bachelor of Science in Chemistry with a concentration in biomedical sciences, a Master of Science in Chemistry and a Doctor of Philosophy in Materials Chemistry.

GOALS AND OBJECTIVES

The goals of the Bachelor of Science program are to let students acquire fundamental knowledge and skills needed to advance to graduate chemistry programs, as well to be able to work as chemists in the rapidly changing work environment presented by industrial and institutional labo-

ratories. This will be accomplished by exposing them to new ideas and a research-oriented curriculum that allows them to create knowledge appropriate to their level while learning. In this way, the program hopes to attract and train students who are adaptable, a key characteristic necessary for success in the scientific world today.

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

Students are exposed to different branches of chemistry—organic chemistry, physical chemistry, biochemistry, polymer chemistry and analytical chemistry. Participation of undergraduates in optional research activities is encouraged. Special programs in the department also expose them to the essential elements of the chemistry of materials and of biological materials.

The department provides curricula that go beyond the requirements of the American Chemical Society for professional training. Courses offered prepare students for graduate studies or work in industry. The American Chemical Society certifies the degree Bachelor of Science in Chemistry; graduates are immediately eligible for society membership.

REQUIREMENTS FOR THE BACHELOR OF SCIENCE

	Credits
Chemistry	40
Chemistry elective	4
Thesis research*	8
Biology	4
Computer Science	4
Humanities/Social Sciences	28
Mathematics	16
Physics	8
Sequence electives	8
Math/Science elective	4
Free elective	4
Total	128

A minimum of 128 credits is required for the Bachelor of Science in Chemistry.

**Students registering for thesis research are required to submit a written report prior to graduation. Students may elect a no-thesis option (such degree programs will not be certified by the American Chemical Society) and select 8 credits of advanced chemistry courses in consultation with an adviser.*

Concentration in Biomedical Sciences

The biomedical sciences concentration of the Bachelor of Science in Chemistry provides a significant exposure to both chemical and biological sciences. The objectives of this concentration are to familiarize the students with chemistry, biochemistry and biology, and to prepare them for biomedical careers, including the necessary prerequisites for medical and other health professional schools. Students may select this curriculum to prepare for professional careers in medicine, dentistry, osteopathy, veterinary science, podiatry, optometry, bioengineering or biomaterials. Students take a two-year core curriculum, providing a strong base that enables them to select concentrations of courses in their chosen area, such as bioengineering, biotechnology or biochemistry, during the last two years.

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 5010, 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 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 5010 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 written preliminary examination during the second year. Two attempts are allowed. (After a second failure, the student is dropped from the doctoral program.) 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. Within six months after the written preliminary examination, students complete an oral preliminary examination, where they present plans and possibly results from specific areas of thesis research for evaluation by the committee. 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 credits 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 5010 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 Science and after completion of preliminary examinations.

UNDERGRADUATE COURSES

CM 1004 General Chemistry for Engineers 3:2:1:4

A one-semester course in general chemistry. Topics include chemical equations, stoichiometry, thermodynamics, gases, atomic and molecular structure, periodic table, chemical bonding, states of matter, chemical equilibrium and electrochemistry.

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.*

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 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, MA 2132 and PH 2004.*

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. *Prerequisites: CM 1004 and CM 2614.*

CM 3214 Industrial Organic Chemistry 3:3:0:4

The second organic chemistry course teaches Organic Chemistry Principles and Industrial Practice with selected laboratory experiments. The course material will focus on petroleum based organic chemistry and polymer organic chemistry. *Prerequisite: CM 2214.*

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 instructor's permission.*

CM 3324 Biochemistry II 2:6:0:4

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. *Pre-/Co-requisite: CM 3614.*

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. *Prerequisite: 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 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 2224 and CM 3614.*

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 5010 Information Sources for the Chemical Sciences 1:0:0:0

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.

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** 3%:0:0:4%

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
2%:0:0:3**PHYSICAL CHEMISTRY****CM 703 Chemical Physics I** 3%:0:0:4%

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 3%:0:0:4%

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
2%: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**
2%: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 2224 and CM 3614 or instructor's permission.*

CM 772 Synthesis of High Polymers
2%: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
2%:0:0:3

Application of osmometry, light scattering, equilibrium ultracentrifugation, electrophoresis, viscosity, diffusion, ultra centrifugal sedimentation, flow birefringence, polarimetry, spectroscopy and other techniques to the characterization of dissolved macromolecules. Properties of poly-electrolytes, association in solutions containing macromolecules and reaction kinetics in macromolecular solutions also are discussed. The course is designed to cover both synthetic and biological macromolecules. *Prerequisite: CM 771.*

CM 782 Macromolecules in Solid States
2%: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
2%:0:0:3

Presentation at intervals of various advanced or specialized topics in polymer chemistry.

CM 790 Biopolymers
2%: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.*

ANALYTICAL CHEMISTRY**CM 802 Applied Spectroscopy**
3%:0:0:4%

Solving chemical problems using spectroscopic methods. Vibrational, electronic, nuclear magnetic resonance spectroscopy and mass spectrometry. Discussion of physical principles, instrumentation, interpretation of spectra, applications to molecular and physical problems.

ORGANIC CHEMISTRY**CM 903 Organic Chemistry I**
3%:0:0:4%

Molecular structure and bonding. Stereochemical and conformational principles. Theories of bonding and the physical parameters of stable and reactive molecular states. Applications in biochemistry and polymer chemistry. Prerequisites: undergraduate physical chemistry and organic chemistry.

CM 904 Organic Chemistry II
3%:0:0:4%

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 907 Organic Spectroscopy
3%:0:0:4%

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
2%: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 2%: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
2%:0:0:3

Selections from the following topics: protein and nucleic acid chemistry; intermediary metabolism; metabolic regulation. *Prerequisite: CM 941 or instructor's permission.*

GENERAL COURSES**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 0:0:1%:1%

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.*

LIFE SCIENCES COURSES

In recent years, Polytechnic has developed life sciences courses that complement those in its teaching and research programs in engineering and physical sciences. Undergraduate students with specific interests in the areas of biology, biochemistry, environmental sciences, bioengineering, pre-medicine and laboratory techniques may select life sciences courses to fulfill specific BS program requirements or to serve as technical or free electives. Biology is concerned with the study of life in all manifestations, from the simple to the complex, from the invisible to the macroscopic, the virus to the human. To move beyond definitions of life to an understanding of life's fundamental nature, the characteristics of living systems must be examined. This includes growth, heredity and reproduction; metabolism; and the study of molecular, cellular and organismal levels.

UNDERGRADUATE COURSES

LS 1004/2004 General Biology I/II
each 3:3:0:4

Fundamentals of biology. Physical, chemical, biochemical bases of life on various organizational levels, cellular morphology, complementarity of form and function. Reproduction, development, genetics. Homeostasis, regulation, integration, coordination. *LS 1004 prerequisite: high school chemistry; LS 2004 prerequisite: LS 1004 or instructor's consent.*

LS 2314 Organismal Physiology 3:3:0:4

Mechanism involved in functional processes of cells and multicellular organisms, including integration and control aspects. Membrane function, transport, excitation, conduction, contraction, luminescence. Lab fee required. *Prerequisites: LS 2004 and CM 1004. Co-requisite: PH 2004.*

LS 3114 Genetics 3:3:0:4

Fundamental aspects of 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 as well as topics in human genetics are included. Laboratory techniques used in the biological and biochemical study of genetic phenomena in prokaryotes, eukaryotes and their viruses. Emphasis placed on modern approaches to genetic research. Lab fee required. *Prerequisite: LS 2004. Co-requisite: CM 2214.*

LS 3214 Microbiology 3:3:0:4

Study of microbial organisms, especially bacteria and viruses. Microbial relationship to disease, infectious and immunologic processes. Mutation, transformation, transduction, induction and bioenergetic processes. Laboratory work 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: LS 2004 and CM 1004 or instructor's permission.*

LS 4314 Cell Physiology 3:3:0:4

Analyses of chemical and physical mechanisms of cellular function. Molecular constituents of biological systems, enzymes and reaction rates, energetics and regulation of metabolic process, 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. *Prerequisite: LS 2004. Co-requisites: CM 2224 and CM 2614.*

LS 4814/4824/4834/4844 Topics in Biology each 4 credits as arranged

LS 4914/4924 Projects in Life Sciences
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.*

LS 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 cosponsors. Faculty conferences and visits required. Open to senior students on approval of departmental adviser. Preplanned experiences provide students with significant exposure to relationships between theoretical information and practical applications. *Prerequisite: senior status or adviser's approval.*

GRADUATE COURSES

LS 561/562 Advanced Topics in Biology
As arranged

From time to time, graduate level courses may be offered in bioethics, electron microscopy, environmental biology, neurophysiology, topics in neurophysiology, topics in neurosciences and cytology.

Typical Course of Study for the Bachelor of Science in Chemistry

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
CM 1004	General Chemistry	3	2	1	4
CS 1114	Intro. Prog. & Problem Solving	3	3	0	4
MA 1012	Calculus IA ¹ (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
EN 1014	Writing & Humanities I ²	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.
LS 1004	General Biology I	3	3	0	4
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 II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

CM 2214	Organic Chemistry I ¹	3	6	0	4
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
					16

Spring Semester

CM 2224	Organic Chemistry II ¹	3	6	0	4
CM 2614	Physical Chemistry I	4	0	0	4
MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi. Calculus B (½ semester)	4	0	0	2
	HU/SS Elective ⁴	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

CM 3114	Inorganic Chemistry ³	3	3	0	4
CM 3314	Biochemistry I	4	0	0	4
CM 3614	Physical Chemistry II	2	6	0	4
CM 5040	Chemical Laboratory Safety	1	0	0	0
	HU/SS Elective ⁴	4	0	0	4
					16

Spring Semester

CM 3324	Biochemistry II	2	6	0	4
CM 3514	Analytical Chemistry ⁵	3	3	0	4
CM 5010	Info. Sources for Chemical Sci.	1	0	0	0
	Sequence Elective I ⁵				4
	HU/SS Elective ⁴	4	0	0	4
					16

SENIOR YEAR

Fall Semester

CM 4114	Polymer Chemistry ¹	3	3	0	4
CM 4914	Undergraduate Research	0	12	0	4
	Sequence Elective II ⁵				4
	HU/SS Elective ⁴	4	0	0	4
					16

Spring Semester

CM 4924	Undergraduate Research	0	12	0	4
	CM Elective				4
	MA/SC Elective				4
	Free elective ⁶				4
					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 or EN 1090 must subsequently register for EN 1034, rather than EN 1014.

3. Laboratory meets on alternate weeks.

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 II Elective courses.

5. A list of approved Sequence Electives is available from the department.

6. The Free Elective could be a course offered by any department, provided it does not duplicate material studied in other courses.

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 chemistry courses at other schools.

Typical Course of Study for the Bachelor of Science in Chemistry—Concentration in Biomedical Sciences

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
CM 1004	General Chemistry	3	2	1	4
CS 1114	Intro. Prog. & Problem Solving	3	3	0	4
MA 1012	Calculus IA ¹ (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
EN 1014	Writing & Humanities I ²	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.
LS 1004	General Biology I	3	3	0	4
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 II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

CM 2214	Organic Chemistry I ³	3	6	0	4
LS 2004	General Biology II	3	3	0	4
PH 2004	Introductory Physics II	4	1½	1	4
HI 2104	Modern World History	4	0	0	4
					16

Spring Semester

CM 2224	Organic Chemistry II ³	3	6	0	4
CM 2614	Physical Chemistry I	4	0	0	4
LS 2314	Organismal Physiology	3	3	0	4
	HU/SS Elective ⁴	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

CM 3314	Biochemistry I	4	0	0	4
LS 3214	Microbiology	3	3	0	4
CM 5040	Chemical Laboratory Safety	1	0	0	0
	MA/SC Elective				4
	HU/SS Elective ⁴	4	0	0	4
					16

Spring Semester

CM 3324	Biochemistry II	2	6	0	4
LS 3114	Genetics	3	3	0	4
CM 5010	Info. Sources for Chemical Sci.	1	0	0	0
	Sequence Elective I ⁵				4
	HU/SS Elective ⁴	4	0	0	4
					16

SENIOR YEAR

Fall Semester

LS 4914	Projects in Life Sciences	0	12	0	4
LS 4314	Cell Physiology	3	3	0	4
	CM/LS Elective				4
	Sequence Elective II ⁵				4
					16

Spring Semester

LS 4924	Projects in Life Sciences	0	12	0	4
	CM/LS Elective				4
	HU/SS Elective ⁴	4	0	0	4
	Free Elective ⁶				4
					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 or EN 1090 must subsequently register for EN 1034, rather than EN 1014.

3. Laboratory meets on alternate weeks.

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 II Elective courses.

5. A list of approved Sequence Electives is available from the department.

6. The Free Elective could be a course offered by any department, provided it does not duplicate material studied in other courses.

CIVIL ENGINEERING PROGRAM

UNDERGRADUATE PROGRAM

The Department of Civil Engineering develops engineering graduates capable of contributing to and advancing the practice of civil engineering and its subdisciplines. 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 program in Civil Engineering are that undergraduates should have sufficient exposure to all major subdisciplines in order to (1) allow them to choose a career path intelligently, (2) elect a program of depth in at least two subdisciplines and (3) continue in a Master of Science program in any civil engineering subdiscipline.

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 subdisciplines of civil engineering: structural and geotechnical engineering, environmental and water resources engineering, transportation engineering and construction engineering
- Have the opportunity to develop depth of knowledge in at least two of these subdisciplines within the scope of their undergraduate education
- Be capable of professional practice at the entry level in any civil engineering subdiscipline or to pursue graduate work in any of the subdisciplines
- Develop design knowledge and skills in at least three subdisciplines 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 subdisciplines through required courses.

Four courses provide the engineering science and professional underpinnings for all subdisciplines: CE 2114 Statics and Dynamics, CE 2124 Mechanics of Materials, CE 2214 Fluid Mechanics and Hydraulics and CE 3012 Civil Engineering Practice.

Structural engineering is covered in CE 3134 Structural Analysis and CE 3144 Structural Design.

The required environmental and water resources sequence includes CE 3222 Introduction to Environmental Engineering, CE 4232 Environmental Engineering and CE 4242 Water Resource Engineering.

CE 4312 Geometric Design of Highways introduces the student to highway and transportation engineering.

CE 4413 Construction Management provides a thorough overview of this important subdiscipline.

Design is covered in many of these courses, giving students exposure to design in the various subdisciplines. Courses CE 2214, CE 3144, CE 4232, CE 4242 and CE 4312 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 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 and transportation engineering. These allow students to gain significant depth in these areas. Selected students with sufficient grade-point averages

may take beginning graduate courses in these areas and in construction management. Special topics courses are provided in each major subdiscipline 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 3012 Civil Engineering Practice 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 3012 Civil Engineering Practice 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 subdiscipline. A typical four-year course of study for civil engineering majors is shown on the full-page chart in this section.

UNDERGRADUATE TRANSFER 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 Admissions 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 students should be aware that they can be awarded transfer credits for courses only for 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 Civil Engineering Design Project.*

TABLE 1: Curriculum for the BS in Civil Engineering

Course No.	Course Title	Credits	Sem ¹
Required Courses in Mathematics²			
MA 1012	Calculus IA	2	F1(a)
MA 1022	Calculus IB	2	F1(b)
MA 1112	Calculus IIA	2	F2(a)
MA 1122	Calculus IIB	2	F2(b)
MA 2012	Linear Algebra I	2	So1(a)
MA 2132	Ordinary Differential Equations	2	So1(b)
MA 2112	Multivariable Calculus A	2	So2(a)
MA 2122	Multivariable Calculus B	2	So2(b)
MA 2212	Data Analysis I	2	J1(a)
MA 2222	Data Analysis II	2	J1(b)
Total credits required		20	

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 credits required		12	

Required Courses in Freshman Engineering and Computer Science

EG 1004	Intro. to Engineering & Design	4	F1/F2
CS 1114	Intro. to Prog. & Problem Solving	4	F1/F2
Total credits required		8	

Required Courses in Civil Engineering

CE 2114	Statics & Dynamics	4	So1
CE 2214	Fluid Mechanics & Hydraulics	4	So2
CE 2124	Mechanics of Materials	4	So2
CE 3134	Structural Analysis	4	J1
CE 3012	Civil Engineering Practice	2	J1(a)
CE 3222	Intro. to Environmental Engineering	2	J1(b)
CE 3144	Structural Design	4	J2
CE 3154	Geotechnical Engineering	4	J2
CE 4232	Environmental Engineering	2	S1(a)
CE 4242	Water Resource Engineering	2	S1(b)
CE 4312	Geometric Design of Highways	2	S2(a)
CE 4162	Structural Materials	2	S2(b)
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 ⁴	3	S1
CE	Civil Engineering Elective	3	S2
CE	Civil Engineering Elective	3	S2
Total credits required		53	

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 credits required		24	

Required 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

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. Students may be required to complete additional remedial courses: MA 0902 Introduction to Pre-Calculus, MA 0912 Precalculus A and/or MA 0922 Precalculus B.

3. Civil engineering electives are technical electives, which must be taken in 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 program for either 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.

6. Level III electives have a prerequisite of a Level II elective.

7. Student are required to complete a two-course elective sequence. Approved sequences are listed in this catalog.

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 4173	Foundation Engineering	Fall
CE 4323	Traffic Engineering I	Fall
CE 4183	Advanced Structural Design & Analysis	Fall
CE 4023	Site Planning & Design	Fall
CE 4263	Environmental Geotechnology	Spring
CE 4273	Environmental Engineering Processes	Spring
CE 4193	Timber & Masonry Structures	Spring
CE 4253	Water Resource Projects	Spring
CE 4333	Traffic Engineering II	Spring
CE 4613	Special Topics Struct. & Geotechnical Eng.	Either
CE 4623	Special Topics Env. & Water Resource Eng	Either
CE 4633	Special Topics Transportation Engineering	Either
CE 4643	Special Topics Construction Management	Either
CE 471X-474X	Readings in Civil Engineering I-IV	As arranged

All courses are 3 credits.

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.

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.

The curriculum presented in this catalog applies to freshman students entering Polytechnic after September 2000. It is being implemented year by year. Thus, sophomore courses will be given for the first time in fall 2001, junior courses in fall 2002 and senior courses in fall 2003. Transfer students entering Polytechnic may fall under the previous curriculum based upon the timing of their entry and transfer credits awarded. For example, a transfer student entering in fall 2001 as a junior would fall under the previous curriculum. In some cases, it will be necessary for advisers to work with the student to arrange a curriculum that incorporates elements of both curricula.

GRADUATE PROGRAMS

Polytechnic offers graduate degree programs leading to the degrees Master of Science in Civil Engineering and Doctor of Philosophy in Civil Engineering.

Within these degree programs, students may choose to specialize in one of the following areas of graduate study:

- Structural Materials and Engineering
- Environmental and Water Resource Engineering
- Construction Management
- Geotechnical and Geo-Environmental Engineering

At the master's level, students may choose to specialize in one of these areas or may pursue a general program. At the doctoral level, all students must select an area of specialization.

The Department of Civil Engineering also offers graduate programs (MS, PhD and graduate certificates) in transportation planning, management and engineering (see the Transportation Program in this catalog) and environmental science and engineering (see Environmental Program in this catalog) and urban systems engineering and management (see Urban Systems Program 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 subdisciplines
- Design and analyze the 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

The PhD in Civil Engineering is a research-oriented degree intended for those whose goal is a 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 subdisciplines of civil engineering
- Perform independent fundamental research in one of the subdisciplines of civil engineering
- Produce a piece of fundamental research that meaningfully advances the state-of-the-art of one of the subdisciplines of 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 must 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.

Students with exceptional scholastic ability may seek admission to the doctoral program. Candidates pursuing a PhD will normally be expected to possess a master's degree in civil engineering (or equivalent) with a 3.5 GPA or better. As with master's applicants, foreign applicants must take the GRE and TOEFL examinations before their admission applications can be processed. The department head may waive these requirements in exceptional cases after a thorough review of the candidate's academic record and a comprehensive interview.

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 a graduate 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, dissertation).

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, dissertation) are assigned advisers for each such activity. The guided studies adviser 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 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 application when necessary.

TRANSFER CREDITS

The residency requirement for MS degrees is 27 units; for the PhD it is 30 units of dissertation research plus 12 units of course work. This is the minimum number of credits/units that must be taken at Polytechnic to be awarded a Polytechnic 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 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.

For PhD degrees, students may transfer up to 48 units of coursework, not including project, thesis or dissertation units. The same criteria as those specified for MS programs apply.

Validation credits by examination may not be used toward any civil engineering graduate degree program.

GRADUATE STUDENT 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

There are three requirements for the MS. Of these, Requirement 1 applies only to students selecting a specialty area for study. Requirements 2 and 3 apply to all students, regardless of whether they are following a specialty area or a more general program.

Requirement 1

A minimum of 15 units (5 courses) must be selected in the specialty area chosen; a minimum of 9 units (3 courses) must be selected from courses outside the specialty area chosen. Some courses within the specialty area may be required of all students selecting it.

Requirement 2

Course work must include courses within five defined skill categories as follows:

- 6 units (2 courses) in Analysis (A)
- 6 units (2 courses) in Design (D)
- 3 units (1 course) in Materials and Monitoring (M)
- 3 units (1 course) in Technologies and Processes (T)
- 3 units (1 course) in Project Management (P)

Requirement 3

All students must complete a 3-unit independent project or a 6-unit Master of Science Thesis. The project or thesis is considered a capstone experience for the degree.

A chart listing graduate courses currently authorized and given on a regular basis (at least once every other year) is shown on the full-page chart at the end of this section.

In addition to the courses listed in the chart, the Department of Civil Engineering offers additional courses for degree programs in transportation planning and engineering, transportation management, environmental engineering and environmental science. See the sections Transportation Program, Engineering and Environmental Program and Urban Systems Engineering Program in this catalog for descriptions. These programs may be included in a civil engineering master's program as appropriate with the approval of the adviser. Courses outside the Department of Civil Engineering may also be taken as electives with adviser's approval. The adviser may designate the skill and specialty areas that applies in these cases.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY

Course Requirements

Doctoral students are required to satisfy the course work required in a major field of study (one of the civil engineering sub-disciplines) and in two minor fields. They must complete a minimum of 60 units of course work beyond the bachelor's degree. At the time of enrollment, the adviser, in consultation with the candidate, will develop an outline of the major and minor fields. Course work completed toward other graduate degrees, either at Polytechnic or elsewhere, may be considered in meeting these requirements, subject to the residency requirements for the PhD. Residency requires that the student complete a minimum of 12 units of graduate course work toward the PhD at Polytechnic.

The major field represents the area of specialization in which the doctorate is sought. Minor fields represent areas of study that are supportive of the student's area of study and research. Nine to 12 units of approved course work are required in each minor. At least one of these minor areas must be selected from outside the specialty areas of the Department of Civil Engineering.

Qualifying Examination

Students must pass qualifying written and oral examinations to achieve the status of "doctoral candidate." Such candidacy must be achieved before registering for dissertation credit. Students are permitted a maximum of three attempts to pass these examinations.

Qualifying exams are generally taken after the student has established competency by completing most or all of the required courses in the major and minor areas of study. This will most often occur within the first year of full-time study beyond the master's degree. The department administers qualifying examinations twice each year at most. Specific dates vary, depending upon the specialty area; students should meet with their advisers for schedules.

Examinations are administered by a committee appointed by the head of the Department of Civil Engineering in consultation with each student's major adviser. The committee must have at least two faculty members from the Department of Civil Engineering and is usually the same as the student's doctoral guidance committee (described below), but may have additional members.

Written examinations are given in the major and in one minor field of study and may be given separately or in a combined format. Each examination normally lasts six to eight hours. Students should consult with members of the examining committee for guidance on the scope of these exams. The oral examination is given after the written exam(s) and may test both knowledge of specific course work and/or other indicators of success in research. In exceptional cases, the department head may waive the oral examination upon the recommendation of the examining committee.

Unsatisfactory performance in the qualifying examination may necessitate re-examination of the student's course work requirements and/or lead to a recommendation that the student withdraw from the doctoral program.

Dissertation Research

Students may register for dissertation units after successfully completing the qualifying examination. To complete the requirements for the PhD, students must complete a minimum of 30 units of dissertation research.

Candidates for the PhD in Civil Engineering must demonstrate the ability to do original research on a topic of current interest in the major field. Students should select the topic for research in consultation with their adviser. Doctoral research is expected to be of sufficient quality and originality to merit publication in appropriate professional journals. One or more papers should be prepared for publication in addition to the dissertation itself.

To advise students on dissertation research, a Guidance Committee will be appointed by the Dean of Engineering and Applied Sciences on the recommendation of the major adviser, who chairs the committee. The committee generally consists of the major adviser, the dissertation adviser, an adviser for each minor area of study and additional members as appropriate. The major adviser may or may not be the dissertation adviser, depending on the specific topic of research selected. The department head approves the membership of the Guidance Committee. The Guidance Committee may be appointed before the qualifying examinations and may be reconstituted later depending upon the scope of the research.

Once research has begun, students must register for dissertation each fall and spring semester. If this is not feasible, students must apply to the Dean of Engineering and Applied Sciences for a leave of absence.

Dissertation Defense and Formal Submittal

After completing the research, students must submit a draft dissertation in a prescribed format to the dissertation adviser. The draft will be reviewed by the Guidance Committee.

If the draft is considered acceptable, a date will be set for the student to orally defend the dissertation. The date of the defense will be announced publicly and is open to all faculty of Polytechnic. On successful completion of the defense, the committee will award a grade and inform the Dean of Engineering and Applied Sciences.

Candidates will then prepare the dissertation in final form, including any required revisions resulting from the defense, in the format prescribed in the booklet *Regulations on Format, Duplication and Publication of Reports, Theses and Dissertations*, available from the Office of the Dean of Engineering and Applied Sciences.

In accordance with University requirements, doctoral students must formally apply for admission to candidacy and to receive their degrees. They should check with the Office of the Registrar for application forms and deadlines.

Time Limits

Full-time students must complete all work for the PhD within six years of the initiation of graduate work at Polytechnic. Part-time students must complete their work within 12 years. Any extension of these periods requires the approval of the Department of Civil Engineering and the Dean of Engineering and Applied Sciences.

GRADUATE CERTIFICATE PROGRAMS IN CONSTRUCTION MANAGEMENT

Certificate in Construction Management

The Department of Civil Engineering, in collaboration with the Department of Management, offers graduate certificates 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 management of construction.

Applicants for certificate programs must hold bachelor's degrees. A certificate program requires five courses, which are selected according to individual needs and with approval of the adviser. Those who choose to work toward the master's degree are able, upon admission to the program, to apply to courses taken in the certificate program toward fulfillment of the degree program, subject to other departmental requirements and guidelines. Additional information may be obtained from the departments.

CIVIL ENGINEERING PROGRAM

Certificate candidates can select any five courses (15 credits) from the following two clusters of courses:

Course No.	Course Title	Credits
CE 825	Project Management for Construction	3
CE 826	Construction Cost Estimating	3
CE 827	Contracts & Specifications	3
CE 828	Risk Analysis	3
CE 829	Construction Operations Analysis	3
CE 830	Information Systems in Project Management	3
CE 831	Construction Engineering Management	3
MG 624	Organization Development	3
or		
MG 631	Organization Theory & Design	3
MG 630	Operations Management	3
or		
MG 635	Managing for Quality	3
MG 820	Project Assessment & Management	3
MG 825	Construction Administration	3
MG 826	Construction Estimates & Costs	3
MG 827	Contracts & Specifications	3

Certificate in Executive Construction Management (Exec21 Program)

The Executive Construction Management (Exec21) Certificate Program is a leadership program for construction professionals who do not wish to commit themselves to full advanced degree programs. These may be students with bachelor's degrees who wish to specialize in construction management, or those already holding advanced degrees who wish to develop additional skills and receive formal certification. Recognized throughout the construction industry as a vital and innovative education experience, the Exec21 Certificate Program (winner of the Construction Management Association of America Academic Achievement Award) is taught by world-class construction industry professionals and faculty members. Students seeking admittance to the program should have three to five years of related professional experience and, upon completion (15 credits of coursework), may apply for transfer to civil engineering-degree programs (the number of credits transferred is subject to requirements of degree program and departmental approval).

The Exec21 Certificate Program consists of the following courses:

Course No.	Course Title	Credits
CE 870	Managing & Leading in the 21st Century	3
CE 871	Construction & the Law	3
CE 872	How to Succeed in Construction	3
CE 873	Infrastructure Financing	3
CE 875	Employer-Focused Residency	3
CE 876	Capital Program Management/Program Development	3

CE 877 Dispute Avoidance & Resolution 3

Electives

CE 827 Contracts & Specifications 3

CE 830 Information Systems in Project Management 3

CE 879 Special Topics in Construction 3

UNDERGRADUATE COURSES

GENERAL COURSES

CE 3012 Civil Engineering Practice 1:3:0:2

This half-semester course introduces the student to a variety of fundamentals in the professional practice of civil engineering. There are three basic components of the course: (1) a review of professional ethics as they affect various aspects of civil engineering practice, (2) an introduction to surveying and related measurements in civil engineering and (3) an introduction to the use of AutoCAD for civil engineering drawings. Surveying and AutoCAD are taught in two 3-hour sessions for each week of the half-semester.

CE 4023 Site Planning and Design 2:3:0:3

Introduces and develops an understanding of site planning, including the process and components of site design, such as site analysis and program development, grading and drainage, utility design, sanitary disposal and water supply and construction administration. Various types of site design are treated, including residential housing, municipal public works, commercial, institutional and recreational sites. *Prerequisite: junior status or instructor's permission.*

STRUCTURAL AND GEOTECHNICAL ENGINEERING

CE 2114 Statics and Dynamics 4:0:1:4

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. *Prerequisite: 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. *Prerequisite: CE 2114 or equivalent.*

CE 3134 Structural Analysis 4:0:1:4

In-depth coverage of structural analysis techniques. Topics covered include: analysis of statically determinate beams, frames and trusses; 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 Structural Design 3:3:0:4

A thorough treatment of structural design principles and techniques. Topic in both steel and reinforced concrete are treated, including: design of reinforced concrete beams, columns, slabs and footings; design of steel tension members, beams and columns; design of bolted, riveted and welded connections for steel structures. The course includes a design laboratory in which students, working in groups, develop design projects. *Prerequisite: CE 3134 or equivalent.*

CE 3154 Geotechnical Engineering 3:3:0:4

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 4162 Structural Materials 1½:1½:0:2

This half-semester course covers the mechanical behavior and durability of structural materials. Properties of concrete, steel, wood, asphalt and fiber composites are discussed. Material processing, optical metrology and stress analysis laboratories are conducted in which students work individually and in groups on material preparation and nondestructive evaluation projects. *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 3154 or equivalent.*

CE 4183 Advanced Structural Design and Analysis 2½:1½:0:3

Matrix analysis of statically indeterminate structures using the stiffness method; stability and seismic analysis of structures; design and analysis of concrete frame systems; seismic design of reinforced concrete structures; design of steel-concrete composite members. *Prerequisite: CE 3144 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 unreinforced 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 3222 Introduction to Environmental Engineering 1½:1½:0:2

This half-semester course, with weekly laboratory, provides an overview and introduction to environmental engineering. The course covers issues of water quality and wastewater characteristics. Chemical and biological concepts for environmental engineering are introduced and discussed. Stream sanitation issues are also treated. *Prerequisite: CE 2214 or equivalent.*

CE 4232 Environmental Engineering 1½:1½:0:2

This half-semester course provides a detailed coverage of water and wastewater treatment unit operations and processes. An introduction to conventional processes employed for municipal water and wastewater treatment is provided. The course covers both theory and design applications. *Prerequisites: CE 2214 and CE 3222 or equivalents.*

CE 4242 Water Resources Engineering 1½:1½:0:2

This half-semester course provides a detailed overview of water resources engineering, including both analysis and design elements. Topics covered include hydrologic techniques; surface water and groundwater supplies; water demand and availability; water supply system design; wastewater and stormwater drainage systems; development of water resources for multiple purposes. *Prerequisites: CE 2214 and CE 3222 or equivalents.*

CE 4253 Water Resources Projects 3:0:0:3

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 4242 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 3154 or equivalent.*

CE 4273 Environmental Engineering Processes 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 3222 or equivalents.*

HIGHWAY AND TRANSPORTATION ENGINEERING**CE 4312 Geometric Design of Highways** 1½:1½:0:2

This half-semester course covers the geometric design of highways. Subjects include critical controls on geometric design, horizontal and vertical alignment, highway cross-sections, intersection layout and channelization. The course includes a design laboratory in which students work on group and individual geometric design projects. *Prerequisite: junior status or instructor's permission.*

CE 4323 Traffic Engineering I 3:0:0:3

Introduction and overview of traffic engineering. Basic traffic stream parameters and characteristics are introduced and study techniques for the collection of volume, speed and travel time data are presented. An overview of traffic control devices and their use is provided. Detailed coverage of isolated signal timing and analysis is included for both pre-timed and actuated signals. 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 and on 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 multilane highways, two-lane rural highways and suburban and urban arterials. *Prerequisite: CE 4323 or equivalent.*

CONSTRUCTION MANAGEMENT

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.*

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 4634 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 471X-474X Readings in Civil Engineering I-IV 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.

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 3154 or equivalents. Co-requisites: CE 4232 and CE 4242 or equivalents.*

CE 4823 Civil Engineering Design Project II 2:0:3:3

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 4312, CE 4162 and CE 4413.*

GRADUATE COURSES

GENERAL COURSES

CE 598 Special Topics in Civil Engineering I 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.

CE 599 Special 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.

CE 781 Infrastructure Planning, Engineering and Economics 2%: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 2%: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.

CONSTRUCTION MANAGEMENT**CE 798/799 Special Topics in Infrastructure Systems and Construction I/II** 2%: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 825 Project Management for Construction 2%: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 826 Construction Cost Estimating 2%: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.

CE 827 Contracts and Specifications 2%: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 2%: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 the complexity of real-world corporate and public problems through case investigations.

CE 829 Construction Operation Analysis 2%:0:0:3

Evaluation and model development of productivity, safety, quality and materials handling in construction operations. Principal methods for analysis and preplanning of work activities, including the use of work sampling, questionnaires and surveys. The implementation of video/timelapse photography in field studies and the incorporation of crew balances, flow diagrams, process charts and five-minute ratings for task measurements. The introduction of task analysis, including queuing theory, to the modeling and analysis of construction operations. Introduction to construction simulation. Field implementation and pro-

jects. *Prerequisite: degree in civil engineering or adviser's approval.*

CE 830 Information Systems in Project Management 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 construc-

tion 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 2%:0:0:3

Increasingly, in infrastructure financing, the emphasis is on identifying a revenue-producing stream. Taught by investment bankers experienced in financing multibillion 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 2%: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 tech-

nology 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 2%: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 2%: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 878 Strategic 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. *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, masonry 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. *Prerequisites: CE 722 or equivalent or instructor's permission.*

CE 735/736 Special 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 hydro-economic models, finite difference and finite element models, synthetic hydrology, desalinated and recycled water systems and others. 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 2½:0:0:3

Introduction to the chemistry and microbiology of polluted and natural waters, including applications of principles developed.

CE 739 Environmental Chemistry and Microbiology II 2½:0:0:3

Advanced topics in chemistry and microbiology of polluted and natural wastewater treatment.

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 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
2%: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 2%: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
2%: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
2%: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
2%:0:0:3

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 metabo-

lism. 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 2%:0:0:3

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, the Clean Air Act and its amendments, the National Ambient Air Quality and the National Environmental Policy Act will be covered in this course. The above legislation and its impact on policy and technology will also be discussed.

CE 758 Air Pollution Engineering Control
2%: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
2.5:0:0:3

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
2%: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 Special Topics in Environmental Engineering I/II
2%: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.*

GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

CE 840 Geotechnics and Geomaterials
2%: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. *Prerequisite: undergraduate soil mechanics.*

CE 841 Experimental Geotechnics and Site Monitoring
2%:0:0:3

Soil behavior characterization (shear, strength, flow, consolidation) using laboratory testing, in-situ testing and geophysical methods. Field instrumentation, monitoring and performance evaluation techniques. *Prerequisites: undergraduate soil mechanics and foundations.*

CE 842 Foundations and Ground Improvement
2%: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 2%: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 Geotechnics 2%: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 Special Topics in Geotechnical Engineering 2%: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 2%: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** 2%: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 Special Topics in Structural Analysis I/II 2%: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 2%: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 2%: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 2%: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 2%: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 625 Structural Dynamics 2%:0:0:3

Dynamic response of single degree of freedom systems. Theory of vibration of finite degree of freedom systems. Influence coefficient method. Analytical and numerical solution of dynamic response problems. Nonlinear analysis of single degree of freedom systems. Emphasis on computer analysis of large complex systems. *Prerequisite: adviser's approval. Also listed as ME 741.*

CE 641 Reinforced Concrete Structures 2%:0:0:3

Ultimate strength of reinforced concrete members. Biaxial bending and slender effects of reinforced concrete columns. Limit design, redistribution of moments. Design of slabs using yield line theory. Deep beams and shear walls. Analysis and design for torsion. *Prerequisite: undergraduate reinforced concrete design.*

CE 643 Prestressed Concrete 2%:0:0:3

Principles and materials for prestressed concrete. Flexural strength of prestressed members. Design of pre-tensioned and post-tensioned beams, columns and slabs. Effect of short-term and long-term deformations. Analysis and design of prestressed concrete structures. *Prerequisite: undergraduate reinforced concrete design.*

CE 651 Condition Assessment of Infrastructure Components 2%:0:0:3

Overview of the condition assessment of structures for the purpose of determining safety and useful life, planning preventative maintenance, rehabilitation and retro-fitting and adaptive re-use. Mechanical properties, critical characteristics, common defects and effective condition assessment procedures for concrete, steel, masonry and wood structures. Non-destructive testing techniques. Current codes, standards and industry practices. *Prerequisites: undergraduate or graduate courses in engineering materials, steel design and reinforced concrete design.*

CE 653 Investigation of Structural/Construction Failures 2%:0:0:3

Review of significant failures. Overview of civil engineering design and construction practices, ethical standards and legal positions necessary to forensic engineering. Process of evaluating structural defects and failures while in construction and while in service. Roles, activities and conduct of the forensic consultant and expert witness. Student project reports on actual failure or non-performance cases required. *Prerequisites: undergraduate or graduate courses in engineering materials, steel design and reinforced concrete design.*

CE 655 Earthquake Engineering
2½:0:0:3

Engineering seismology, strong ground motion, earthquake magnitude, intensity and frequency. Structural response and seismic damage, elastic and inelastic static and dynamic modeling. Earthquake load analysis, including response spectra, normal mode and direct integration techniques. Seismic design principles applied to building structures and special facilities. Code provisions for earthquakes. Local site effects and design ground motions, liquefaction potential, soil improvement for remediation of seismic hazards. Seismic rehabilitation strategies for buildings. *Prerequisite: CE 625 or equivalent.*

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.

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 ½ 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.*

ADDITIONAL COURSE GIVEN INFREQUENTLY (LESS THAN ONCE EVERY OTHER YEAR)*

- CE 605 Plate and Shell Structures (ST-A,D)
- CE 609 Computer Methods of Structural Analysis (ST-A)
- CE 611 Limit Analysis of Structures (ST-A)
- CE 617 Introduction to Modern Concepts of Structural Safety (ST, CM-T)
- CE 621 Advanced Mechanics of Materials (ST-A,M)
- CE 626 Applied Structural Dynamics (ST-A,D)
- CE 632 Piping System Analysis and Design (EN-A,D)
- CE 645 Fracture Mechanics-Modeling and Design (ST-A,D)
- CE 712 Water Resource Projects (EN-D)
- CE 715 Open Channel Hydraulics (EN-A)
- CE 724 Advanced Groundwater Hydraulics and Pollution (EN-A,D,T)
- CE 725 Water Resources Mathematical Modeling (EN-A)
- CE 726 Computer Applications in Water Resources (EN-A,T)
- CE 727 Urban Hydrology (EN-A,D)
- CE 728 Optimization Methods in Water Resources (EN-A,D)
- CE 780 Analysis of Uncertainty in Civil Engineering (CM,EN,GT,ST-A)
- CE 790 Fire Protection Engineering (CM-A,D)
- CE 791 Infrastructure Systems Analysis (CM-A)
- CE 797 Flexible and Rigid Pavements (ST-D)
- CE 820 Project Management (CM-P)
- CE 862 Physical and Chemical Soil Behavior (GT-M)
- CE 864 Slope Stability and Earth Retaining Structures (GT-D,T)
- CE 868 Soil Dynamics and Seismic Refitting (GT-A,D)
- CE 869 Rock Mechanics and Underground Structures (GT-A,D)

*Course descriptions are not included in this catalog. Students should consult with their adviser for specific information concerning the offering and content of these courses.

Typical Course of Study for the Bachelor of Science in Civil Engineering

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week				Cr.
		Class	Lab	Rec.	Cr.	
MA 1012	Calculus IA ¹ (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 ²	4	0	0	4	
EG 1004	Intro. Engineering & Design ³	1	3	2	4	
SL 1010	Freshman Seminar	1	1	0	0	
16						

Spring Semester

Course No.	Course Title	Hours/Week				Cr.
		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 II	4	0	0	4	
CS 1114	Intro. Prog. & Problem Solving ³	3	3	0	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
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					

Spring Semester

MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi. Calculus B (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 ⁴	4	0	0	4
16					

JUNIOR YEAR

Fall Semester

MA 2212	Data Analysis I (½ semester)	4	0	0	2
MA 2222	Data Analysis II (½ semester)	4	0	0	2
CE 3012	Civil Eng. Practice (½ semester)	1	3	0	2
CE 3222	Intro. Environ. Eng. (½ semester)	1½	1½	0	2
CE 3134	Structural Analysis	4	0	1	4
	HU/SS Elective ⁴	4	0	0	4
16					

Spring Semester

CE 3144	Structural Design	3	3	0	4
CE 3154	Geotechnical Engineering	3	3	0	4
	HU/SS Elective ⁴	4	0	0	4
	Sequence Elective I ⁵				4
16					

SENIOR YEAR

Fall Semester

CE 4232	Environmental Eng. (½ semester)	1½	0	1½	2
CE 4242	Water Resources Eng. (½ semester)	1½	0	1½	2
CE 4812	Design Project I	1½	0	1½	2
	CE Elective I				3
	Sequence Elective II ⁵				4
	Technical Elective				3
16					

Spring Semester

CE 4312	Geo. Design Hwys. (½ semester)	1½	1½	0	2
CE 4162	Structural Materials (½ semester)	1½	1½	0	2
CE 4413	Construction Management	3	0	0	3
CE 4823	Design Project II	2	0	3	3
	CE Elective II				3
	CE Elective III				3
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 or EN 1090 must subsequently register for EN 1034, rather than EN 1014.

3. EG 1004 and CS 1114 may be interchanged by semester.

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 II Elective courses.

5. A list of approved Sequence Electives is available from the department.

Graduate Courses in Civil Engineering by Specialty and Skill Area

COURSE NO.	COURSE TITLE	SKILL AREA	CM	SPECIALTY AREA		
				EN	GT	ST
CE 601	Theory of Structural Analysis and Design	A				E
CE 606	Bridge Engineering	D				E
CE 613	Stability of Structures	A				E
CE 614	Steel Structures	D				R
CE 616	Finite Element Methods	A			E	R
CE 625	Structural Dynamics	A				R
CE 641	Reinforced Concrete Structures	D				R
CE 643	Pre-stressed Concrete	D				E
CE 651	Condition Assessment	M			E	E
CE 653	Structural/Construction Failures	A, T				E
CE 655	Earthquake Engineering	A, D			E	E
CE 722	Hydrology	A		R		
CE 723	Groundwater Hydrology and Pollution	A		R		
CE 737	Environmental Chemistry and Microbiology I	M		R		
CE 739	Environmental Chemistry and Microbiology II	M		E		
CE 742	Water and Wastewater Treatment I	D, T		R		
CE 743	Water and Wastewater Treatment II	D, T		E		
CE 747	Analysis of Stream and Estuary Pollution	A		R		
CE 752	Air Pollution	A, M		E		
CE 753	Hazardous/Toxic Waste Management	A, M, P		E		
CE 754	Site Remediation	D, T		E		
CE 770	Solid Waste Management	P		E		
CE 781	Infrastructure Planning, Engineering and Economics	P	E			
CE 782	Forensic Structural Engineering	A	E			E
CE 783	Infrastructure Rehabilitation: Practical Approach	A	E			
CE 796	Pavement Design and Analysis	A, D				E
CE 813	Advanced Highway and Construction Management	M	E			
CE 814	Infrastructure Management Systems	T	E			
CE 825	Project Management for Construction	P	R			
CE 826	Construction Cost Estimates	P	E			
CE 827	Contracts and Specifications	P	R			
CE 828	Risk Analysis	A	E		E	
CE 829	Construction Operations Analysis	A	E			
CE 830	Information Systems in Project Management	T	E			
CE 831	Engineering for Construction I	T	E			
CE 832	Engineering for Construction II	D	E			
CE 840	Geotechnics and Geomaterials	M			E	
CE 841	Experimental Geotechnics and Site Monitoring	M			E	
CE 842	Foundations and Ground Improvement	T			R	
CE 843	Urban Geotechnology	T, D			E	
CE 849	Environmental Geotechnics	T, D			E	
CE 866	Advanced Foundation Design	D			R	
CE 870	Managing and Leading in the 21st Century ¹	P	E			
CE 871	Construction and the Law ¹	P	E			
CE 872	How to Succeed in Construction ¹	P	E			
CE 873	Infrastructure Financing ¹	P	E			
CE 874	International Engineering and Construction ¹	P	E			
CE 875	Project: Employer-Focused Residency ¹	A, D, T, P ²	E			
CE 876	Capital Program Management/Project Development ¹	P	E			
CE 877	Dispute Avoidance and Resolution ¹	P	E			
CE 878	Strategic Construction Management and Planning ¹	P	E			
CE 879	Advanced Construction Systems ¹	P	E			

1. Part of the Exec 21 Program. Courses have special admission requirements (see course descriptions).

2. Depends upon subject of the project assignment.

CM = construction management, EN = environmental and water resource engineering, GT = geotechnical and geo-environmental engineering, ST = structural materials and engineering, R = required in specialty area, E = elective in specialty area, A = analysis, D = design, M = materials and monitoring, T = technologies and processes, P = project management

COMPUTER ENGINEERING PROGRAM

The Department of Electrical and Computer Engineering offers a Computer Engineering Program for the degrees Bachelor of Science and Master of Science. The BS program 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 to improve 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 tech-

nology, 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.icee.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 educational component that complements the technical content of the computer engineering discipline, including multidisciplinary experience, humanistic and societal issues and 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 local area 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 controller. The economic aspects of engineering are addressed by allowing undergraduates to choose electives such as macro/micro economics, organizational behavior 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 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 2000 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 2000 should consult the previous edition of this catalog or 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.

Computer Architecture
 CS 3254 Intro to Parallel & Distributed Systems
 CS 342 Algorithms for Parallel & Distributed Systems
 CS 613 Computer Architecture I
 CS 618 Fault Tolerant Computers

Microcontroller and Embedded Systems
 EE 115 Digital Electronics
 CS 613 Computer Architecture I
 EL 548 Embedded Systems
 EL 949 Digital System Testing

Integrated Circuit Design
 EE 115 Digital Electronics
 EL 547 VLSI Circuit Design
 EL 644 VLSI System & Architecture

Control and Robotics
 EE 3054 Signals and Systems
 EE 106 Feedback Systems
 EL 522 Sensor Based Robotics
 EL 548 Embedded Systems

Software Engineering
 CS 4513 Software Engineering
 CS 3234 Data Base Systems
 CS 391 Java Programming & Web Design
 CS 905 Java Programming

Data Communications
 EE 3054 Signals & Systems
 EE 116 Communication Electronics
 EE 3404 Communication Theory
 EE 136 Communication Networks
 EL 537 Local Area Networks
 EL 930 Wireless Communication Laboratory
 EL 514 Multimedia Laboratory
 EL 501 Wireless Personal Communication Systems
 CS 681 Information, Privacy & Security

Artificial Intelligence
 CS 661 Artificial Intelligence I
 CS 662 Artificial Intelligence II
 CS 664 Computer Vision & Scene Analysis
 CS 665 Expert Systems
 CS 667 Neural Network Computing

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 2004 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 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 undergraduate studies before fall 2000 should consult the previous edition of this catalog for program and course requirements 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" section in this catalog for more details.) Students on 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 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 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 PROGRAM

The BS/MS Accelerated Honors Program 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 Program 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 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, 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 under-

standing 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 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 Master of Science program 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 architectures. 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 subdisciplines
- 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. (Please note: formal course numbers have not been assigned to proposed future courses).

GROUP 1: Core courses

- EL 536 Principles of Communication Networks
- EL 549 Advanced Hardware Design (VHDL)
- CS 613 Computer Architecture I

9 units

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 calculating 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.

REPRESENTATIVE MS IN COMPUTER ENGINEERING SEQUENCES

Three representative MS sequences are outlined below. The first sequence focuses on VLSI and CAD; the second sequence focuses on high-speed networking and VLSI; the third sequence focuses on embedded systems.

MS in Computer Engineering (focus on VLSI, CAD)

EL 536	Principles of Communication Networks
EL 547	Introduction to VLSI
EL 649	Digital VLSI System Testing
EL 549	Advanced Computer Hardware Design (VHDL)
EL 645	VHDL based Behavioral Synthesis
EL	Advanced Hardware Design Lab (VHDL + FPGA)
EL 948	VLSI CAD
CS 603	Algorithms I
CS 606	Software Engineering I
CS 613	Computer Architecture I
CS 618	Fault-Tolerant Computers
EL 995	Project

MS in Computer Engineering (focus on high-speed networking, VLSI)

EL 536	Principles of Communication Networks
EL 537	Protocols for Local Area Networks
EL 547	Introduction to VLSI
EL 548	Real-Time Embedded Systems
EL 549	Advanced Hardware Design (VHDL)
EL	Advanced Hardware Design Lab (VHDL + FPGA)
EL 638	SONET/ATM Broadband Networks
EL 737	Broadband Packet Switching
CS 603	Algorithms I
CS 613	Computer Architecture I
CS 623	Operating Systems I
EL 995	Project

MS in Computer Engineering (focus on embedded systems)

EL 536	Principles of Communication Networks
EL 548	Real-Time Embedded Systems
EL 549	Advanced Hardware Design (VHDL)
EL 645	VHDL-Based Behavioral Synthesis
EL	Advanced Hardware Design Lab (VHDL + FPGA)
EL	DSP/Embedded Systems Lab
EL	Micro-controller Based Systems
CS 603	Algorithms I
CS 613/614	Computer Architecture I/II
CS 623	Operating Systems I
EL 995	Project

Descriptions of graduate electrical engineering and computer science courses used in the Computer Engineering Program are located in those programs sections of this catalog.

Typical Course of Study for the Bachelor of Science in Computer Engineering

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		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 1012	Calculus IA ² (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
EN 1014	Writing & Humanities I ³	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.
PH 1004	Introductory Physics I	4	1½	1	4
CS 1124	Object-Oriented Programing ¹	3	3	0	4
MA 1112	Calculus IIA (½ semester)	4	0	0	2
MA 1122	Calculus IIB (½ semester)	4	0	0	2
EN 1204	Writing & Humanities II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

PH 2004	Introductory Physics II	4	1½	1	4
CS 2204	Dig Logic & State Mach Design ¹	3	3	0	4
CS 2134	Data Structures & Algorithms ⁶	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
					16

Spring Semester

CM 1004	General Chemistry	3	2	1	4
EE 2004	Fund. of Electric Circuits ¹	3½	1½	1	4
MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2312	Discrete Math I (½ semester)	4	0	0	2
HI 2104	Modern World History	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

EE 3114	Fundamentals of Electronics I	3½	1½	1	4
CS 2214	Computer Architech. & Organ.	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
	HU/SS Elective ⁴	4	0	0	4
					16

Spring Semester

EE 3124	Fundamentals of Electronics II	3½	1½	1	4
	Concentration I ⁵				3-4
	Sequence Elective I ⁶				4
CS 3224	Operating Systems	4	0	0	4
					15-16

SENIOR YEAR

Fall Semester

EE 4313	CompE Design Project I	1	3	1	3
	EE Restricted Elective ⁷				3-4
	Concentration II ⁵				3-4
	HU/SS Elective ⁴	4	0	0	4
	Sequence Elective II ⁶				4
					17-19

Spring Semester

EE 4323	CompE Design Project II	0	6	1	3
	EE/CS/EL Elective				3-4
	EE/CS/EL Elective				3-4
	Technical Elective ⁸				3-4
	HU/SS Elective ⁴	4	0	0	4
					16-19

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 1012.

3. 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.

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 II 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.

7. The Restricted Elective must be selected from the following: EE 3054, EL 547 and EL 549.

8. The Technical Elective may be any 3- or 4-credit engineering, mathematics or science course.

COMPUTER SCIENCE PROGRAM

Program Director: Stuart 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 Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB), a specialized accrediting body recognized by the Council on Post-secondary Accreditation (COPA) and the U.S. Department of Education. The program in computer science offers a curriculum that prepares students for a professional career as computer scientists or graduate studies in computer science leading to research or teaching careers. The undergraduate program in computer science at Polytechnic is based on the principle that a well-rounded graduate should have a rigorous education in the fundamentals of computer science, including significant exposure to the design and operation of computers. 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
- Communication Networks
- Compilers
- 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 com-

puter 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 2064 Ethics and Technology.

University Elective Sequence (8 credits)

A list of approved Elective Sequences for computer science majors is available in the Office of Computer Science Advising.

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.

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 1012, 1022 and 1112 (AP Calculus BC, grade of at least 4 or 5); and CS 1114 (AP Computer Science A, grade of 5); or AP Computer Science AB, grade of 4 or 5).

TRANSFER STUDENTS

Transfer students are accepted into the 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 variation in the amount of credits granted from year to year. Thus, students completing the same program, but in different years, may have 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 must arrive and present their records for evaluation at least one week before the regular registration period for their first semester.

DEPARTMENTAL STANDARDS, PROBATIONS AND 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. A grade of C (2.0) or better in all CS courses
2. A grade of C- or better in the following courses: MA 1012/1022 Calculus IA/IB; MA 1112/1122 Calculus IIA/IIB; 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 in which an I grade is received may not be used to satisfy any prerequisites until the incomplete is resolved. See "Policies on Grading and Grades for the University" in this catalog for additional information on Incomplete grades.

Students failing to meet any of the above requirements are placed on departmental probation as a warning that they are not progressing acceptably toward their degree. Repeated failure to meet probation requirements may lead to disqualification from the undergraduate 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/Machine Language
CS 206	Compiler Design
CS 239	Advanced UNIX System Programming
CS 342	Algorithms for Parallel and Distributed Systems
CS 391	Java and Web Design
CS 392	Computer Security
CS 393/394	Special Topics in Computer Science
CS 2204	Digital Logic and State Machine Design
CS 3234	Introduction to Databases
CS 3254	Introduction to Parallel and Distributed Systems
EE 136	Communication Networks
MA 358	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 Vision and Scene Analysis
CS 667	Neural Networking Computing
CS 684	Network Protocols
CS 901	UNIX Systems
CS 902	Applied Electronic Commerce
CS 904	Cryptography with Financial Applications
CS 905	Introduction to Java Programming
CS 907	Human and Computer Interaction
CS 907	Wireless Electronic Commerce
CS 908	Advanced Java Programming
CS 909	Computer Simulation
CS 909	Biometric Identification
CS 910	Object Oriented Design with Java
CS 9XX	Object Oriented Design with C++
EL 514	Multimedia Laboratory
EL 547	Introduction to VLSI Design

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 stu-

dents 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
- EE 536 Principles of Communication Networks
- and EE 537 Protocols for LAN

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.

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 credits)

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 206 Compilers 3:0:0:3

Grammars, lexical analysis, parsing theory and algorithms, intermediate languages, storage assignment, stack machines and run-time organization. A large programming project is required. *Prerequisites: CS 2134 (C- or better) and CS 205 (C- or better). Suggested co-requisites: CS 3414 and CS 3314.*

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 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.*

CS 393/394 Selected Topics in Computer Science 3:0:0:3

Advanced courses in computer science. These courses are vehicles for presenting novel material, trying new educational methods and courses, and taking advantage of the special competencies of visiting staff. *Prerequisite: 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 1012/1022. 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). Co-requisite: PH 2004.*

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 (C- or better for undergraduate computer engineering majors) or CS 2134 (C- or better) and MA 2312/2322.*

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 3234 Introduction to Databases 4:0:0:4

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. *Prerequisite: CS 3224.*

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 2312/2322.*

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 4513 Software Engineering I 2½:1½:0:3

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. *Prerequisite: CS 2134 (C- or better).*

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.*

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 microprogrammed 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 multiuser 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 2%: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 2%: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 2%:0:0:3

Advanced design and analysis techniques: amortized analysis of algorithms. Advanced data-structures: binomial heaps, Fibonacci heaps, data structures for disjoint sets, analysis of union by rank with path compression. Graph algorithms: elementary graph algorithms, maximum flow, matching algorithms. Randomized algorithms. Theory of NP-completeness and approach to finding (approximate) solutions to NP-complete problems. Selected additional topics that may vary. *Prerequisite: CS 603.*

CS 606 Software Engineering I 2%: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 2%: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 2%: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 2%:0:0:3

Uniprocessor computer architectures: performance and cost, instruction set design and measurements, basic processor implementation techniques, simple pipeline techniques, memory hierarchy design and computer arithmetic. *Prerequisite: CS 580.*

CS 614 Computer Architecture II 2%:0:0:3

Computer architectures that exploit parallelism: pipelining, super-scalar, vector processors, overview of parallel machines and selected parallel computing topics, such as, MIMD and SIMD machines and their interconnection structures. *Prerequisite: CS 613.*

CS 616 Microprocessors 2%: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 2%: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 2%:0:0:3

Operating systems for uniprocessors: processes, mutual exclusion, job scheduling, memory, storage hierarchy, file systems and analytical modeling of computer systems. *Prerequisite: CS 590.*

CS 624 Operating Systems II 2%:0:0:3

Operating systems for parallel and distributed computers: concurrent programming, process synchronization, deadlocks, distributed computing, networks, distributed concurrency control and analytical modeling of computer systems. *Prerequisite: CS 623.*

CS 627 Performance Evaluation of Computer Systems 2%: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
2%:0:0:3

The structures, notations and semantics of conventional programming languages. Issues of scoping, binding, type structure and parameter passing. Abstract data types. Programming in the large. Language support for parallelism. Implementation issues. Functional, logic and object-oriented languages. *Prerequisites: CS 540.*

CS 641 Compiler Design and Construction I
2%: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
2%:0:0:3

Further considerations of syntactic analysis, semantic analysis and code optimization techniques. *Prerequisite: CS 641.*

CS 653 Interactive Computer Graphics
2%:0:0:3

This course introduces students to the fundamentals of computer graphics. Topics covered include graphics 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
2%: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
2%:0:0:3

Further study of automation of intellectual processes. Automatic theorem proving. Expert systems. Simulation of verbal learning behavior. Learning machines, adaptive systems, robots, decision-making problems. Adequacy of existing theoretical treatments. *Prerequisite: CS 661.*

CS 664 Computer Vision and Scene Analysis
2%:0:0:3

This course introduces students to the many techniques, applications and current research areas in computer vision and scene analysis. Topics include polyhedral scene analysis, early 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
2%:0:0:3

This course introduces students to the various techniques used in building an expert system. An introduction to the rule-based programming language OPS5 will be given, and a prototype expert system will be built using it. Topics covered include: knowledge representation methods, production systems, inference procedures, uncertainty and evidence combination, expert systems architectures and control, knowledge acquisition, programming languages for expert systems and various case studies. *Prerequisites: CS 661 and programming experience.*

CS 667 Neural Network Computing
2%:0:0:3

An introduction to neural network models and their applications. Discussion of organization and learning in neural network models including perceptrons, adalines, backpropagation networks, recurrent networks, adaptive resonance theory and the neocognitron. Implementations in general and special purpose hardware, 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
2%:0:0:3

Analysis and synthesis of combinational and sequential switching circuits. Boolean algebras, switching functions, minimization, single and multiple output networks, realization of functions. Finite-state sequential machines, state-transition diagrams, machine and state equivalence, incompletely specified machines, state reduction, machine realizations. *Prerequisite: CS 600.*

CS 675 Theory of Computation
2%:0:0:3

Computability and decidability. Computable and primitive recursive functions. The Halting Problem. Recursively enumerable sets. Relationships between languages, grammars and machines. Solvable and unsolvable linguistic questions. *Prerequisite: CS 600 or instructor's permission.*

CS 681 Information, Privacy and Security
2%:0:0:3

Introduction to security and privacy issues associated with information systems. Cost/risk tradeoffs. Technical, physical and administrative methods of providing security. Control of access through technical and physical means. Identification and authentication. Encryption, including the Data Encryption Standard (DES) and public key systems. Management of encryption systems, including key protection and distribution. Privacy legislation and technical means of providing privacy. *Prerequisite: graduate status.*

CS 682 Network Management and Security
2%:0:0:3

Human aspects of network management; performance measures; classical and vendor network management systems; unified systems; OSI network management; fault and performance; configuration control; security; encryption. *Prerequisite: EL 536.*

CS 684 Network Protocols I 2%:0:0:3

ISO syntax, addressing in Transmission Control Protocol/Internet Protocol (TCP/IP) and ISO. Address space management. Mapping of physical addresses to Internet addresses and the Address Resolution Protocol (ARP). Reverse Address Resolution Protocol (RARP) and Bootstrap Protocol (BOOTP). Fundamentals of the connectionless datagram delivery services IP and ISO IP. Comparisons with X.25 and X.75. routing protocols: Interior Gateway Protocol (IGP) and Exterior Gateway Protocol (EGP). Discussion of Routing Information Protocol (RIP). Open Shortest Path First (OSPF), Border Gateway Protocol (BGP) and Interdomain Routing Protocol (IDRP). The transport layer: ISO TP-1 through TP-3, analysis of User Datagram Protocol (UDP) and TCP. Introduction to ISO TP-4 and comparison with TCP. *Prerequisite: EL 536.*

CS 685 Network Protocols II 2%:0:0:3

Introduction to Multicasting. Internet Group Management Protocol (IGMP) and Multicast Backbone (MBONE). domain name services. remote login applications in TCP/IP and ISO. TELNet. VTAM and Rlogin: File Transfer and Access (FTP). TFTP. Network File System NFS). Introduction to mail handling systems (822. simple mail transfer protocol, multipurpose Internet mail extensions. X400), X500 and directory services. Introduction to Internet management (Simple Network Management Protocol and SNMP v2. management information bases. CMIP and CMOT) TCP/IP and ISO futures. *Prerequisite: CS 684.*

CS 687 Project in Telecommunication Networks 2%: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 901-912 Selected Topics in Computer Science each 2%:0:0:3

Topics of current interest in computer science. Recent offerings include software specification and validation, parallel algorithms and architectures, 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 941/942 Readings in Computer Science I/II each 2%:0:0:3

Intended primarily for advanced graduate students who wish to study in a specialized area under the supervision of a faculty member. Permission of graduate director is required. Regular meetings with the adviser. 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 2%: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 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 1012	Calculus IA (½ semester) ³	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
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 1112	Calculus IIA (½ semester)	4	0	0	2
MA 1122	Calculus IIB (½ semester)	4	0	0	2
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
					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	0	0	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 2064	Ethics & Technology	4	0	0	4
	CS Elective ⁵				3
	Technical Elective ⁷				3
	University Elective Sequence II ⁶				4
					17

Spring Semester

CS 4523	Design Project II	1	6	0	3
	CS Elective ⁵				3
	HU/SS Elective ⁴	4	0	0	3
	HU/SS Elective ⁴	4	0	0	4
	Free Elective ⁸				3
					16

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 EN 1080 or EN 1090 must subsequently register for EN 1034, rather than EN 1014.

3. Students who are placed by examination or by an adviser into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1012.

4. 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 II Elective courses.

5. At least two of the four required CS Electives must be chosen from the following: CS 206, CS 2204, CS 3234, CS 3254, CS 661. With departmental

approval, certain graduate CS courses may also be used as CE Electives depending on course content and prerequisites.

6. A list of approved Sequence Electives is available from the department.

7. 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.

8. The Free Elective could be a course offered by any department, provided it does not duplicate material studied in other courses.

ELECTRICAL ENGINEERING PROGRAM

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/sloancareers/sloancareers.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 and 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 de-regulated 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 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.

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, organizational behavior 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 2000 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 2000 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 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, CS 2204, EE 2004 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 2000 should consult the previous edition of this catalog or 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" section in this catalog for more details.) Students on 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.

THE BS/MS ACCELERATED HONORS PROGRAM

The BS/MS Accelerated Honors Program 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 Program 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 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 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 of the 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 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, students 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 subdisciplines 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 subdisciplines 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 expected to ignite 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 scat-

tering 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. 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 specific groups of courses, 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.

An overall B average is required in the combination of the five to seven courses offered to satisfy groups 1 and 2 above.

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 quali-

fying 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.

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 thesis adviser. Students work with their thesis adviser to find an adviser for a minor outside of electrical engineering and a guidance committee of three or four faculty members, with the thesis adviser usually acting as chairman. At least one other guidance committee member must be in the students' area of major research interest; this member may be from outside of 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 thesis adviser approves the program of study in the student's major, and the minor adviser approves the program of courses in the minor. When the requirements for minor or major are completed,

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 thesis defense and approves the final thesis.

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 thesis requires the approval of the department's Graduate Committee.

Submission of the Thesis 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@isaacs.poly.edu.

GRADUATE CERTIFICATE IN IMAGE PROCESSING

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. 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 (formerly EL 593)	3
EL 612	Video Signal 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 send e-mail to yao@vision.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 (formerly EL 635)	3
EL 537	Protocols for Local Area Networks (Internet course)	3
or		
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 send e-mail to 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 Intranet, 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 Courses:

Course No.	Course Title	Units
EL 501	Wireless Personal Communication Systems	3
EL 630	Probability	3

Recommended Elective Courses (choose 3):

Course No.	Course Title	Units
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 675	UIHF 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 send e-mail to cassara@rama.poly.edu.

UNDERGRADUATE COURSES

Students should consult departmental 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.

EE 2004 Fundamentals of Electric Circuits 3/1/1:4

Circuit models and Kirchhoff's circuit laws. Passive and active d-c circuit elements. Node and loop analysis, voltage and current division, linearity and superposition. Thevenin's and Norton's Theorems. Natural and forced responses for RLC circuits. Sinusoidal Steady-State response. Complex voltage and current. Average power, maximum power transfer, root mean square

values. Mutual Inductance. Alternate-week laboratory. Minimum of C- required to take other EE courses. Objectives: fundamental knowledge of DC and AC circuit analysis, and laboratory practice required in upper level EE courses, ability to formulate problems in a manner that facilitates their solution, and to develop student's ability to communicate effectively through written reports. *Prerequisites:* MA 2012, MA 2132 and PH 2004. *ABET competencies a, b, e, g, k.*

EE 3054 Signals and Systems 3/1/1:4

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. Alternate-week 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 2004 (C- or better), MA 2012 and MA 2132. *Co-requisite:* MA3112. *ABET competencies a, c, e, k.*

EE 3064 Feedback Control 3/1/0:4

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, c, e, g, k.*

EE 3114 Fundamentals of Electronics I
3/1/1:4

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 2004 (C- or better) and PH 2004. ABET competencies a, e, g, k.*

EE 3124 Fundamentals of Electronics II
3/1/0:4

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, e, g, k.*

EE 3404 Fundamentals of Communication Theory
3/1/0:4

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. *Prerequisites: EE 3054 (C- or better) and MA 3112. Co-requisite: MA 3012. ABET competencies a, c, e, k.*

EE 3604 Electromagnetic Waves
3/1/0:4

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 transmission 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, transmission lines, and materials; increase appreciation for properties of materials through physical experiments. *Prerequisites: EE 2004 (C- or better) and MA 3112. ABET competencies: a, b, e, g, k.*

EE 3824 Electric Energy Conversion Systems
3/1/1:4

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 2004 (C- or better). Co-requisite: EE 3604. ABET competencies: a, e, 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 DP I, 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 DP I 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 exercise 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, c, e, 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.

EE 115 Advanced Digital Electronics

3:0:0:3

Flip-flops, shift registers, counters, arithmetic operations, semiconductor memories, switches, A/D converters D/A converters and selected applications of digital circuits. *Prerequisites:* EE 3124 and CS 2204.

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.

EE 136 Communication Networks

3:0:0:3

This course develops the basic techniques used in communication networks. After protocol layering is introduced, algorithms 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.

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.

EE 183 Electric Power Systems

3:0:0:3

Principles of operating electric power systems. Transmission lines: inductance and capacitance parameters and current-voltage relations. Power system representation. Introduction to network calculations, symmetrical phase components and economic dispatch. Computer exercises on power-load flows. *Prerequisite:* EE 2004 (C- or better).

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.ecc.poly.edu)

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** 2%: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 2%:0:0:3

See course listings under Telecommunications and Networking.

EL 601 Principles of Digital Communications: Modulation and Coding 2%: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.*

EL 602 Wireless Communications: Channel Modeling and Impairment Mitigation 2%:0:0:3

Wireless communication models and practical techniques for mitigating transmission impairments. Channel models: path loss, long-term fading, short-term fading, frequency selective fading, delay spread, angular spread, and Doppler spread; channel estimation techniques. Handoff and power control. Diversity: selection combining and gain combining. Smart antenna: inversion, LMS and MMSE space processing and space-time processing approaches. Mitigation of Doppler spread: pilot symbol techniques. Equalizers: zero forcing, MMSE, LMS, decision feedback,

etc. Rake receiver in DS-CDMA systems. Adaptive schemes: decision direct and CMA algorithms. Multiuser detection in DS-CDMA systems. *Prerequisites: EE 3404, MA 3012 and programming skill in MATLAB or equivalent.*

EL 603 Modern Wireless Communication Techniques and Systems 2%:0:0:3

Spread spectrum techniques: Direct sequence and Code division multiple access (CDMA), Frequency hopping. Third Generation Wireless systems. Multicarrier techniques: Orthogonal Frequency division multiple access (OFDM) and Multicarrier CDMA (MC-CDMA). Wideband CDMA (W-CDMA). Ultra Wideband communications. *Prerequisites: EE 3404 and EL 630.*

EL 604 Wireless and Mobile Networking Protocols 2%:0:0:3

The presence of wireless links and/or mobile endpoints poses a set of special requirements on networking protocols, creating the need for new types of protocols. For example, mobility management protocols are needed for mobile location management and handoff management. This course teaches the principles behind the protocols needed in wireless and mobile networks. This includes MAC (Medium Access Control), DHCP (Dynamic Host Configuration Protocol), mobile location management, mobile handoff management, and authentication protocols. Network architectures and protocols used in wireless/mobile networks such as mobile IP, cellular networks, GSM, IEEE 802.11, cordless phones, paging networks, PCS, UMTS, WAP, adhoc networks, etc., will also be covered. *Prerequisite: EE 136 or EL 536.*

EL 606 Information Theory 2%: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.*

EL 607 Algebraic Codes (formerly EL 738) 2%: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 2%:0:0:3

See course listings under Telecommunications and Networking.

EL 631 Engineering Applications of Stochastic Processes 2%:0:0:3

See course listings under Telecommunications and Networking.

EL 633 Detection and Estimation Theory 2%:0:0:3

See course listings under Telecommunications and Networking.

EL 642 RF Electronics for Wireless Applications 2%:0:0:3

See course listings under Computer Electronic Devices and Systems

EL 675 UHF Propagation for Wireless Systems 2%:0:0:3

See course listings under Electrodynamics, Wave Phenomena and Plasmas.

EL 930 Wireless Information Systems Lab 2%:0:0:3

See course listings under Telecommunications and Networking.

EL 901-909 Selected Topics in Wireless Communications each 2%: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** 2%:0:0:3

Introduction of basic concepts and techniques in digital image processing: image acquisition and display using digital devices, properties of human visual perception, sampling and quantization, sampling rate conversion, two-dimensional transforms, linear and nonlinear filtering, morphological operations, contrast enhancement, noise removal, image deblurring, image registration and geometric transformation, and edge detection. Students will learn to perform some basic image processing operations using computers equipped with special imaging hardware such as video cameras and frame grabbers. *Prerequisites: EE 3054 and MA 3012; MA 2012 or knowledge of basic matrix algebra; C programming skill; senior or graduate status. Instructor permission required for senior students.*

EL 514 Multimedia Information Processing and Communications Lab 2:3:0:3cd

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. Scanning, digitization, image contrast enhancement, color palettes, frame rate conversion, Ethernet LANs and multipoint video conference. Includes weekly experiments and two-week miniproject. This course is subject to final faculty review. *Prerequisites: graduate status or EE 3054 or instructor's permission. Co-requisite: EE 3404.*

EL 611 Signals, Systems and Transforms 2%:0:0:3

Continuous and discrete linear systems, system function, Fourier transforms, periodic functions, Z transforms, discrete Fourier series, fast Fourier transforms, Analog and digital filters, finite order system functions, Digital processing of analog signals, Sampling theorems. *Prerequisites: graduate status and EE 3054.*

EL 612 Video Processing 2%:0:0:3

Advanced topics in digital image processing, such as image compression, image recovery, medical imaging, advanced television systems, etc. (See department mailings for detailed description of each particular offering.) Both basic principles and recent research developments will be introduced. In addition to the lecture material, each student is required to finish a term project implementing in software or hardware an existing or new image processing algorithm. *Prerequisites: EL 512, EL 630, EL 625, C programming skill and graduate status.*

EL 713 Digital Signal Processing I 2%: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.*

EL 714 Digital Signal Processing II 2%:0:0:3

Two-dimensional signals and systems; Fourier representations and multidimensional sampling, 2-D discrete Fourier transform and convolution, Difference equations, Z transforms and multi-dimensional stability, Design and implementation of non-recursive and recursive digital filters, Multiparameter statistical estimation theory: the principle of maximum likelihood, Signal parameter estimation in additive noise and performance degradation due to parameter uncertainty, The Kalman filter: steady state theory and frequency domain analysis, Kalman filters for smoothing, correlated signal in noise and colored noise. *Prerequisites: graduate status, EL 631 and EL 713.*

EL 715 Array Signal Processing 2%: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 spa-

tial 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 and EL 631.*

EL 716 Multiresolution Signal Decomposition: Transforms, Subbands and Wavelets 2%: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.*

EL 911-919 Selected Topics in Signal Processing each 2%: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** 2%:0:0:3

Robot mechanisms, robot arm kinematics (direct and inverse kinematics), robot arm dynamics (Euler-Lagrange, Newton-Euler, and Hamiltonian Formulations), trajectory planning, sensing, end-effector mechanisms, force and moment analysis, introduction to control of robot manipulators. *Prerequisite: graduate status. Pre-/co-requisite: EE 3064. Also listed under ME 661.*

EL 525 Applied Matrix Theory (formerly EL 613) 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: graduate status, MA 2012, MA 2132, MA 2112 and MA 2122.* Also listed under MA 601.

EL 621 System Theory and Feedback Control I 2:0:0:3

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 622 Nonlinear and Sampled-Data Control Systems 2½:0:0:3

Introduction to nonlinear systems. Phase plane analysis, nonlinearities, linearization, limit cycles and averaging. Stability techniques: describing function, Lyapunov functions, Popov locus and circle criterion. Analysis and design of sampled-data systems by Z-transforms and state variable methods. *Prerequisites: graduate status, EL 625 and EE 3064 or equivalent.*

EL 625 Linear Systems 2½:0:0:3

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 721 System Theory and Feedback II 2½:0:0:3

A continuation of EL 621 for multi-input-output systems. Matrix fractions, optimal and suboptimal design considerations for two-degree-of-freedom systems. *Prerequisites: graduate status, EL 621 and EL 525 (formerly EL 613).*

EL 723 System Optimization Method 2½:0:0:3

Formulation of system optimization problems. Elements of functional analysis applied to system optimization. Local and global system optimization with and without constraints. Variational methods, calculus of variations, and linear, nonlinear and dynamic programming iterative methods. Examples and applications. *Prerequisites: graduate status and EL 525 (formerly EL 613) or EL 625.*

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 Application of Nonlinear Control to Robotics 2½:0:0:3

Differential geometric approaches for control of nonlinear systems and applications to robot manipulators. Introduction to Lie algebra and Lie bracket. Multivariable inverses for nonlinear systems, external feedback linearization and zero dynamics. Application of nonlinear control to robotics: inverse dynamics, feedforward control, PD and PID controllers, variable-structure control, adaptive control techniques (STR and MRAC) and force control. *Prerequisites: graduate status and EL 725 (EL 522 is recommended but not essential).* Also listed under ME 860.

EL 823 Optimal Control Theory 2½:0:0:3

Optimal control problem for deterministic systems with various constraints. Solution for both continuous and discrete-time systems using the maximum principle and dynamic programming. Hamilton-Jacobi theory as applied to the synthesis problem. *Prerequisites: graduate status, EL 723 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 826 Adaptive Control 2½:0:0:3

Controllable and observable system models (ARMA models), parameter estimation (least squares, projection algorithm, lattice filters), one and multi-step ahead prediction control, minimum variance, pole placement, LQG control, model reference adaptive control. *Prerequisites: graduate status and EL 725 or equivalent.* Also listed under ME 871.

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 535 Elements of Communications Networks** 2½:0:0:3

An introductory course in telecommunications networks. Review of calculus and probability theory in the context of telecommunications. Modulation of sinusoidal waves. Amplification and regeneration. Characterization of telecommunications traffic in terms of spectrum, capacity, response and duty cycle. Voice communications systems, switches, PBXs and transmission options. Circuit switching. Facsimile, image and video communications. ISDN and other integrated services approaches. *Prerequisite: graduate status.* This course cannot be applied toward degrees offered by Department of Electrical and Computer Engineering.

EL 536 Principles of Communication Networks 2%: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 signalling and encoding. Data communication techniques: asynchronous and synchronous transmission, error detection, data link control and multiplexing. Circuit switching and packet switching, local metropolitan area networks. ISDN and Broadband ISDN, frame relay and other high speed networks. Introduction to protocols, architecture, and Internetworking. *Prerequisite: seniors may take course; juniors must have a 3.0 GPA or better and preferably EE 3054; MA 3012 or instructor's permission.*

EL 537 Protocols for Local Area Networks 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: CSMA/CD, Token Ring, 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.*

EL 630 Probability 2%:0:0:3

Events, probability, repeated trials, Random variables distributions moments, characteristic functions. Functions of random variables. Sequences of random variables. Limit theorems. Engineering applications of statistics. *Prerequisites: graduate status and MA 3012.*

EL 631 Engineering Applications of Stochastic Processes 2%:0:0:3

Correlation, power spectrum, coherence, with applications in linear systems. Nonstationary signals, normal processes, mean square estimation, spectral analysis. Topics in Markov processes. *Prerequisites: graduate status and EL 630.*

EL 633 Detection and Estimation Theory 2%:0:0:3

Detection of signals in noise, matched filters, M-ary digital communications. Signal detection and feature extraction in noisy environment based on likelihood ratio tests. Game-theoretic formulation of classification problems. Bayesian and point estimators: near-optimum detectors. Combined estimation and detection. Wiener theory and Kalman-Bucy filters. *Co-requisites: graduate status and EL 631.*

EL 636 Introduction to Communications Networks: Protocols 2%:0:0:3

A continuation of EL 536 with emphasis on higher layer protocols. Overview of the seven layer OSI model. Review of data link and networking layer protocols. Introduction to routing and internetworking. Transport layer considerations. Connection management. Analysis of major session, presentation and application layer protocols. Emphasis on issues involved in interactive, file transfer and mail transport. Discussion of syntax and Abstract Notation One (ASN.1). Introduction to directory services, remote procedure calls and client-server computing. *Prerequisites: graduate status and EL 536.*

EL 637 Local and Metropolitan Area Networks 2%:0:0:3

Introduction. Local Area Networks: CSMA/CD, Token Ring, Token Bus; IEEE Standards, protocols and performance analysis. LAN interconnection: Bridges, Routers, Gateways. Metropolitan Area Networks: FDDI, DQDB; Standards and performance analysis. Higher Level Protocols used in LAN/MANs; LAN/MAN management, LAN/MAN interconnection: Frame Relay, ISDN, emerging standards and protocols. Other current topics. *Prerequisites: graduate status and EL 536 or EE 136.*

EL 638 SONET-/ATM-Based Broadband Networks 2%:0:0:3

Future broadband networks will be based on SONET (Synchronous Optical Network) standards and ATM (Asynchronous Transfer Mode) techniques. This course covers three layers of broadband network transfer protocols, namely, SONET, ATM, and ATM adaptation layer (AAL), as well as design implementation issues of transporting connectionless data packets (IP datagram and SMDS packets) over ATM networks, signaling/routing, LAN emulation and congestion flow control. *Prerequisites: graduate status and EL 536.*

EL 658 Fiber Optic Communications 2%:0:0:3

See course listings under Electro-Optics, Quantum Electronics and Materials Science.

EL 735 Communication Networks I: Analysis, Modeling and Performance 2%: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, ground radio, local area networks. *Prerequisites: graduate status, EL 630 and EL 536*

EL 736 Communications Networks II: Design and Algorithms 2%: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 and knowledge of data structures.*

EL 737 Broadband Packet Switching Systems 2%:0:0:3

Broadband integrated service digital networks (B-ISDNs) provide end-to-end transport for a wide range of services, such as voice, data, image and video signals. Broadband packet switches are essential components in B-ISDN and many architectures have been proposed. In this course, we will discuss these switches and compare their performance and implementation complexity. Course topics include Introduction of B-ISDN and Asynchronous Transfer Mode (ATM) Technology, ATM switch design criteria and performance requirement, survey of existing ATM switch architecture, shared-medium switch, shared-batcher-banyan switch, large-scale ATM switch, multicast ATM switch, optical ATM switch and VLSI chips for ATM switches. *Prerequisites:* graduate status and EL 536.

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 545 Microwave Integrated and Semiconductor Circuits I** 2%:0:0:3

Transmission line review; co-axial, two-wire, parallel plate transmission lines, Printed transmission lines: microstrip line, stripline and other printed lines; quasistatic analysis, introduction to spectral-domain analysis, Green's functions; characteristic impedance; attenuation; perturbation method. Coupled transmission lines, directional coupler, coupled line filters, Transmission line transitions: bends, junctions, cross-overs, qualitative equivalent models. *Prerequisites:* graduate status and EE 3604.

EL 546 Microwave Integrated and Semiconductor Circuits II 2%:0:0:3

Review of semiconductor physics, introduction to microwave integrated circuits (MICs) S-parameter analysis, flow graphs, stability criteria of amplifiers, Oscillators and amplifiers, noise figure, noise measurement, PN junction diodes, varactors, Schottky-barrier, PIN, IMPATT and Gunn diodes; bipolar and field-effect transistors; device physics and applications to VCO, frequency multipliers, detectors, mixers, attenuators, phase shifters, switches. *Prerequisites:* graduate status, EL 545 and EE 3124.

EL 547 Introduction to VLSI Design System 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 (formerly EL 590) 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 2004.

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.*

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.*

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 networking 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 2%: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 2%: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 2%:0:0:3

This courses 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 2%: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 2%: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 prerequisites: graduate status and EE 164 or equivalent. EL 552 prerequisites: graduate status and EL 551.*

EL 651 Statistical Mechanics I 2%: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 2%: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 2%: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 2%:0:0:3

Quantum mechanics with applications to atomic systems. The use of Schrodinger's equations. Angular momentum and spin. Problems and approximation methods. Semiclassical theory of field-matter interaction. *EL 655 prerequisite: graduate status. EL 656 prerequisite: EL 655. Also listed under PH 667/668.*

EL 658 Fiber Optic Communications
2%:0:0:3

Preview of fiber optic communications, optical fibers, light sources, detectors and modulation techniques. Transmitter, receiver and repeater technology. System applications. Integrated optics. *Prerequisite: graduate status.*

EL 951-959 Selected Topics in Electro-Optics, Quantum Electronics and Materials Science
each 2%: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 567 Electronic Power Supplies
2%:0:0:3

Review of power relationships. Power semiconductor switching devices. Rectifiers. Basic PWM de-dc switching cells. Nonisolated and isolated PWM de-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 Characteristics and Controls
2%: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 de and ac drives with static converter supply. Worked examples effectively illustrate the application of the mathematical derivations. *Prerequisites: graduate status and EE 3824.*

EL 660 Power Electronics (formerly EL 647)
2%: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, EE 3054 and EE 3124.*

EL 661 Introduction to Power System Engineering
2%:0:0:3

Power system engineering analysis: three-phase circuit calculations, network representations and load flow calculations. Reliability analysis: generation reliability. Generation costing and economic dispatch. *Prerequisite: graduate status.*

EL 662 Power Systems Economics and Planning
2%: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 661.*

EL 663 Transients, Surges and Faults in Power Systems
2%: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 EE 183 or equivalent.*

EL 664 Relay Fault Protection
2%: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 EL 663.*

EL 665 Power System Stability
2%: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 EE 183.*

EL 666 Distributed Generation Systems
2%: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 661 or equivalent. *Co-requisite:* EL 660.

EL 961-969 Selected Topics in Power Engineering
each 2%: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 571 Engineering Electromagnetics**
2%:0:0:3

Engineering applications of electromagnetics. A device-hardware oriented course for graduate and advanced undergraduate students. Topics include hollow conducting waveguides, dielectric guides; two-wire, coaxial and strip transmission lines; linear antennas, arrays, horn and dish antennas. Waveguide components: attenuators, phase shifters; waveguide-coaxial transitions, etc. Electromechanical transducers: loud speakers, microphones, relays. *Prerequisites:* graduate status and EE 3604.

EL 573 Introduction to Microwave Engineering
2%:0:0:3

Review of EM theory, transmission lines, S, Z, Y, ABCD parameters, network theory, network analyzer, signal flow graphs, CAD methods, Impedance matching, multisection and tapered impedance transformer, Bode-Fano criteria, Power divider, directional coupler, hybrid circuits, Microwave resonators: series, parallel resonant circuits, stubs, and cavities. Filter theory and design: microstrip and stripline designs, coupled line filters, Kuroda identities, Chebychev and maximally flat filters. *Prerequisites:* graduate status and EE 3604.

EL 575 Introduction to Plasma Engineering (formerly EL 581) 2%: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. *Prerequisites:* graduate status and EE 3604.

EL 671 Fields and Waves 2%:0:0:3

The course lays the groundwork to the theory and understanding of electromagnetic fields, their sources and their propagation in the form of waves. The treatment starts from basic physical concepts and develops the description of electromagnetic fields in terms of Maxwell's equations by using vector analysis and related techniques. *Prerequisites:* graduate status and EE 3604.

EL 672 Electrodynamics: Wave Propagation and Guidance 2%:0:0:3

The electrodynamics of waves guided by metallic and dielectric structures, resonators, radiation and other relevant theoretical aspects of modern electromagnetic engineering are covered. The emphasis is on understanding wave phenomena and on studying the basic concepts and techniques that are useful when treating relevant problems over the entire electromagnetic spectrum. *Prerequisites:* graduate status and EL 671.

EL 675 UHF Propagation for Wireless Systems 2%: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 773/774 Guided Waves and Beams I/II
each 2%:0:0:3

Theory and application of guided waves and beams in areas of electromagnetics (radar), microwave acoustics and integrated optics. Propagation characteristics of surface and leaky waves; effects of loss; mode coupling; characterization of discontinuities. Propagation in periodic structures. Beam fields; properties of laser beams; divergence, Fresnel and Fraunhofer approximations; scattering and guiding of beams by planar structures; beam displacement and distortion; coupling to surface waves. *EL 773 prerequisites:* graduate status and EL 672. *EL 774 prerequisites:* graduate status and EL 773.

EL 775 Antenna Theory 2%:0:0:3

Concepts of antenna radiation patterns, radiation resistance equivalent network; gain; effective area; reciprocity. Electromagnetic fields due to prescribed sources. Huygens' principle. Fresnel and Fraunhofer regions. Finite and infinite arrays. Mutual coupling. Aperture antennas. Traveling-wave antennas. Frequency independent antennas. *Prerequisites:* graduate status and EE 3604.

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.*

WEB-BASED GRADUATE COURSES

An increasing number of Polytechnic's graduate courses in electrical and computer engineering are available online for convenient study in students' home or office.

Students can use their browser to download professors' audio presentation, which include lively, dynamic motivation and explanation of text, equations and diagrams. Students studying over the Internet will find online discussion groups and will get quick response to e-mailed questions.

Prior lectures, which are frequently updated based on student questions, are always available for review and clarification of concepts and analysis techniques.

Polytechnic offers the following electrical engineering courses online:

EL 514	Multimedia Information Processing & Communications Lab
EL 536	Principles of Communication Networks
EL 537	Protocols for Local Area Networks
EL 549	Advanced Computer Hardware Design (formerly EL 590)
EL 602	Wireless Communications: Channel Modeling & Impairment Mitigation
EL 611	Signals Systems & Transforms
EL 625	Linear Systems
EL 630	Probability Theory
EL 675	UHF Propagation for Wireless Systems
EL 713	Digital Signal Processing
EL 949	VHDL-Based Behavioral Synthesis

Typical Course of Study for the Bachelor of Science in Electrical Engineering

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		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 1012	Calculus IA ² (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
EN 1014	Writing & Humanities I ³	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.
PH 1004	Introductory Physics I	4	1½	1	4
CS 1124	Object-Oriented Programming	3	3	0	4
MA 1112	Calculus IIA (½ semester)	4	0	0	2
MA 1122	Calculus IIB (½ semester)	4	0	0	2
EN 1204	Writing & Humanities II	4	0	0	4
					16

SOPHOMORE YEAR

Fall Semester

PH 2004	Introductory Physics II	4	1½	1	4
CS 2204	Dig Logic & State Mach Design ¹	3	3	0	4
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
					16

Spring Semester

CM 1004	General Chemistry	3	2	1	4
EE 2004	Fundamentals of Elect. Circuits ²	3½	1½	1	4
MA 2112	Multi. Calculus A (½ semester)	4	0	0	2
MA 2122	Multi. Calculus B (½ semester)	4	0	0	2
	HU/SS Elective ³	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

EE 3114	Electronics I	3½	1½	1	4
EE 3054	Signals & Systems ²	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 ³	4	0	0	4
					16

Spring Semester

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

Fall Semester

EE 4XX3	Design Project I	1	3	1	3
	EE/EL Elective ⁸				3
	EE/EL Elective ⁸				3
	Technical Elective ⁹				3
	Sequence Elective II ⁶				4
					16

Spring Semester

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 ³	4	0	0	4
					16

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 1012.

3. 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.

4. 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 II Elective courses.

5. Restricted Electives must be chosen from the following: EE 3124, EE 3404, EE 3804 and EE 3064.

6. A list of approved Sequence Electives is available from the department.

7. One first semester Design Project course is selected from the following areas: wireless communication, electrical power and control and robotics.

8. 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.

9. The Technical Elective may be any 3- or 4-credit engineering, mathematics or science course.



ELECTROPHYSICS PROGRAM

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 (formerly EL 581)
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 Wener

The Department of Humanities and Social Sciences offers a Master of Science program in Environment-Behavior Studies. 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.

This program offers a Master of Science degree (36 units) and a Certificate in Environment-Behavior Studies (15 units).

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 lifelong 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)

DEGREE REQUIREMENTS FOR MASTER OF SCIENCE

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 CERTIFICATE PROGRAM

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 a formal application for admission to the program, along with 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, along with an official transcript of undergraduate work and any graduate work.

GRADUATE COURSES

PS 905 Psychology: Applied 2%:0:0:3

This course will show how various problems, particularly in work, can be solved through the judicious use of psychological principles. Phenomena addressed will 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 will learn to employ the method of behavioral analysis in gaining an understanding of various problems. They will 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 2%: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 2%:3:0:3

This course will introduce students to human behavioral issues in the design and use of interfaces for information systems. Basic issues of behavioral research and evaluation methods will be discussed. Sensory systems and memory and learning theory relevant to human factors systems will be reviewed and related to specific interface issues, such as interaction devices, dialogue design and reference material. The focus will be on understanding the issues involved in creating systems amenable to human use.
Prerequisite: SPS 2104 or equivalent.

PS 908 Experimental Psychology I 2%: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 will perform a series of experiments with human and animal subjects.
Prerequisite: PS 2104.

PS 909 Experimental Psychology II
2%: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 2%: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
2%: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
2%:0:0:3

Review of different sensory systems: vision, audition, taste, smell, touch, temperature sensitivity, vestibular and kinesthetic senses and their relations to nonsensory controlling stimuli such as states of the organism, learning 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
2%: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
2%: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
2%: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
2%: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
2%: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
2%: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; adverse 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
each 3 units

Independent research project demonstrating scientific competence performed under guidance of advisers.

PARTICIPATING FACULTY

Francine L. Dolins, Assistant Professor of Psychology

Sheila Lehman, Research Associate Professor of Psychology

Donald S. Phillips, Lecturer of Psychology

Richard E. Wener, Associate Professor of Psychology

ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL SCIENCE PROGRAMS

Academic Adviser: Dipak Roy

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.

GENERAL REQUIREMENTS FOR ENVIRONMENTAL PROGRAMS

ADMISSION REQUIREMENTS

To be eligible for admission as a graduate student, applicants must hold at least a baccalaureate degree from an acceptable institution. Students pursuing the MS in Environmental Science typically have undergraduate or graduate preparation in the field of science. Undergraduate courses may be recommended or required by the adviser to make up the deficiencies of students' academic preparedness. The MS in Environmental Engineering is designed for students with an undergraduate degree in engineering. Students with an undergraduate and/or graduate degree in science with

a minimum background of one year of chemistry and physics, basic courses of calculus and differential equations will be admitted to the program with a requirement of 15 credits of additional undergraduate makeup or prerequisite courses. Students should consult with department advisers to determine the expected scheduling of such courses. Transfer credit for undergraduate courses and for non-engineering graduate courses from other institutions will not normally be allowed. Individual programs will depend on the previous preparation of the student and may be approved by a department committee. Students with a bachelor's in engineering may have the requirements partially or fully waived.

Admission to the PhD program requires a suitable MS degree from an acceptable institution. Students wishing to pursue a PhD program who do not meet this requirement will generally be initially admitted as MS students. A 3.5 GPA or better in master's level work is generally required for admission to the PhD program.

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 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 units 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.

For PhD degrees, the same criteria as those specified for MS programs apply.

GRADUATE PROGRAMS

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.

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 goals 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	3
or		
CE 997*	Master's Thesis	6
and		
CE 722	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 753	Hazardous/Toxic Waste Management	3
	At least 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	3
or		
CE 997*	Thesis for the Master of Science	6
and		
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 753	Hazardous/Toxic Waste Management.	3
or		
CE 770	Solid Waste Management	3
	At least 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 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 with exceptional scholastic ability may pursue a doctorate in civil engineering. Doctoral applicants must hold a master's degree in civil or environmental engineering. Applicants with degrees in other fields may be admitted with deficiencies as evaluated by a departmental graduate adviser and upon approval of the department head.

All doctoral students must complete a minimum of 90 units of work beyond the bachelor's degree. Minimum requirements of formal course work (not including guided readings, seminars, projects and theses) are 48 units beyond the bachelor's degree or 24 units beyond the master's degree. Generally, at least 12 units of formal course work must be completed at Polytechnic. PhD students must select a major field and two minor fields in consultation with their advisers. Each minor consists of 9 to 15 units of approved courses.

To qualify as PhD candidates, students must pass a written and oral qualifying examination on the major and one minor. The oral examination may be waived in exceptional cases by the department head upon the recommendation of the examining committee. Generally, students take the qualifying examination within their first year of full-time course work beyond the MS degree. Students are allowed a maximum of three attempts to pass the qualifying examination.

Students must submit and orally defend dissertation proposals within one semester after the initial registration for dissertation units or before going beyond 9 dissertation units.

Registration for a minimum of 30 units of dissertation research is required. Registration should be continuous until the dissertation has been completed and accepted.

GRADUATE COURSES**CE 737 Environmental Chemistry and Microbiology I** 2%:0:0:3

Introduction to the chemistry and microbiology of polluted and natural waters, including applications of principles developed.

CE 739 Environmental Chemistry and Microbiology I 2%:0:0:3

Advanced topics in chemistry and microbiology of polluted and natural wastewater treatment.

CE 742 Water and Wastewater Treatment I 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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.

CE 758 Air Pollution Engineering Control 2%: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 2%: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 2%: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 Special Topics in Environmental Engineering I/II each 2%: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 is 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 program 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 or in financial technology. 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 working professionals in financial services who aspire to a diverse range of information technology management careers. Such professionals need a solid knowledge of financial products and the markets in which these products are transacted, along with a sophisticated foundation in information technology, strategy, electronic business and innovation management.

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. These adjunct faculty work closely with Polytechnic's full-time faculty.

ADVANCED CERTIFICATES

The Advanced 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 Advanced 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
- Information Management

Visit www.fe.poly.edu for the most current information.

ADMISSION

Admission to the Financial Engineering Program requires a baccalaureate from an accredited institution. 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.

Score = (160 X GPA) + (9.6x (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.

Score = (160 X 3.1) + (9.6 x 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.

Two letters of recommendation are also required for admission.

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 Advanced 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 advanced certificate are not required to take the GRE/GMAT, but should have obtained a minimum GPA of 3.0.

Conditional Admission: applicant 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.

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	1
FE 605 Microeconomic Foundations of Finance I	3
FE 611 Investment Banking & Brokerage	1
FE 620 Financial Theory with Corporate Applications	3
FE 621 Financial Market Regulation	1
FE 655 Accounting for Financial Product	1
MG 695 Economics for Business Decisions	1

Required Classes for the Capital Markets Track

	Units
FE 608 Quantitative Methods in Finance	3
FE 627 Valuation of Equity Securities & Financial Statement Analysis	1
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	1

Core Courses:	15
Required Courses:	15
Electives Units:	6
Total Units:	36

Electives

The program allows for 6 elective units. For students obtaining a waiver from core or required courses, additional electives must be taken. Permission of the student's adviser is required in selecting electives. 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 or financial engineering.

Required Classes for the Financial Technology Track

	Units
FE 613 Clearing & Settlement of Financial Transactions	1/2
FE 615 Foundations of Financial Technology	1/2
FE 617 Management of Financial Institutions	1/2
FE 629 Introduction to Futures, Options & Swaps	1/2
MG 650 Management of Information & Information Technology	3
MG 655 Introduction to Management of Data Communications & Networks	3
MG 867 Technology Strategy	3

Core Courses:	15
Required Courses:	15
Electives Units:	6
Total Units:	36

Electives

The program allows for 6 elective units. For students obtaining a waiver from core or required courses, additional electives must be taken. Permission of their adviser is required in selecting electives. 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 or financial engineering.

GRADUATE CERTIFICATE PROGRAMS

Advanced 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 & Nonlinear Programming	MA 614 or equivalent
Microeconomic Foundations of Finance	FE 605 or equivalent

* Knowledge of spread sheets expected. Some exposure to computer programming languages.

Core Classes	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

Advanced 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 spread sheets expected. Some exposure to computer programming languages.

Core Classes	Units
FE 608 Quantitative Methods & Finance	3
FE 627 Valuation of Equity Securities & Financial Statement Analysis	1
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	1
FE 673 Credit Risk Measurement & Management	1
FE 675 Operational Risk Measurement & Management	1
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

**Knowledge of spread sheets expected. Some exposure to computer programming languages*

Required Courses	Units
FE 613 Clearing and Settlement of Financial transactions	1/2
FE 615 Foundations of Financial Technology	1/2
FE 617 Management of Financial Institutions	1/2
FE 620 Financial Theory with Corporate Applications	3
FE 629 Introduction to Futures, Options and Swaps	1/2
MG 650 Management of Information and Information Technology	3
MG 750 Management of Electronic Business	3
MG 820 Project Assessment and Management	3
Total Units:	18

Students may satisfy this requirement by either

1. Demonstrating completion of a formal course
2. Demonstrating the completion of the essential components of this course from the contents of other courses
3. Passing a proficiency examination

GRADUATE COURSES

Courses ending in even numbers are full-semester courses. Courses ending in odd numbers are half-semester courses. Most often, the half-semester courses, when taken in the correct sequence, can substitute for full-semester requirements.

FE 600 Financial Accounting 2/0:0:3

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 1/0:0:1/2

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 1/0:0:1/2

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 2/0:0:3

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 1/0:0:1/2

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 1/0:0:1/2

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 1/0:0:1/2

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 1½:0:0:1½

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 600, FE 603 and 620.*

FE 619 Advanced Topics in Financial Technology 1½:0:0:1½

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 policy, 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 contracts and specialty contracts such as insurance derivatives and macroeconomic derivatives may also be discussed, at the instructor's discretion. *Prerequisites: FE 605, FE 608, 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 657 Asset Backed Securities 1½:0:0:1½

Asset-backed securities (ABSs) have become a hot topic in today's fixed income arena, with a potential for returns exceeding that of other investments. This course examines the writings of leaders in this field and provides comprehensive coverage of the major asset-backed securities, structuring issues and relative value analysis. Topics covered include: the expanding frontiers of asset securitization, introduction to ABS accounting; trends in the structuring of ABSs and prepayment nomenclature in the ABS market. *Prerequisites: FE 640 and FE 650.*

FE 659 Mortgage Backed Securities 1½:0:0:1½

Takes the student from a general introduction to mortgage-backed securities (MBS) to a detailed treatment of some of the issues that make these instruments some of the most complex and least understood of all financial products. Students learn the fundamentals of yield curves, mortgage cash-flows and analysis. The course covers pass-throughs, CMOs, mortgage derivatives and ARMs. Asset/Liability management of MBS is discussed. Students build a price-yield calculator for MBS pass-throughs (using a spreadsheet) and complete a course project. *Prerequisites: FE 657 and FE 640.*

FE 662 Derivatives: Advanced Applications and Analysis 2½:4:0:0:3

Focuses on advanced financial engineering applications using derivative securities and derivative securities in combination with other financial instruments. When possible, 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 2½:4:0:0:3

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 2½:0:0:0:3

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 1½:0:0:1½

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 650 and FE 640.*

FE 670 Portfolio Theory and Applications 2½:0:0:0:3

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, 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 673 Credit Risk Measurement and Management 1%:0:0:1%

A specialty course intended for those individuals who feel they might become involved in credit risk measurement, credit risk 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 675 Operational Risk Measurement and Management 1%:0:0:1%

The operational difficulties faced by financial institutions have created a need for tools to measure and management 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 effect 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) 2%: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-credit course the first time student 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 a 1% credit 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 credits.*

FE 682 Empirical Methods in Finance 2%: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 generalized 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.*

HISTORY OF SCIENCE PROGRAM

Academic Adviser: Alexi Assmus

MASTER OF SCIENCE

The master's program 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 libraries contain 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 program 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 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 advisers, taking into consideration individual backgrounds and interests. The stu-

dent will be 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. 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. In addition to these requirements, students must demonstrate reading knowledge of one foreign language, whether French, German, Russian or Spanish.

GRADUATE COURSES

SS 600 History of Science: 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 History of Science: Scientific Revolution to Darwin 2%/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 2%/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 2%/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 2%/0:0:3

SS 626 History of Technology: Industrial Revolution to the Present 2%/0:0:3

These two courses involve 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. *SS 625 prerequisite: SS 600 or equivalent. SS 626 prerequisite: SS 601 or equivalent.*

SS 635 History of Psychology 2%/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 will prepare a forecast on a topic of their choice. *Prerequisites: HI 2104 and one introductory history of science/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/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.

INDUSTRIAL ENGINEERING PROGRAM

Director: Blair R. Williams

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

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 and construction management). 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, budgeting 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 processes 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

INFORMATICS IN CHEMISTRY AND BIOLOGY 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 Informatics in Chemistry and Biology Program 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, 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 Informatics in Chemistry and Biology 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 (CM871, CM872) with submission of a written report. Electives can be selected from the existing courses.

Main Courses for the MS degree:

Basic Core Courses	Units
CM 751 Chemical Foundation for Bioinformatics	3
CM 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
CM 753 Bioinformatics I: Sequence Analysis	3
CM 754 Bioinformatics II: Protein Structure	3
CM 755 Bioinformatics III: Functional Prediction	3
CM 756 Chemoinformatics	3

GRADUATE COURSES

CM 751 Chemical Foundation for Bioinformatics 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.

CM 752 Biological Foundation for Bioinformatics 2/;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 1/;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 1/;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 1/;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 1/;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 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.

INFORMATION SYSTEMS ENGINEERING PROGRAM

Director: Robert Flynn

Administrative Director: LaVerne Clark

The Information Systems Engineering (ISE) Executive Degree Program is designed for professionals who want to be leaders in designing, developing and running today's information systems using the latest software tools and methodologies.

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 Sciences 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 where 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.

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 program 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 credits plus an independent research project, which must be completed in the second year of the program. The courses 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 2%:0:0:3

Groupware is middleware that is designed to allow many people to work together. It often incorporates business processes with communications 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, communications, information sharing and object technologies. *Prerequisite: regular graduate status.*

CS 691 Integrated Development Environment 2%: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 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 2%: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 2%: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 2%: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 thirty-six units in graduate courses with a capstone experience and at least one fifteen unit graduate advanced certificate in an engineering department or in the Computer and Information Science Department.

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, Poly 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.*

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
- Traffic Engineering

Department of Computer Science and Information Science

- Software Engineering

Department of Electrical and Computer Engineering

- Wireless Communication
- 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

- Telecommunications Network Management

Department of Humanities and Social Sciences

- Environment-Behavior Study
- Technical Communications

Department of Management

- Construction Management
- Financial Engineering
- Human Resources
- Organizational Behavior
- Technology Management
- Telecommunications Management

***Pending New York State approval.*

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—currently offered in executive format and focused on wireless innovation—that fulfill 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 credits 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 Management & Innovation in Wireless e-Commerce
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.

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 1022. Co-requisite: MA 1112.*

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 1122.*

Discontinued Courses (Last regular offering in fall 2001)

PH 109 Waves, Optics and Thermodynamics 3:0:1:3

Water, sound and radio waves. Reflection, scattering and absorption. Standing waves and spectra. Superposition: diffraction and beats. Geometrical optics. Applications of temperature, heat and entropy. *Prerequisites: PH 108, MA 107. Co-requisites: PH 119 and preferably MA 108 or MA 109.*

PH 119 Physics Laboratory for PH 109 0:1½:0:½

Principles of measurement in acoustic and optical experiments. Lab fee required. *Prerequisite: PH 118. Co-requisite: students who register for PH 119 must co-register for PH 109 unless excused in writing by director of the Introductory Physics Program. If students withdraw from one, they must withdraw from the other.*

LIBERAL STUDIES PROGRAM

Director: Harold P. Sjursen

UNDERGRADUATE PROGRAMS

Academic Adviser: Bethany Saltman

Liberal Studies is an interdisciplinary liberal arts degree that emphasizes the place of technology in world civilization and provides students interested in science and technology 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 BS in Liberal Studies degree is offered by the Department of Humanities and Social Sciences. All students must complete an interdisciplinary liberal arts major which includes a core concentration in one of the following focus areas:

- 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
- Digital Media Studies
- Education
- Information Design
- Interdisciplinary Physics
- International & Global Studies
- Legal and Political Studies
- Technical & Professional Communication
- Urban Studies

For more information, please call the Liberal Studies Office at 718/260-3135 or send e-mail to philtech@poly.edu.

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 6 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 a program academic adviser.

A description of second majors is available from the program academic adviser.

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

THE BS/MS ACCELERATED HONORS PROGRAM

The Liberal Studies Program, in conjunction with the Department of Management, offers an honors program for exceptional first year or advanced undergraduate students. Through this program a student can earn a Bachelor of Science in Liberal Studies—with a concentration in behavioral sciences—and a Master's of Science in Organizational Behavior in four to five years.

This accelerated program allows undergraduate liberal studies majors concentrating in behavioral sciences to apply for admission to the graduate Organization Behavior Program during their junior year for entry in their senior year, and to be guaranteed admission if they have met the program's academic and grade-point requirements.

The accelerated program allows students to use up to 9 credits of organizational behavior graduate courses in fulfillment of liberal studies degree requirements.

Minimum Admissions Requirements

To be eligible for this program, high school students must meet the following criteria:

- A minimum of 3.4 GPA
- A minimum of 1200 SAT

Polytechnic undergraduates must meet the following criteria to be enrolled into the graduate Organizational Behavior Program

- A minimum of 3.4 GPA (honors status)

Students in this program must maintain a 3.4 GPA throughout their academic career. In any semester when the cumulative drops below 3.4, the student may be dropped from the program or placed on probationary status.

Current Degree Requirements

Requirements for the BS in Liberal Studies:	
General Education	52
Interdisciplinary Liberal Arts	36
Behavioral Science Specialization	40
Total Credits:	128

Requirements for the MS in Organizational Behavior	
Core Courses	9
Area of Concentration	18
Free Electives	6
Research Project	3
Total Units:	36

The program is offered in Brooklyn only and limited to 15 incoming students per semester.

Students who meet all of the course and GPA requirements will be formally admitted to the MS in Organizational Behavior Program in the Department of Management at the end of their junior year.

UNDERGRADUATE COURSES

All liberal studies courses are required for students in the Liberal Studies Program. LA 1014, LA 1024 and LA 2014 can not be applied toward a humanities or social science 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.

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.

LA 2014 Technology and the Human Condition 4:0:0:4

A consideration of the impact of technology on ordinary experience. The influence of technology on the growth and development of children, on the expectations of older individuals and the quality of life in general. Course draws on the literature of sociology, anthropology, psychology and biology.

HUMANITIES AND SOCIAL SCIENCES COURSES

Head of Department of Humanities and Social Sciences: Harold P. Sjørusen

A minimum of six courses/24 credits in humanities and social sciences disciplines are required in all undergraduate programs for graduation. These courses must be distributed to cover several areas, including communications skills, and breadth and depth of exposure to selected disciplines within the humanities and social sciences.

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
PS	Psychology

Courses that carry the following prefixes may not be used to fulfill the requirement:

LA	Liberal Arts
LW	Law
TC	Technical Communications

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 or EN 1034, and EN 1204 and HI 2104, taken in this 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)

UNDERGRADUATE COURSES

ART HISTORY ELECTIVES

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-twentieth 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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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 tradition within the visual arts; 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. ABET competencies: g, h.*

AH 3124 Special Topics 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. ABET competencies: g, h.*

ECONOMICS ELECTIVES**EC 2504 Basic Economics** 4:0:0:4

An introduction to the field of economics. Covering both micro- and macro-economics, 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 micro-economic 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 Technology and Information 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 macro-economy in the post-World War II period. Course focuses on macroeconomic phenomena and macro-economic 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 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. Course focuses on the period since 1973. 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, budgetary slowdown that characterized this period. 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.*

ENGLISH/LITERATURE ELECTIVES

The English/Literature offerings are divided into two levels: Introductory (2000-level) and Advanced (3000-level).

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. 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. All literature courses include a final exam or final project.

Introductory Literature Courses

The introductory literature courses are designed to introduce students to intensive reading and research in either a particular literary genre or in survey courses.

Genre Courses (2000-level)

Prerequisite: EN 1204

- EN 2114 Poetry
 EN 2124 The Novel
 EN 2134 Drama
 EN 2144 The Short Story
 EN 2154 The Novella
 EN 2164 Science Fiction

Survey Courses (2000 level)

Prerequisite: EN 1204

- EN 2214 World Literature
 EN 2224 English Literature
 EN 2234 American Literature
 EN 2444 Shakespeare

Advanced Literature Courses: (3000 level).

Prerequisite: one 2000-level EN course.

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.

- 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

BASIC ENGLISH/LITERATURE COURSES

EN 1080 Reading and Writing in English as a Second Language 6:0:0:0

Taught at the high intermediate level. Students will learn to develop grammatical control in writing, improve their comprehension of college-level texts, practice in listening and speaking and expand their language skills for academic and professional purposes. *Prerequisite: placement examination.*

EN 1090 Introductory Composition 6:0:0:0

An intensive course in reading comprehension and composition skills for native speakers of English who have not been adequately prepared for college composition. Emphasis is on development of control over standard written English and fluency in writing. *Prerequisite: placement examination.*

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, forms and techniques of philosophy, art and literature, with emphases on fluency, precision and imaginative use of source materials in writing. *Prerequisite: placement examination.*

EN 1034 Writing and the Humanities I (English as a Second Language) 4:0:0:4

Introduction to the humanities and to effective techniques of college-level writing designed for students for whom English is a second language. This course examines basic concepts, forms and techniques of philosophy, art and literature, with emphases on fluency, grammar, syntax, precision and imaginative use of source materials in writing. *Prerequisite: placement examination.*

EN 1204 Writing and the Humanities II 4:0:0:4

An introduction to the humanities and to advanced techniques in 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 study of great words 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, formal report and research paper. In some cases, this course may be presented as an introduction to literature. *Prerequisite: EN 1014 or EN 1034 or advanced placement.*

GENRE COURSES

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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.*

SURVEY COURSES**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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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 lit-

erary texts. *Prerequisite: EN 1204. ABET competencies: g, h.*

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: one 2000-level EN course. ABET competencies: g, h.*

**ADVANCED ENGLISH/
LITERATURE COURSES****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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

EN 3224 Media Studies 4:0:0:4

Exploration of the ways in different media (print, broadcast, and/or electronic media) address and affect social, cultural and political issues. 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 literature in relation to emerging media. *Prerequisite: 2000-level EN course. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

**HISTORY ELECTIVES
INTRODUCTORY LEVEL****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 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 and the writing of reasoned arguments based on evidence are an important part of the course. Films may also be used.

HI 2210 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 2215 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 2223 United States History to 1865
4:0:0:4

Surveys the history of the United States, from its origins in the rivalries and colonialist expansion of early modern European powers such as Spain, France and England through the Civil War. Focuses 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. *Prerequisite: HI 2104.*

HI 2224 United States from 1865 to present
4:0:0:4

Surveys the history of the United States since the 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 what historian Eric Hobsbawm has labeled the "Age of Catastrophe," 1914-1945. The course reaches into the postwar world to explore the Cold War and examine American participation in the wars in Indochina, 1941-1975. *Prerequisite: HI 2104.*

HI 2250 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 2260 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 2270 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.*

**HISTORY ELECTIVES
ADVANCED LEVEL**

Requires one course from Introductory Level in addition to HI 2104.

HI 3110 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 3120 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. *Prerequisites:* HI 2104 and one of the following: HI 2123 or HI 2124, HI 2210, AP American or European history or instructor's permission.

HI 3125 Growth of the U.S. Constitution: 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 and one of the following: HI 2223, HI 2224, History Law 2101 or instructor's permission.

HI 3160 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 2260, HI 2210, PL 2104 or instructor's permission.

HI 3165 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. *Prerequisites:* HI 2104 and one of the following: HI 2260, HI 2210, HI 2224, PL 2104, PL 2094, PI 2064, EN 2164 or instructor's permission.

SENIOR LEVEL CAPSTONE

Requires consent of professor.

HI 4180 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 discus-

sion. 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, international organizations and other transnational regimes for global management including the UN, the Bretton Woods Accords, the economic recovery of Western Europe. *Prerequisites:* HI 2104 and one of the following: HI 3306, HI 3120 or instructor's permission.

MUSIC ELECTIVES

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.

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. *ABET competencies:* g, h.

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. *ABET competencies:* g, h.

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. *ABET competencies:* g, h.

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. ABET competencies: g, h.*

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. ABET competencies: g, h.*

**PHILOSOPHY ELECTIVES
INTRODUCTORY LEVEL****PL 2014 Symbolic Logic** 4:0:0:4

An introduction to the methods and applications of 1st-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.

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.

PL 2034 Philosophy of Religion 4:0:0:4

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.

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?

PL 2054 Ethical Theories I 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 several historical sources (Plato, Aristotle, Hobbes, Mill, 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).

PL 2064 Ethics and Technology 4:0:0:4

The study of the ethical questions that arise as a consequence of the development and use of computers and computer technologies. It involves two activities: (1) identifying and bringing into focus the issues and problems that fall within its scope, raising awareness of the ethical dimensions of a situation; and (2) providing an approach to these issues or a means of advancing understanding and suggesting a way of reaching reasonable solutions to these problems. Class considers such issues as information acquisition, access and stewardship, computer crime, abuse, hacking, intellectual property, privacy, liability, professional responsibility and the social implications of computer technology.

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.

PL 2084 Science and Society 4:0:0:4

Investigates the relation between science and society. It 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 U.S., 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 pub-

lic 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.

PL 2094 Philosophy of Science I
4:0:0:4

The philosophy of science can broadly be divided into two subfields: the methodology of science and the philosophy of particular sciences. This course is a general introduction to topics in the latter. It is offered in two forms: (1) Philosophy of Spacetime: 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? 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. (2) Philosophy of Physics: an introduction to topics in the philosophy of physics. The course is split into three parts: special relativity, general relativity and quantum mechanics. Philosophical topics covered include verificationism, the conventionality of simultaneity, the conventionality of geometry, operationalism and the operational definition of simultaneity, the twin paradox, time travel, the nature of time in general relativistic cosmologies, determinism, realism and interpretations of quantum mechanics. The objectives are to gain a firm understanding of the fundamental theories of modern physics in order to be able to distinguish relevant issues related to them from popular misunderstandings, and to be introduced to some of the subject matter of contemporary philosophy of physics.

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 history 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.

**PHILOSOPHY ELECTIVES
ADVANCED LEVEL**

Requires one prior course from Intro level.

PL 3014 Metalogic 4:0:0:4

Metalogic, the "logic of logic." Course demonstrates the soundness and completeness of first-order logic courses, the Gödel incompleteness theorem for formal arithmetic and, time permitting, reviews Turing machines and the notions of computability and undecidability. *Prerequisite: PL 2104 or a strong mathematical background (third-/fourth-year mathematics major).*

PL 3034 Critical Theory 4:0:0:4

The interactions between the explanatory, the normative and the ideological dimensions of social and political thought. It bridges the usual divides between explanation and justification, philosophical and substantive concerns, and theory and practice. Examines a range of contemporary issues in critical theory, among them the fate and meaning of the ideal of a universal humanity, the standpoint of critique, the fragmentation of culture and politics, the rise in identity politics, the challenge to nationalism, feminist philosophies, race theory and other issues of historic and contemporary theoretical and practical importance.

PL 3044 Political Philosophy 4:0:0:4

Evaluating the ways people should live together in communities and with finding the appropriate, legitimate, governing institutions that promote the ideals of freedom, justice, equality, and happiness. The question is 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. 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 of the connections among such issues as democracy, freedom, justice, rights, private property, economic equality, global justice and community.

PL 3054 Ethical Theories II 4:0:0:4

Advanced level ethics course addresses meta-ethical considerations about the nature of ethical theories, such as what rules of argumentation can apply to it, in what way it is possible for ethical judgments to be true or false and what, if anything, can provide a grounding for them. Examines the structure of moral judgments, their relationship to moral standards and ideals and the justification of moral judgments, before considering several contemporary moral philosophers, their challenges to moral objectivity and their proposals for overcoming or rethinking the basis for moral philosophy itself.

PL 3064 Philosophy of Technology
4:0:0:4

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 our technologically textured ecosystem, or technosystem. Course focuses on the ways in which technologies change human life, individually, socially and culturally. Also considers the effects of human-technology relations on science, culture, democracy, and human values. The aim of this course 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.

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? Course looks at how contemporary philosophers have attempted to answer these and related questions.

PL 3094 Philosophy of Science II
4:0:0:4

An advanced introduction to topics in the philosophy of science. 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.

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? 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.

PL 4052 Business Ethics 4:0:0:2

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. The influence of technology on the ethics of corporate decision-making. A case study approach is used. *Prerequisite: required for students in Technology and Information Management Program. Does not satisfy general education requirements in Humanities and Social Sciences.* Note: 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.

PSYCHOLOGY ELECTIVES

The fourth credit hour for the Psychology courses are used for experimental investigations, laboratory work, fieldwork or trips to museums and/or zoos and opportunity to make descriptive observations of subjects. The Psychology electives are divided into two levels: Introductory (2000-level) and Advanced (3000-4000 levels). PS 2104 is prerequisite for all advanced PS electives for a two or more course sequence.

A. Prerequisite Psychology Courses

PS 2104 Introduction to Psychology

B. Advanced Electives

PS 3314 Social Psychology
PS 3324 Environmental Psychology
PS 3124 Comparative Psychology
PS 3214 Learning and Cognition
PS 3114 Physiological Psychology
PS 3414 Developmental Psychology
PS 3424 Abnormal Psychology
PS 3434 Personality Psychology
PS 3704 Humans and Their Environment
PS 3714 It's About Time

C. 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.

D. 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.

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 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 effect 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 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; optional: PS 3214.*

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 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 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.*

MANAGEMENT PROGRAM

Academic Director: Barry Blecherman

The Department of Management at Polytechnic University is the New York City/Tri-state region's premier 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 degree (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 continually 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, 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 MG 505, or its equivalent. Students with this knowledge may apply for a waiver of this requirement.

Visit the department's Web site at www.managementdept.poly.edu for the most current information.

GOALS AND OBJECTIVES

The goal of the Master of Science in Management Program 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 nondegree 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 two exceptions, undergraduates may not enroll in graduate MSM classes. The two exceptions are: (1) undergraduate students enrolled in a joint BS-MS program associated with the Management Department may, with the approval of the Management 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. No other undergraduate may register for any Graduate Management MSM courses. No undergraduates are permitted in any other MSM classes.

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:

- Construction Management
- Human Resource Management
- Information Management
- Operations Management
- Technology Management
- Telecommunications Management

THE 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 and the Economic Environment
MG 609	Managerial Accounting and Finance
MG 650	Management of Information and 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.

Entrepreneurship

The Entrepreneurship Concentration is offered for the manager, professional or specialist who is interested in entrepreneurial 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 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 864	New Product Development

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 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 864	New Product Development
MG 820	Project Assessment & Management

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 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 867	Technology Strategy

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

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 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

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 innovation 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 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 631 Organization Theory & Design
- MG 635 Managing for Quality

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 Exec21 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 Exec21 Program.

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 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

UNDERGRADUATE COURSES

MG 300 Management Process 3:0:0:3

Introductory management course for undergraduates. Primary focus is the management process: planning, organizing, staffing, controlling, directing and decision making. Attention is given to the roles of various disciplines within management as well as to the traditional business functions of marketing, accounting, finance, production, engineering, research and development.

MG 301 Organizational Behavior 3:0:0:3

Study of human behavior in organizational settings. Emphasis on motivation, informal and formal group dynamics, interpersonal relationships, supervision, leadership, communication theory, attitude and job satisfaction, work stress, career development, creativity. Analyses of organizational behavior problems by case studies and simulated situations.

MG 305 Foundations of Business Systems 3:0:0:3

Provides the student with a systems perspective on the specification, development, implementation and maintenance of organizational information technology. *Prerequisite: MG 300.*

MG 310 Project Planning and Quality Management 3:0:0:3

Introduces engineering and computer science students to the theories and practice of project planning and quality management. Project planning topics include choosing whether or not to undertake a project, choosing between project possibilities, scheduling projects, and controlling and managing ongoing projects. Quality and concepts of quality management such as quality control, continuous improvement and customer satisfaction are explained in the second half of the course.

MG 392: Special Topics: Introduction to Retailing and Supply Chain Management 3:0:0:3

Provides an introduction to retailing and supply chain management. Both qualitative and quantitative aspects retailing and supply chain management issues will be covered by this course. The underlying objectives are 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 among them; and (3) examine and discuss the important role played by technology and integration at various points in the supply chain.

GRADUATE 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.

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 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

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 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 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. *Prerequisite: MG 601 or instructor's permission.*

MG 612 Human Resource Management 2½:0:0:3

Personnel functions are investigated from the perspectives of individual managers and the total organization. Topics include work force characteristics, recruitment and development, performance evaluation and rewards, effects of legislation and the changing labor force. *Prerequisite: MG 601 or instructor's permission.*

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. *Co-/Prerequisite: MG 601 or instructor's permission.*

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. Students design effective programs for class analysis. *Prerequisite: MG 601 or instructor's permission.*

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. *Prerequisite: MG 601 or instructor's permission.*

MG 617 Performance Measurement and Reward Systems 2%: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 compensation benefits and other rewards in attracting, retaining and motivating employees. *Prerequisite: MG 601 or instructor's permission.*

MG 622 Staffing Organizations 2%: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. *Co-/Prerequisite: MG 601 or instructor's permission.*

MG 623 Training in Organizations 2%: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. *Co-/Prerequisite: MG 601 or instructor's permission.*

MG 624 Organization Development 2%: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. *Co-/Prerequisite: MG 601.*

MG 625 Seminar in Organization and Career Change 2%:0:0:3

Examination of organizational restructuring, including downsizing, reengineering, delaying, 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. *Co-/Prerequisite: MG 601 or instructor's permission.*

MG 626 Human Resource Information Systems 2%:0:0:3

Design, selection, implementation, enhancement and operation of Human Resource Information Systems (HRIS) in organizations. Organizational, legal and political issues as well as hardware, software, applications and communications in HRIS. The uses of time-sharing, personal and minicomputers and mainframes. Focus on design and use of HRIS to facilitate objectives of human resource functions as well as to support entire organizations.

MG628 Internet Applications in Human Resource Management 2%: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 630 Operations Management 2%:0:0:3

Analytical techniques for designing and operating production and service systems, including facility layouts and locations, capacity planning, job sequencing, inventory control and quality control. Introductory linear programming and other formal methods. Cases and PC usage.

MG 631 Organization Theory and Design 2%: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. *Co-/Prerequisite: MG 601 or instructor's permission.*

MG 633 Research Methods 2%: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 601, MG 605 or instructor's permission.*

MG 634 Applied Research Methods 2%: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.*

MG 635 Managing for Quality 2%: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 2%: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.

MG 650 Management of Information and Information Technology 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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.

MANAGEMENT PROGRAM

MG 750 Management of Electronic Business 2%: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 2%: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 an 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 2%:0:0:3

Network planning techniques for project management and resource allocation. Emphasis on PERT, I.O.B, 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 2%: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 2%: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 2%: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 2%: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 2%: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 Technological Change and Innovation 2%: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 867 Technology Strategy 2%: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 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 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 PROGRAM

Academic Co-Directors: Mel Horwitch and Nina Ziv

For forward-thinking managers, the Management of Technology (MOT) Program is the "MBA of the future."

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 skills and 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, aerospace and financial and professional services
- Deals with the impact of technology and innovation throughout an enterprise
- Addresses physical and digital (including Internet-based) 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
- The entrepreneurship explosion
- Integrating technology and management
- Venture capital and venture creation
- The Internet and the Web-innovation's new platform
- 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

The program is also 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 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

- A 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 new 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: Managing Technology and Innovation in Financial Services (MOTIFS) and an e-Business track.

MOT classes are held every other Friday morning and all day Saturday or held every other Thursday evening and all day Saturday at the New York Information Technology Center, 55 Broad Street, 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.

How to apply

1. Mail completed application and application fee to:

Administrative Director, MOT-TIM
Polytechnic University
55 Broad Street, Suite 13B
New York, NY 10004

or at www.mot-tim.poly.edu, complete the electronic application available.

2. Arrange to have transcripts for previous college and university work sent directly by the academic institution to the MOT-TIM Master's Degree Program Administrative Director at the above address.

3. Arrange for two letters of recommendation to be sent to the Executive Master's Degree Administrative Director. These letters are generally from a supervisor or high-level colleague who is familiar with your professional work.

4. The final step to 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 to which they have applied.

For further information please contact the program:

Tel: 212/547-7030, ext. 207

Fax: 212/547-7029

E-mail: mot-tim@poly.edu

Web: www.mot-tim.poly.edu

DEGREE REQUIREMENTS AND CURRICULUM

The 36-credit program consists of the following:

First Semester

- MG 603 Organizational Behavior & Management Processes in Innovative Corporations
- MG 609 Managerial Accounting & Finance
- MG 865 Managing the Innovation

Second Semester

- MG 607 Marketing
- MG 610 Quantitative Analysis for Managerial Decisions
- MG 693 Information Technologies, Systems & Management in Organizations

Third Semester

- MG 608 Managerial Economics & the Economic Environment
- MG 775 Operations Management for Knowledge-Based Enterprises
- MG 786 High Technology Entrepreneurship

Fourth Semester

- MG 783 New Frontiers in Electronic Business**
- 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 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**
- MG 820 Project Management & Assessment for Technology Managers**

* half-semester 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 students.

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 607 Marketing
- MG 693 Information Technologies, Systems & Management in Organizations
- MG 796 Modern Financial Institutions & Their Competitive Environment

Third Semester

- MG 608 Managerial Economics & the Economic Environment
- MG 786 High Technology Entrepreneurship
- FE 603 Money, Banking & Financial Markets***

Fourth Semester

- MG 799 Modern Financial Products*
- 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 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**

* half-semester course

** half-semester courses offered in third or fourth semesters

*** existing financial engineering course; see Financial Engineering Program catalog course section

SPECIAL MOTIFS 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 2%: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 2%: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.

MG 608 Managerial Economics and the Economic Environment 2%: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 2%: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 2%: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 693 Information Technologies, Systems and Management in Organizations 2%: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 775 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 781 Selected Topics in Networking and Information Technologies
1%:0:0:1%
 (half-semester course)

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 783 New Frontiers in Electronic Business
1%:0:0:1%
 (half-semester course)

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 competitive survival and dominance; and (4) 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 market-space. Classes are conducted using the case method, and a high level of class participation is expected.

MG 784 Negotiation in Technology-Intensive Sectors
1%:0:0:1%
 (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. 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, includ-

ing 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) *1%:0:0:1%*

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
3:0:0:3

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) *1%:0:0:1%*

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
1%:0:0:1%
 (half-semester course)

Introduction to the role of information technology in supply chain management. Course builds on some of the concepts covered by the 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
1%:0:0:1%
 (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 795 Global Innovation *1%:0:0:1%*
 (half-semester course)

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
2%: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.

MG 797 Financing for Value Creation
(half-semester course) 1%:0:0:1%

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 799 Modern Financial Products
(half-semester course) 2%: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.

MG 820 Project Management and Assessment for Technology Managers
(half-semester course) 1%:0:0:1%

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
2%: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
2%: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

MANUFACTURING ENGINEERING PROGRAM

Director: Blair R. Williams

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/FQC, 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 has made 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 at either the Brooklyn or the Westchester campus.

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, Kepco and Lucent Bell Labs.

This program is designed to:

- Empower the engineer 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 credits, typically made up of 11 courses and a 3-credit master's report, or 10 courses and a 6-credit master's report. Credit may be granted for up to three relevant graduate level courses (9 credits) 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 credits. 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 credits 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 2%: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 2%: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) 2%: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) 2%: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 IE 776.

MN 785 Computer Integrated Manufacturing Systems (CIMS) 2%: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 2%: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 2%: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) 2%: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 2%: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 2%: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 regularly offered courses. The topic must be agreed upon by the student and adviser prior to registration. A written report on the topic is required. 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 credit 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 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.

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.

MATERIALS SCIENCE 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, defor-

mation 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 scholarship.

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 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 2%: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 2%: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 2%: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 2%: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 0:0:0:2%

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

Director of Freshman Mathematics:
Chandni Shah

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 degree Bachelor of Science.

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 mathematics 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
PII 1004, 2004	8
CM 1004	4
EN 1204	4
HU 1014; HI 2104	8
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	6
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 credits 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: trigonometric 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.*

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 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 1022 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.*

† Course may be accepted for graduate credit in department other than Mathematics.

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.*

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 prerequisites: 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
2%: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
2%: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 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 621 and MA 630.*

MA 640 Elements of Geometry and Topology
2%: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
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. *Prerequisite: MA 640.*

MA 651 Applied Statistics I (Data Analysis)
2%: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
2%: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 Variations2%: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 2%: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
2%: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
2%: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
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 601 and MA 630.*

MA 681 Elements of Probability
2%: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 2%: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 2%: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 2%: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
2%:0:0:3

Linear regression of one or more independent variables. Least square estimates of regression coefficients. Gauss-Markov theorem. Confidence regions for and tests of 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 2%: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 2%: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 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 681 and MA 683.*

MA 701 Abstract Algebra 2%: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
2%: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
2%: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 2%: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 2%: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
2%:0:0:3

Elementary theory of manifolds. Tangent space, mappings, submanifolds, 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
2%: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 2%: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 2%:0:0:3

Foundations of stochastic processes, Kolmogorov's extension theorem. Properties of sample paths. Conditional expectation, Martingales. Classes of stochastic processes. Gaussian processes, Markov processes, 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 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. *Prerequisite: MA 701.*

MA 818 Advanced Topics in Algebra
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. *Prerequisite: MA 701.*

MA 828 Advanced Topics in Real and Complex Analysis 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 721 and MA 722.*

MA 838 Advanced Topics in Differential Equations 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 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 IA ¹ (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
CS 1114	Intro. Prog. & Problem Solving	3	3	0	4
CM 1004	General Chemistry	3	2	1	4
EN 1014	Writing & Humanities I ²	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
EN 1204	Writing & Humanities II	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 I 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				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 ⁵				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 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 II Elective courses.

4. A list of approved Sequence Electives is available from the department.

5. The Free Elective could be a course offered by any department, provided it does not duplicate material studied in other courses.

MECHANICAL ENGINEERING PROGRAM

The undergraduate degree 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, bio-engineering, 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 2114 Computers in Mechanical Engineering to further develop proficiency in computer-aided drawing, and ME 2514 Measurement Systems to learn to design experiments. Junior year, students take MT 3814 Materials Science and Engineering to examine the impact of material properties on design; ME 3314 and 4314 Flow and Thermal Systems I and II to understand design of fluid and thermal systems; ME 2214 and ME 3214 Structural Systems I and II, to consider the structural design of engineering structures; and ME 3414 and ME 3424 Dynamics Systems and Control I and II to consider the design of dynamic systems. Finally the design experience culminates with the capstone ME 4114 and ME 4124 Engineering Design I and II sequence, during which students work in teams of two or three 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 technical electives available to seniors also contain significant design experience. ME 4364 HVAC Systems teaches design of HVAC systems. ME 4354 Internal Combustion Engines addresses design issues for engines, while MN 3714 and MN 4714 Manufacturing Systems I and II offers the methodology of design via concurrent engineering and other modern concepts.

GOALS AND OBJECTIVES

The objectives of the BS program 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 communicate 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. 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.

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 a 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 decision; 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 three components: (1) engineering core, 64 credits, of which 24 are from humanities and social sciences courses; (2) mechanical engineering, 44 credits; and (3) free and technical electives, 20 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 pro-

gram. Senior year, aerospace concentration students take three courses particular to their concentration: (1) AE 4614 Aerodynamics, in place of ME 4314 Flow and Thermal Systems II, (2) AE 4634 Aerospace Propulsion and (3) AE 4654 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 program 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 program 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 of the MS program 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 credits permitted as electives is reduced from 9 by the number of transfer credits granted. For example, if a student has been granted 6 credits of transfer, the total number of electives that the student can take outside the department is 3 credits.

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 of 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 of 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 degree 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 credits 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 90⁰ 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 4614 Aerodynamics 4:0:0:4

Introduction to the study of external and internal aerodynamics. Airfoil and wing geometry and characteristics. Lift and drag. Incompressible inviscid flows. Incompressible laminar and turbulent boundary layers. Compressible flow and shock waves. Design considerations for aerodynamic performance. High lift devices.

AE 4634 Aerospace Propulsion 4:0:0:4

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, staging of rocket vehicle, introduction to combustion.

AE 4654 Aircraft Flight Mechanics 4:0:0:4

Development of equations of motion. Characteristics of aircraft propulsion systems. Level flight performance of turbojet and propeller driven aircraft. Unaccelerated climbing flight and aircraft ceiling. Takeoff and landing performance. Longitudinal and lateral static stability. Linearized equations of motion. Longitudinal and lateral modes of motion.

ME 2114 Computers in Mechanical Engineering Analysis and Design 3½:1½:0:4

Introduction to the use of computers and industry standard software to solve problems in mechanical engineering. Computer-aided drawing through the use of parametric, feature-based, 3-D solid modeling design software. Computer aided analysis. Introduction to the use of finite element software packages. Use of computer software for math-

ematical computation and data presentation.

ME 2214 Structural Systems I 4:0:0:4

Introduction to the study of statics and strength of materials. Static equilibrium of particles and rigid bodies. Distributed forces. Static analysis of frames and trusses. Friction. Centroids and inertia. Stress and strain in tension, torsion, and bending. Mohr's circle. Bending and deflection of beams. Torsion and design of shafts.

ME 2514 Measurement Systems 3½:1½:0:4

Electrical measurement and devices. Instrument systems and components: analog to digital conversion, signal processing, filtering and readout devices. Static and dynamic measurements. Sensors and actuators. Calibration. Study of measurement systems via computer simulation. Digital Logic. Computer interfacing. Computer-aided, real-time data acquisition for real world electrical, robotic, mechanical, and fluid systems.

ME 3214 Structural Systems II 4:0:0:4

Fundamental aspects of the linear theory of elasticity and the finite elements method. The course focuses on the concepts of stress and strain, transformation equations, equilibrium equations, compatibility, stress-strain relations, boundary conditions, stress concentration, two-dimensional problems in elasticity, torsion and bending of beams with various symmetric and unsymmetrical cross sections, and linear buckling of columns and plates. Finite element procedures will be implemented by the use of commercial finite element codes and the classical solutions will be compared with the corresponding finite element results. Hands-on experience in the use of finite element methods will also be enhanced by a course project.

ME 3314 Flow and Thermal Systems I 4:0:0:4

The basic laws of classical mechanics; introduction to the basic concepts of fluids and thermodynamics; hydrostatics; properties of pure substances; work, heat and internal energy; first law analysis for a closed system; second law of thermodynamics; basic equations for a control volume; basic equa-

tions in differential form; Navier-Stokes equations; Euler's equations; Bernoulli's equation; heat conduction equation; steady state heat conduction.

ME 3414 Dynamic Systems and Control I 4:0:0:4

Introduction to the study of dynamics and vibrations. Kinematics and dynamics of particles and rigid bodies. Energy analysis. Impulse and momentum methods. Free vibrations of damped and undamped single degree of freedom systems. Forced vibrations. Vibration instruments. Two degree of freedom systems. Introduction to the vibrations of continuous systems.

ME 3424 Dynamic Systems and Control II 4:0:0:4

Dynamic system modeling, analysis, and feedback control design with extensive, hands-on computer simulation. Modeling and analysis of multiple degree-of-freedom systems with application to mechanical vibration (e.g., vibration absorbers and isolators). 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.

ME 4114 Engineering Design I 4:0:0:4

The first part of the Capstone Engineering Design sequence based on knowledge and skills acquired in earlier course work. Product design, development, building and testing prototype hardware, with an emphasis on teamwork. Design of machine elements and selection criteria for commonly used components. 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. Content to follow in ME 4124.

ME 4124 Engineering Design II 4:0:0:4

A continuation of the Capstone Engineering Design sequence. Continuation of presentation of the various elements of the Product Realization Process. This section will emphasize manufacturing, producibility and customer satisfaction concern; building effective teams/teamwork; communication skills; ethical issues. Student project is a major component of the course.

ME 4314 Flow and Thermal Systems II 4:0:0:4

Power production; gas and vapor power cycles; refrigeration cycles; chemical reactions and combustion; dimensional analysis and similitude; internal and external incompressible viscous flow, piping systems, fluid machinery; flow measurement; transient heat transfer; convection heat transfer; numerical methods; radiation heat transfer; introduction to compressible flow.

ME 4354 Internal Combustion Engines 4:0:0:4

Fundamentals of internal combustion engines; types of and principles of operation; thermodynamic principles; performance parameters; principles of combustion; fuels; operation of spark ignition and compression ignition engines; emissions for ICEs; design of ICEs; engine modeling; experimental methods for engine analysis and performance

ME 4364 Heating, Ventilating and Air Conditioning 4:0:0:4

Review of thermodynamic principles, fluid dynamics and heat transfer fundamentals as applied to heating, ventilating, air conditioning, and refrigeration systems. Psychrometric analysis. Human comfort. Heating and cooling analysis of buildings. Types of HVAC systems. HVAC system design and equipment selection. Use of software packages for design and analysis. Design project.

ME 4514 Mechanical Engineering Laboratory 2½:4½:0:4

Theory and principles of experimentation related to mechanical engineering. Report writing and analysis of experimental data including data reduction and uncertainty analysis. Experiments demonstrating the concepts relating to thermo-fluid, structural, dynamic and control systems. Demonstration of principles of thermodynamics, heat transfer, and fluid mechanics for mechanical engineering applications. Stress and strain measurement; load, fatigue, and failure testing. PC-based data acquisition and real-time control. Analytical and experimental modeling of electro-mechanical and thermo-fluid systems. Modeling and control of dynamic systems using state-space methods. The study of procedures necessary for the efficient planning and conducting mechanical engineering experimentation.

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.

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 company being visited.

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.

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

ME 600 Applied Computational Methods 2½:0:0:3

Computational methods used in formulation and solving problems that occur in engineering. Methods of interpolation, numerical differentiation and integration, solution of linear and nonlinear equations and eigenvalue problems. Finite difference methods. Particular attention to continuum techniques, e.g., Rayleigh-Ritz, Galerkin and collocation.

ME 700 Finite Elements 2½:0:0:3

Derivation of element stiffness matrices. Construction of general stiffness matrices in global coordinates. Application to problems in plane stress, plates and shells under static and dynamic loads. Applications in thermal, heat transfer and fluid mechanics. Emphasis on problems involving analysis of systems with many unknowns.

THERMAL AND FLUID SCIENCES**ME 601 Thermodynamics I** 2%:0:0:3

Availability functions, general thermodynamic relations, equations of state, general thermodynamic equilibrium criteria. *Prerequisite:* ME 201 or equivalent. Also listed under CH 771.

ME 604 Transport Phenomena 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. *Prerequisite:* ME 231 or equivalent.

ME 605 Heat Transfer 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. *Prerequisite:* ME 203 or equivalent.

ME 610 Fluid Dynamics 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. *Prerequisite:* ME 231 or equivalent. Also listed under CH 631.

ME 701 Advanced Thermodynamics 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%: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 or ME 605 or adviser's approval.

ME 707 Conductive Heat Transfer 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 or ME 605 or adviser's approval.

ME 708 Radiative Heat Transfer 2%:0:0:3

Fundamentals of radiative mechanisms of energy transfer. Definitions of basic quantities. Equations of transfer, radiative heat-flux vector and conservation equations. Properties of surfaces and participating media. Applications to engineering systems. *Prerequisite:* ME 604 or ME 605 or adviser's approval.

ME 711 Viscous Flow and Boundary Layers 2%: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 2%: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 2%: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 2%: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 2%: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 2%: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 special concentration in stationary and flowing reacting systems. Chemical kinetics of homogeneous and heterogeneous reacting systems. Branching chain reactions and explosion limits. *Prerequisites: ME 201 and 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. Air-breathing 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; drop-wise and film condensation. Critical heat flux. *Prerequisites: ME 201 and ME 706.*

MECHANICAL ANALYSIS AND DESIGN**ME 621 Stress Analysis I** 2½:0:0:3

Review of theory of beam bending. Use of energy methods applied to statically indeterminate structures. Columns, beam columns, beams on elastic foundations. Circular cylindrical shells. Discontinuity analysis in complex structures. *Prerequisite: ME 271 or equivalent.*

ME 622 Stress Analysis II 2½:0:0:3

Stress-strain relationships. Two-dimensional stress and strain analysis; equations of compatibility and equilibrium; the Airy stress function. Solutions of various classic two-dimensional problems, including those of stress concentration and thermal stress. Torsion of prismatic bars, open and closed thin-walled structures, and multi-cellular structures. *Prerequisite: ME 621.*

ME 643 Energy Methods in Structural Analysis 2½:0:0:3

Unified treatment of structural analysis using the principles of virtual work, total potential energy, total complementary potential and mixed energy. Applications to trusses, beams, frames, rings, sandwich structures, and to plane stress and plane strain problems. Rayleigh-Ritz procedure, Galerkin method. *Prerequisite: 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 multicylinder engines, crank mechanism dynamics and rotating machinery. *Prerequisite: ME 261.*

ME 645 Mechanical Vibrations II 2½:0:0:3

Free and forced longitudinal, torsional and transverse vibrations of bars, shafts and beams. Lagrange's equations. Rayleigh-Ritz and Dunkerley's approximations. Holzer's and transfer matrix methods. *Prerequisite: ME 644.*

ME 651 Advanced Dynamics I 2½:0:0:3

Kinematics and dynamics of a particle in space: translating and rotating frames of reference. Systems of particles: plane motion of rigid bodies. Two-body central force problem. Lagrange equations with holonomic and nonholonomic constraints: applications. *Prerequisite: ME 261.*

ME 652 Advanced Dynamics II 2½:0:0:3

General motions of rigid bodies, Euler's equations, gyroscopic motions and stability, impulsive motions. Linear oscillations of two-degree- and n-degree-of-freedom systems, matrix formulations, applications, variational principles. *Prerequisite: ME 647.*

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 micro-mechanics 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 2%: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 2%: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 2%:0:0:3**

Introduction to discrete systems, z-transform, s-to-z transformation, system stability criteria, digital control design via continuous design (root locus technique, frequency domain compensation), discrete design of digital control, sampling rate selection, quantization errors. *Prerequisite: ME 322 or equivalent.*

ME 661 Sensor Based Robotics 2%: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 2%:0:0:3

Basic system concepts. Equations describing continuous and discrete-time linear systems. Time domain analysis, state variables, transition matrix, impulse response. Transform methods. Time-variable systems. Controllability, observability and stability. Also listed under EL 610.

ME 671 State Space Design for Linear Control Systems 2%: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 2%: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 2%: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. *Prerequisites: ME 322 and ME 670.*

ME 771 Optimal Control Theory 2%: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 2%: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 2%: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.* Also listed under EL 724.

ME 871 Adaptive Control 2%:0:0:3

Controllable and observable system models, parameter estimation (least squares, projection algorithm, lattice filters), one and multi-step ahead prediction control, minimum variance, pole placement, LQG control, model reference adaptive control. *Prerequisite: ME 671.* Also listed under EL 826.

ME 872 Stochastic Control 2%:0:0:3

Introduction to stochastic control, stochastic processes, covariance and spectral density, stochastic state models, spectral factorization of continuous or discrete time processes, parametric optimization, introduction to prediction and filtering theory. *Prerequisite: ME 771.* Also listed under EL 827.

ME 873 Large-Scale Systems and Decentralized Control 2%: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 over-lapping 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. *Prerequisites are tailored to the offering.*

ME 886/887 Advanced Topics ½:0:0:3

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. *Prerequisites are 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 IA ¹ (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 ²	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
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 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
ME 2114	Computers in Mechanical Eng.	3½	1½	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 (½ semester)	4	0	0	2
ME 2214	Structural Systems I	4	0	0	4
ME 2514	Measurement Systems	3½	1½	0	4
	HU/SS Elective ³	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

MT 3814	Materials Science & Eng.	3	3	0	4
ME 3414	Dynamics Systems & Control I	4	0	0	4
ME 3314	Flow & Thermal Systems I	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					16

Spring Semester

ME 3214	Structural Systems II	4	0	0	4
ME 3424	Dynamic Systems & Control II	4	0	0	4
	Sequence Elective I ⁴	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					16

SENIOR YEAR

Fall Semester

ME 4114	Engineering Design I	4	0	0	4
ME 4314	Flow & Thermal Systems II	4	0	0	4
ME 4514	Mechanical Eng. Lab	2½	4½	0	4
	Sequence Elective II ⁴	4	0	0	4
					16

Spring Semester

ME 4124	Engineering Design II	4	0	0	4
	ME Elective				4
	ME Elective				4
	Technical Elective				4
					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 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 II Elective courses.

4. A list of approved Sequence Electives is available from the department.

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. Engineering & Design	1	3	2	4
MA 1012	Calculus IA (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
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 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
ME 2114	Computers in ME	3½	1½	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 (½ semester)	4	0	0	2
ME 2214	Structural Systems I	4	0	0	4
ME 2514	Measurement Systems	3½	1½	0	4
	HU/SS Elective ³	4	0	0	4
					16

JUNIOR YEAR

Fall Semester

MT 3814	Materials Science & Eng.	3	3	0	4
ME 3414	Dynamic Systems & Control I	4	0	0	4
ME 3314	Flow & Thermal Systems I	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					16

Spring Semester

ME 3214	Structural Systems II	4	0	0	4
ME 3424	Dynamic Systems & Control II	4	0	0	4
	Sequence Elective I ⁴	4	0	0	4
	HU/SS Elective ³	4	0	0	4
					16

SENIOR YEAR

Fall Semester

ME 4114	Engineering Design I	4	0	0	4
AE 4614	Aerodynamics	4	0	0	4
ME 4514	Mechanical Eng. Lab.	2½	4½	0	4
	Sequence Elective II ⁴	4	0	0	4
					16

Spring Semester

ME 4124	Engineering Design II	4	0	0	4
AE 4634	Aerospace Propulsion	4	0	0	4
AE 4654	Aircraft Flight Mechanics	4	0	0	4
	Technical Elective				4
					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 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 II 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 and productivity.

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
- 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. 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. Students without an adequate background in computers may be required to enroll in one or more of the preparatory courses in computer science, such as CS530 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.insob.poly.edu, the program's Web site.

CERTIFICATE PROGRAMS IN ORGANIZATIONAL BEHAVIOR

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.

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.

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 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 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 616 Job & Workplace Design
- 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 and 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 634 Applied Research Methods. 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 UNDER-GRADUATE COURSES

For course descriptions, please refer to the Master of Science in Management (MSM) 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.

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 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

Henry L. Bertoni, Professor of Electrical and Computer Engineering

David C. Chang, Professor of Electrical and Computer Engineering and University President

Bruce A. Garetz, Professor of Physical Chemistry

Hellmut J. Juretschke, Professor of Physics

Kalle M. Levon, Professor of Chemistry

Said Nourhakhsh, Professor of Materials Science

Abraham Ulman, Alstadt-Lord-Mark Professor of Chemistry

Edward L. Wolf, Professor of Physics

ASSOCIATE PROFESSORS

Lorcan M. Folan, Associate Professor of Physics

Sunil Kumar, Associate Professor of Mechanical Engineering

Iwao Teraoka, Associate Professor of Polymer Chemistry

ASSISTANT PROFESSORS

Jonathan Bain, Assistant Professor of Philosophy of Science

Yitzhak Shnidman, Assistant Professor of Chemistry

FACULTY EMERITI

Raphael Aronson

Hilda Bass

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 teaching. Some students use their major in physics as preparation for work in mathematics, chemistry, biology, medicine, engineering, law, history of science, writing or business.

The program's emphasis on fundamental knowledge, thorough analytic training and the universal logic of science enables physics students to take these different paths.

The BS in Physics offers four tracks to interested students, depending upon their selection of electives: (1) Pre-PhD, (2) Computational Science and Engineering, (3) Entrepreneurial and (4) Teaching. The teaching track is envisioned for students who would become high school physics teachers after obtaining appropriate certification. See chart for typical course of study at the end of this section.

UNDERGRADUATE COURSES

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 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: PH 2344 and MA 2122.*

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 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: PH 2004 and MA 2122.*

PH 3234 Electricity and Magnetism 4:0:0:4

Properties of the electrostatic, magneto-static and electromagnetic field in vacuum and in material media. Maxwell's equations with applications to elementary problems. *Prerequisites: MA 2122 and PH 2004.*

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.

PH 3811-3841 Reading Course in Interdisciplinary Physics 1:0:0:1

Special topics in interdisciplinary physics supervised by staff member. *Prerequisites: PH 2344, major must be in interdisciplinary physics.*

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*

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 transforms 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 Schrodinger'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.*

POLYMER SCIENCE AND ENGINEERING PROGRAM

Academic Director: Jovan Mijovic

For over half a century, Polytechnic University has had a traditional commitment to strong polymer programs of worldwide renown. At the present time, the Department of Chemical Engineering, Chemistry and Materials Science offers a graduate program leading to the degree Master of Science in Polymer Science and Engineering. Candidates interested in the PhD program in Polymer Science and Engineering can conduct their studies according to the requirements described in Chemical Engineering and Chemistry Programs section of this catalog.

GOALS AND OBJECTIVES

The objective of the Polymer Science and Engineering Program is to provide students with a well-rounded advanced level education covering major areas of chemistry, physics and engineering of polymeric materials. Polytechnic has all of the elements necessary to conduct such a program, owing to its long tradition of excellence in the area of polymers. The philosophy followed in this program is to expose full-time and part-time students to all aspects of polymer science and engineering and to enable them to (1) choose a new career path, (2) advance in the sub-specialty at a professional level and/or (3) continue in a PhD program.

ADMISSION REQUIREMENTS

To be eligible for admission as a graduate student, applicants must hold a baccalaureate degree in either chemical engineering or chemistry with a mathematics background, including at least one course in differential equations. Applicants who have earned bachelor's degrees from foreign institutions are required to submit Graduate Record Examinations (GRE) and TOEFL scores. Applicants with degrees in other fields or from other colleges may be admitted with undergraduate or graduate deficiencies with the consent of a graduate adviser. The program leading to Master of Science is designed to meet the needs of engineers and chemists well versed in the fundamental principles of polymer science and engineering.

REQUIREMENTS FOR THE MASTER OF SCIENCE

Candidates for the Master of Science in Polymer Science and Engineering are to include in their programs the following required courses:

Course No.	Course Title	Units
CH 930*	Guided Studies in Polymer Science and Engineering	6
	Electives	6
or		
CH 997*	Thesis for Master of Science in Polymer Science and Engineering	12
and		
CH 921	Polymer Processing	3
CH 926	Engineering Properties of Polymers	3
CH 991/992	Departmental Seminar	0
CM 771	Introductory Polymer Chemistry	3
CM 783	Laboratory Methods in Polymer Chemistry	3
	Electives**	12
Total		36 Units

To meet graduate requirements, students must have an overall B average in all courses and must not obtain more than two C grades in required subjects.

**Students may opt for a guided study option plus 6 units of electives instead of the thesis option*

***Any graduate course offered by the department may be chosen as electives. The approval of the graduate adviser will be needed in order to take courses in other disciplines*

GRADUATE COURSES

CH 921 Polymer Processing 2½:0:0:3

Applications of engineering principles to polymer processing. Non-Newtonian polymeric systems. Discussions and problem-solving in extrusion, injection molding, fiber spinning, film blowing and coextrusion as well as other polymer engineering processes. *Prerequisites:* CH 231 and CH 232 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:* CH 372 or 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 771 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.

CM 771 Introductory Polymer Chemistry 2½:0:0:3

Synthesis of polymers by step reaction and addition polymerization, formation of three-dimensional networks, block and graft polymers, polymer degradation, characterization of polymers in solution, rubber elasticity, polymer crystallization. Spectroscopic techniques for polymer study, properties of commercial polymers. *Prerequisites: CM 123 and CM 125*

CM 772 Syntheses of High Polymers 2½:0:0:3

Organic aspects. Chemistry of monomer and polymer formation. Modern mechanistic analyses of reactions. Stereochemistry of polymer structures and forces of stereo regulation. Condensation, free radical (bulk, suspension, emulsion, solution), ionic, ring-opening and nonclassical polymerization reactions.

CM 781 Solution Properties of High Polymers 2½:0:0:3

Application of osmometry, light scattering, equilibrium ultracentrifugation, electrophoresis, viscosity, diffusion, ultracentrifuge sedimentation, flow birefringence, polarimetry, spectroscopy and other techniques used in the characterization of dissolved macromolecules. Properties of polyelectrolytes, association in solutions containing macromolecules and reaction kinetics in macromolecular solutions. Synthetic and biological macromolecules are covered. *Prerequisites: CM 771 or CM 783 and CM 161.*

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 or CH 372.*

CM 783 Laboratory Methods of Polymer Chemistry 0:5:0:3

Experiments on free radical, condensation, ionic and polymerization, absorption, NMR spectroscopy, intrinsic viscosity, light scattering, gel permeation chromatography, x-ray diffraction, thermogravimetric analysis, differential scanning calorimetry, dilatometry, concentrated solution viscosity and other aspects of polymer synthesis and characterization. Lab fee required. *Prerequisite: CM 771.*

CM 785 Special Topics in Polymer Chemistry 2½:0:0:3

Presentation at intervals of various advanced or specialized topics in polymer chemistry.

PROJECTS, THESES AND SEMINARS**CH 930 Guided Studies in Polymer Science and Engineering**

6 units, each 2 units

Presentations of a comprehensive report of some problem involving polymer science and engineering, such as polymer synthesis, processing, evaluation, or equipment design is required. Master's degree candidates are required to submit three unbound copies of a typewritten project report to advisers one week before the last day of classes. *Prerequisite: degree status.*

CH 987 Thesis for Degree of Master of Science in Polymer Science and Engineering 12 units, each 3 units

Thesis for master's degree in polymer science and engineering should give results of original investigations of problem in polymer science and engineering. Theses may involve experimental research, theoretical analyses, or process designs, and possibly a combination thereof. Master's degree candidates are required to submit four typewritten unbound thesis copies to advisers before or on the seventh Wednesday prior to commencement. *Prerequisite: degree status.*

CH 991/992 Departmental Colloquium 0:2½:0:0

Recent developments in the field of chemical engineering, chemistry and materials science will be presented through lectures given by experts from industry, research, and educational institutions as well as by staff members or qualified graduate students. Required for two semesters of all graduate students seeking degrees.

SYSTEMS ENGINEERING PROGRAM

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 1: Core Courses

Three courses from among the following:

EL 525	Applied Matrix Theory (formerly EL 613)
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

21-15 Units

Total:

36 Units

A complete course of study, including the choice of the one-year sequences, should be arranged in consultation with an adviser. A master's thesis of 9 units may be included as part of the elective courses. At least 24 of the 36 units must be in courses in engineering subjects, computer science or operations research, and at least 18 units must be in EL 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.ccc.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 AND PROFESSIONAL COMMUNICATION PROGRAM

Academic Adviser: Elizabeth Chesla (Undergraduate), Anne Eisenberg (Graduate)

The Department of Humanities and Social Sciences offers the following programs of study through its Technical and Professional Communication Program:

- Bachelor of Science in Technical and Professional Communication
- BS/MS Accelerated Degree
- Master of Science in Technical and Professional Communication
- Graduate Certificate in Technical Communication

The Technical and Professional Communication Program is designed to train students to synthesize or “translate” technical or specialized information so that it can be easily understood and used in business, academic and private settings. Students develop their research, writing, editing and design skills as well as their interpersonal, organizational and management abilities. Students should have a strong foundation in communication skills as well as an interest in, or aptitude for, business, science or technology.

While the curriculum explores the theoretical foundations of contemporary communications, the program’s emphasis is on the practice of effective communication. Through course projects and internships, students develop a solid portfolio that demonstrates a wide range of writing, editing and design skills as well as in-depth knowledge within a particular area of specialization.

GOALS AND OBJECTIVES

The objectives of the graduate and undergraduate programs in Technical and Professional Communication are to:

- Foster the art of clear and precise writing and communication across the full range of technical and professional endeavors
- Introduce students to the new technical media used in science, business and the professions, and have them develop effective communication skills using these media
- Help students become “translators” of technical jargon into the idiom of common discourse

AREAS OF SPECIALIZATION

To address the diversity of writing, editing and design tasks available to today’s technical and professional communicators, the program offers three areas of specialization:

1. Writing about Medicine, Science and Technology
2. Writing for Business: Advertising, Public Relations, Corporate Communications and the Trade Press
3. Documentation, Training and New Media

Students work closely with an adviser to select the courses most suitable for their intended area of specialization.

Writing about Medicine, Science and Technology

As scientific knowledge continues to expand, it is more important than ever that information about medicine, science and technology be conveyed clearly and succinctly to both technical and lay audiences. Medical, science and technology writers and editors work on publications that serve physicians, nurses, computer scientists and other technical and scientific personnel; on the news staffs of print and broadcast media; on the public relations staffs of pharmaceutical houses and hospitals, medical schools and scientific research centers; in the writing departments of pharmaceutical and technology corporations; in museums and nonprofit institutions; for publishers of children’s literature; and in the editing departments of textbook publishers. They write scientific biographies, science essays, newsletters and books on technology, as well as articles and freelance pieces, often in addition to full-time work in the field.

Writing for Business: Advertising, Public Relations, Corporate Communications and the Trade Press

Advertising and public relations work is concerned with the promotion of corporate products and services to industrial clients and to the general public. The program focuses on advertising and public relations for medical, health care, technological and

industrial products and services. Advertising involves copywriting, graphic design, media selection, campaign organization and market research; students may find careers as copywriters, account executives, advertising managers and media directors. Public relations professionals generate publicity for new products and services through press releases, technical articles and press conferences. They also write speeches, handle press inquiries and write case histories.

Writers in corporate communications manage the form and flow of information both within a corporation and to customers, potential clients and the general public. This information takes a variety of forms, such as proposals, newsletters, brochures, progress reports, manuals, memoranda, analyses, meeting minutes and annual reports. These writers may also be called upon to write speeches and trade magazine articles. Corporate communicators, therefore, are often responsible for how employees, customers and clients perceive an organization.

The trade press offers a variety of research, writing and editing opportunities. Hundreds of industry-specific magazines need technical journalists to report on industry trends and developments, to review new products and procedures, and to analyze industry issues. Trade journalists develop industry expertise through their research and may work closely with public relations professionals.

Documentation, Training and New Media

- **Documentation.** Large numbers of technical communicators are needed to plan, write and evaluate effective hardware, software and systems documentation. Documenters create user manuals, online tutorials and hypertext user guides and often work closely with software developers, trainers and information managers to meet the needs of the end user. Along with a basic knowledge of programming, computer documenters must understand the basic principles of human-computer interaction and be able to manage a documentation project from the critical stage of needs analysis to usability testing and benchmarking.

- **Training.** End users often need skilled professionals to teach them how to use the latest software, hardware and systems technology. Trainers and instructional designers use a variety of training methods, including demonstrations, computer-based tutorials, online help, documentation and interactive exercises. Trainers and instructional designers have backgrounds in human learning systems, human-computer interaction, business process analysis, user interface, design and effective teaching practices.
- **New Media.** Today's documenters, trainers and other professional communicators can use a variety of media to convey their message. Ideas and information can be communicated through words and pictures: in text, sound and video; on paper, computer, slides and film. New media specialists understand these technologies, their applications and their effectiveness both individually and in combination with other media. They are valuable marketers and presentation developers who know which types of media to select for each project and how to design, sequence, script and link a presentation. Interactive multimedia is a particularly powerful new technology used by new media specialists who also study the social, political, economic and cultural effects of multimedia communications.

**UNDERGRADUATE PROGRAM
BACHELOR OF SCIENCE**

See requirements for BS in Liberal Studies degree in the Liberal Studies Program section in this catalog. Students earning the Technical and Professional Communications degree 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.

**THE BS/MS ACCELERATED
HONORS PROGRAM**

The Technical and Professional Communication 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 and Professional Communication 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 a program adviser. Once enrolled in the program, students are expected to maintain a 3.0 GPA.

**GRADUATE PROGRAMS
MASTER OF SCIENCE**

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	Intro. to Technical & Professional 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

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.

**Upon adviser approval, students with prior experience in technical or professional communication may waive JW 600 and replace it with an elective course.*

**CERTIFICATE IN TECHNICAL
COMMUNICATION**

The Graduate Certificate in Technical Communication trains students in the fundamentals of technical and professional communication through a combination of core courses and electives. To earn a certificate, students must complete 15 credits (five courses). All credits earned in the certificate program are transferable to the Master of Science degree.

In general, all certificate students should take the following core courses:

Course No.	Course Title	Units
JW 600	Intro. to Technical & Professional 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 or professional communication may waive JW 600 and replace it with an elective course.

Students are recommended to 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.

**RECOMMENDED COURSES FOR
SPECIALIZATIONS**

Writing about Medicine, Science and Technology

JW 603	Reporting on Medicine, Science & Technology	
JW 605	Libel Law & Press Ethics	
JW 606	Technical Presentations	
JW 607	Writing News for Radio & Television	
JW 621	Reporting and Editing for the Trade Press	
JW 625	Corporate Communications in Medicine, Science & Technology	
JW 627	Writing Copy on Pharmaceuticals & Biotechnology	
JW 635	Online Journalism	
JW 636	The Feature Article	
JW 637	Computer-Assisted Reporting	

Writing for Business: Advertising, Public Relations, Corporate Communications and the Trade Press

JW 604	Graphic Design & Technical Illustration	
JW 606	Technical Presentations	
JW 618	Web Page Authorship & Design	
JW 621	Reporting and Editing for the Trade Press	
JW 623	Project Management	
JW 624	Writing Product Information Copy	
JW 626	Public Relations for Medicine, Science & Technology	
JW 627	Writing Copy on Pharmaceuticals & Biotechnology	

- JW 628 Business-to-Business Advertising
- JW 631 Proposal Writing
- JW 632 Writing Technical Manuals & Procedures
- JW 641 Desktop Production Workshop

Documentation, Training and New Media

- JW 604 Graphic Design & Technical Illustration
- JW 608 Computer Documentation I
- JW 609 Computer Documentation II
- JW 611 Technical Translation & Localization Practices
- JW 613 Human Factors & Product Design
- JW 615 Multimedia Technologies
- JW 618 Web Page Authorship & Design
- JW 623 Project Management
- JW 632 Writing Technical Manuals & Procedures
- JW 641 Desktop Production Workshop
- JW 645 Instructional Design & Development
- JW 646 End-User Training
- JW 647 Computer-Based End-User Training

UNDERGRADUATE COURSES

TC 1014 Introduction to Technical and Professional Communication I 4:0:04

Introduction to the research, writing and design principles and practices of technical and professional 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 1014.*

TC 1024 Introduction to Technical and Professional Communication II 4:0:04

Introduction to the research, writing and design principles and practices of technical and professional 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 new and digital media. *Prerequisite: EN 1014; course does not require EN 1014, but both courses must be taken before 2000-level.*

TC 2104 Professional Reporting Writing 4:0:04

Fundamentals of report writing applied to short, informal papers written by scientists and engineers in actual business situations: technical correspondence, memorandums,

trip reports, periodic reports and new product information sheets; summaries, process and technical descriptions, instructions and analyses. Effective style, organization of material and mechanics. Students learn to coordinate tales, graphs and other illustrative matter with text. *Prerequisite: EN 1204.*

TC 2114 Information and Graphic Design 4:0:04

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 is covered. Students begin to develop a portfolio of class projects. *Prerequisites: TC 1014 and TC 1024.*

TC 2214 News and Feature Writing 4:0:04

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 copy-editing techniques, including editing, revising, and rewriting copy intended for a variety of audiences, publications and media. Peer and self-editing projects and assignments. *Prerequisites: TC 1014 and TC 1024.*

TC 2314 Computer Documentation 4:0:04

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: TC 1014 and TC 1024.*

TC 3124 Digital and Multimedia Production 4:0:04

Introduction to multimedia technologies and applications for technical writers and editors. Students learn tools and techniques for producing presentations in a variety of new media. Audience analysis and objectives, media selection and production, design coordination and sequencing. Multimedia project. *Prerequisites: TC 1014 and TC 1024, TC 2114, TC 2214.*

TC 3224 Critical Writing 4:0:04

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 proof-readers. For final project, students research and write text targeted for specific publications. *Prerequisites: TC 1014 and TC 1024, TC 2214, TC 2114 or TC 2314.*

TC 3324 Writing for New Media 4:0:04

Planning, writing and designing an effective project for digital or new media formats such as Intranet, Internet, Newsgroups 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. *Prerequisites: TC 1014 and TC 1024, TC 2114, TC 2214.*

TC 3404 Special Topics in Technical and Professional Communication 4:0:04

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 and 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 and professional communication majors and minors only: junior or senior standing; appropriate courses for internship project; 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 and professional communication majors only: senior status; completion of 1000-, 2000- and 3000-level course requirements.*

GRADUATE COURSES

JW 600 Introduction to Technical and Professional 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 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

Copyeditors are at the center of any print-media organization. Course addresses skills copyeditors 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.

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 604 Graphic Design and Technical Illustration 2½:0:0:3

Workshop in developing and producing graphics and illustrations for technical communications. Topics covered include concept development, computer-assisted graphic design, integrating text and graphics and layout for technical reports, manuals and proposals.

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 609 Computer Documentation II 2½:0:0:3

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.*

JW 610 Information Design 2½:0:0:3

A workshop providing extensive practice in strategies for information design. Students learn how to categorize or chunk information into small, digestible components that can be easily absorbed and recalled by user or reader. Course explores history of information design and links between information design and other writing strategies. Students apply information design to various types of documents, including news articles, business reports, documentation (both print and online) and scripts for multimedia and radio. *Prerequisite: JW 600 or instructor's permission.*

JW 611 Technical Translation and Localization Practices 2½:0:0:3

Students learn and practice concepts of writing and revising technical communications for effective translation. They explore elements of translatability, especially cultural concerns, syntactic structures and style. Includes case studies and a translation project. *Prerequisite: JW 600 or instructor's permission.*

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 615 Multimedia Technologies 2½:0:0:3

Covers various multimedia technologies and their applications in technical communications. Elements of each medium; methods of media selection; media production; design coordination and media integration. Importance of audience analysis, clear understanding of goals and objectives, and project evaluation. Includes major multimedia project. *Prerequisites: JW 600 and JW 604 or instructor's permission.*

JW 618 Web-Page Authorship and Design 2½:0:0:3

Workshop in writing and designing a World Wide Web page. Students examine elements of effective World Wide Web page

authorship and design, including coding, linking, information hierarchy and effective integration of graphics, text and sound. Students write and produce Web pages for a mock organization. *Prerequisites: JW 600 and JW 604 or instructor's permission.*

JW 620 Financial and Business Reporting 2:1½:0:3

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, energy, industry and the environment, and advertising. 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 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, liaisoning 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 inter-relationship 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 On-Line Journalism 2½:0:0:3

Examination of the growing field of on-line 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 637 Computer-Assisted Reporting (CAR) 2½:0:0:3

Workshop focusing on using the computer as a key newsgathering tool. Students learn techniques involved in finding, accessing, analyzing and using databases on the World Wide Web when researching technical and non-technical news and feature stories. Course explains how reporters and editors use CAR methods not only for essential online research but also with spreadsheet software, CD-ROMs, mapping and electronic mail. Students write articles that depend heavily, but not exclusively, on CAR-based research. *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 and produce effective business and technical documents: newsletters, brochures, etc. *Prerequisites: JW 600 and JW 604 or instructor's permission.*

JW 645 Instructional Design and Development 2½:0:0:3

Fundamentals of computer-assisted instructional design and curriculum development. Topics include the different learning modalities, how to organize information into lessons, how to develop effective exercises and tests, and elements of effective instruction. Students create a training curriculum as a semester project. Scope of project includes needs analysis, project planning and management, and usability testing. *Prerequisite: JW 600 or instructor's permission.*

JW 646 End-User Training 2½:0:0:3

Workshop on the effective delivery of training programs. Students go through training development process, from program assessment and design to delivery and evaluation. Course reviews elements of effective instructional design (with an emphasis on different learning styles) and then focuses on choosing appropriate method of instruction and elements of effective instruction. Students conduct several training sessions throughout the semester. *Prerequisite: JW 645 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

2%: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

2%: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

2%: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 and Professional Communication

2%: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 and Professional Communication

2%: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 and professional communication; approval of sponsoring organization and department.*

JW 704 Master's Project

2%:0:0:3

Students work with faculty adviser to write and produce master's project in technical and professional communication. After project proposal is approved, students research and develop technical communication project in area of specialization. *Prerequisites: completion of 27 credits or more toward MS in Specialized Journalism; instructor's permission.*

TECHNOLOGY AND INFORMATION MANAGEMENT PROGRAM

Director: Barry Blecherman

GOALS AND OBJECTIVES

The Bachelor of Science in Technology and Information Management (T&IM) 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. T&IM 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 an Impressionist work of art, 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 T&IM 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
- 8 credits in computer science
- 8 credits in a two-semester junior and senior course sequence. Students are free to fulfill this requirement by taking courses from any department
- 60 credits in management

Courses for the BS in T&IM 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 the calculus courses of 2 credits each are taken; in the fourth semester, when two 2-credit courses in data analysis are required; and in the fifth semester of the program, when two 2-credit courses in project management and business ethics are required.

Course Numbering

T&IM courses are numbered using the following schema:

- The first digit of a course number corresponds to the year in which a T&IM 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 processes 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.

Graduation Requirements

To remain in good standing, candidates for the degree BS T&IM 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

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.

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 Web site at www.bs-tech-info-mgmt.poly.edu. Students are responsible for keeping informed and are encouraged to visit the BS T&IM Web site 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 information 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, build-

ing, 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: MA 1112.*

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 Management of Technology and Innovation 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: MA 1112 and MG 2234.*

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, 2224 and 2304.*

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, MG 3404 and MG 4404.*

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: MA 1112 and MG 2234.*

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. *Prerequisites: MG 2004, MG 2104, MG 2204, MG 2214, MG 2304, MG 3204 and MG 3404.*

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 multi-national 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. *Prerequisites: MG 3012, MG 3024, MG 3204, MG 3304, MG 3404, MG 4004 and MG 4014.*

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 Technology and Information Management

FRESHMAN YEAR

Fall Semester

Course No.	Course Title	Hours/Week			
		Class	Lab	Rec.	Cr.
MA 1012	Calculus IA ¹ (½ semester)	4	0	0	2
MA 1022	Calculus IB (½ semester)	4	0	0	2
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 1112	Calculus IIA (½ semester)	4	0	0	2
MG 1002	Found. of Mngt. (½ semester)	4	0	0	2
EN 1204	Writing & Humanities II	4	0	0	4
CS 1124	Object-Oriented Programming	3	3	0	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 1014	Intro. to History & Phil. of Tech.	4	0	0	4
					16

Spring Semester

EC 2524	Managerial Microeconomics	4	0	0	4
MG 2304	Marketing	4	0	0	4
MG 2014	Operations Management	4	0	0	4
MA 2212	Data Analysis I (½ semester)	4	0	0	2
MA 2222	Data Analysis II (½ semester)	4	0	0	2
					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 (½ semester)	4	0	0	2
PL 4052	Business Ethics (½ semester)	4	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.	4	0	0	4
	Sequence Elective I ⁵				4
	HU/SS Elective ⁴	4	0	0	4
					16

SENIOR YEAR

Fall Semester

MG 4004	Mngt. Strategy in Tech. Sectors ⁶	4	0	0	4
MG 4404	Entrepreneurship ⁶	4	0	0	4
	Sequence Elective II ⁵				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	4	0	0	4
	HU/SS Elective	4	0	0	4
					16

Total credits required for graduation:

128

1. Students who are placed by examination or by an advisor into MA 0902, MA 0912 or MA 0922 must defer registration for MA 1012.

2. Students who are placed by examination or by an advisor into EN 1080 or EN 1090 must subsequently register for EN 1034, rather than EN 1014.

3. Science/Engineering Electives are CM 1004, EG 1004, LS 1004 and PH 1004.

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 II Elective courses.

5. A list of approved Sequence Electives is available from the department.

6. 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.

TELECOMMUNICATION NETWORKS PROGRAM

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 program 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 21 Units

EL 536	Principles of Communication Networks (formerly EL 635)
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
CS 684	Network Protocols I or EL 537 Protocols for Local Area Networks (an approved core elective course)

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 EE or CS master's thesis or project as long as it is telecommunications related. Additional thesis credits will replace free elective courses.

GROUP 3: Program Elective Courses

6 Units

Students are required to take two 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.

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
EL 501	Wireless Personal Communication Systems
EL 514	Multimedia Laboratory
EL 638	SONET/ATM-Based Broadband Networks
EL 601	Principles of Digital Communication
EL 602	Wireless Communications
EL 630	Probability
EL 735	Communications Networks I
EL 736	Communications Networks II
EL 737	Broadband Packet Switching
EL 930	Wireless Information Systems Lab
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 graduate management, computer science or electrical engineering courses used in the Telecommunications Networks Program are located, respectively, in the Management, Computer Science and Electrical Engineering program sections of this catalog.

TELECOMMUNICATIONS AND INFORMATION MANAGEMENT EXECUTIVE PROGRAM

Academic Co-Directors: Mel Horwitch and Nina Ziv

GOALS AND OBJECTIVES

The objective of the Telecommunications and Information Management Executive Program is to deliver the highest level of learning experience focusing on the intersection of broadly defined information technology and management at the heart of the modern economy.

The Department of Management, supported by the Department of Computer and Information Science and other relevant departments, offers a highly accelerated Master of Science in Telecommunications and Information Management (TIM).

TIM deals with managing in a drastically transformed, challenging and critical business environment. This setting includes:

- Knowledgeable and demanding IT customers
- Emergence of electronic business, electronic commerce and the Internet
- A reconfigured telecommunications industry
- Widespread deregulation/re-regulation/privatization on a Domestic and International Basis.
- New information-based markets and businesses
- New organizational forms and management
- Revitalized established and new competitors
- Speed, feedback and co-creation with customers, suppliers and other partners as key elements in new business models
- IT providers/integrators/users as innovators
- Continuous development and introduction of information technology, thereby adding value to markets and firms

The TIM Program was established in 1984 and serves a wide variety of executives faced with new challenges and opportunities in the broad arena where telecommunications and information technology, and management intersect the rapidly developing areas of networking telecommunications and networking information

management. TIM is a rigorous 16-month, four-semester state-of-the-art program.

The TIM Program focuses on the critical interface that integrates networking telecommunications, information technologies, the Internet and management.

The perspective of TIM is high-level, yet grounded. The orientation of TIM is pragmatic and managerial (not simply technical). TIM is geared for the growing set of professionals who must use information and networking technology and the Internet in carrying out critical tasks and in developing and delivering value within their organizations and for customers. The TIM Program has several key characteristics, including the following:

- Explores how networking, telecommunications, information technology, electronic business and the Internet can transform enterprises and organizations
- Examines how networking, telecommunications, information technology, electronic business and the Internet create and change markets
- Uncovers and helps build new effective business models that take advantage of networking, telecommunications, information technology, electronic business and the Internet
- Focuses on integrating information and communications technology, e-business and decision making

Courses in TIM are managerial, technological or integrative (blending management and information technology). The entire curriculum is 36 credits.

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 new Internet based technologies and methods
- The incorporation of technology is undertaken with ease of use and access as key watchwords

TIM classes are held every other Friday morning and all day Saturday or 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 Web site 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, an ability to benefit professionally from a rigorous two-year 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 TIM Programs. But the TIM Executive Master's Management Degree Program office may ask applicants to submit scores later in the admissions process.

How to apply:

1. Mail a completed application and application fee to:

Administrative Director, MOT-TIM
Polytechnic University
55 Broad Street, Suite 13B
New York, NY 10004

or complete an electronic application on www.mot-tim.poly.edu.

2. Arrange to have transcripts for previous college and university work sent directly by the academic institution to the MOT-TIM Master's Degree Program Administrative Director at the above address.

3. Arrange for two letters of recommendation to be sent to the Executive Master's Degree Administrative Director. These letters are generally from a supervisor or high-level colleague familiar with student's professional work.

4. The final step to admission is a personal interview with one of the program co-directors to discuss career objectives and to make sure students' aims fit the goals of the program to which they have applied.

For further information please contact the program:

Tel: 212/547-7030 ext. 207

Fax: 212/547-7029

E-mail: mot-tim@poly.edu

Web: www.mot-tim.poly.edu

TELECOMMUNICATIONS AND INFORMATION MANAGEMENT

The courses that constitute the TIM program curriculum are:

First Semester

MG 609	Managerial Accounting & Finance
MG 690	Managerial Decision Making for Information-Intensive Businesses
MG 790	Foundations of Telecommunications & Networking Technology

Second Semester

MG 693	Information Technologies, Systems & Management in Organizations
MG 695	Economics For Business Decisions*
MG 791	Principles of Modern Networking
MG 793	Global Management in the Telecommunications & Information Industries*

Third Semester

MG 607	Marketing
MG 792	Modern Network Environment Management
MG 786	High Technology Entrepreneurship

Fourth Semester

MG 782	Competitive Information Strategy*
MG 783	New Frontiers in Electronic Business*
MG 960	TIM 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 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**
MG 820	Project Management & Assessment for Technology Managers**

* half-semester course

** half-semester courses offered in third or fourth semesters

SPECIAL TIM TRACK: The e-BUSINESS TRACK

e-Business constitutes for many professionals in the TIM environment 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 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 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 implement-

ing 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 695 Economics For Business Decisions *1%:0:0:1%*
(half-semester course)

Foundations of economic thinking for information business managers. Analysis of supply and demand. Competitive implications of market structure—perfect competition, monopoly, monopolistic competition and oligopoly.

MG 781 Selected Topics in Networking and Information Technologies *1%:0:0:1%*
(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 *1%:0:0:1%*
(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 783 New Frontiers in Electronic Business *1%:0:0:1%*
(half-semester course)

Investigation of 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 competitive survival and dominance; and (4) business applications involving collaborative communication, computation and teamwork. The 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 also 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 market-space. Classes are conducted using the case method and a high level of class interaction is expected.

MG 784 Negotiation in Technology-Intensive Sectors *1%:0:0:1%*
(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 *1%:0:0:1%*
(half-semester course)

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 *1%:0:0:1%*
(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 *1%:0:0:1%*
(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 *1%:0:0:1%*
(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 *1%:0:0:1%*
(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 *2%: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 *2%: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); inter-networking; 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 Environment Management *2%: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 inter-organizational 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 *1%:0:0:1%*
(half-semester course)

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) *1%:0:0:1%*

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
(half-semester course) *1%:0:0:1%*

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 *2%: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 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. 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

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.

GENERAL REQUIREMENTS FOR TRANSPORTATION PROGRAM

ADMISSION REQUIREMENTS

To be eligible for admission as a graduate student, 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.

Admission to the PhD program requires a suitable MS degree from an acceptable institution. Students wishing to pursue a PhD program who do not meet this require-

ment will generally be initially admitted as MS students. A 3.5 GPA or better in master's level work is generally required for admission to the PhD program.

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 graduate degrees or certificates, students must 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.

In addition, transportation 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.

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, 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 or to select additional electives.

Students registering for any guided studies (readings, projects, theses, dissertations) are assigned project advisers for each such activity. The project adviser 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 units for a MS degree, 30 units for a PhD. 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 transfer credits are accepted only after students have earned 12 units at Polytechnic.

For PhD degrees, students may transfer up to 60 units of coursework, not including project, theses or dissertation units. The same criteria as those specified for MS programs apply.

Validation credits by examination may not be used toward any transportation degree program.

GRADUATE PROGRAMS

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 goals 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 Mgt	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	Transportation Electives*	12
	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 goals 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 850	Transportation Management	3
TR 851	Transportation Policy	3
TR 852	Public Transportation Systems & Operations	3
TR 855	Intermodal Facilities: Operation & Management	3
MG	General Management Electives	6
TR	Transportation Electives*	9
	Free Electives*	6
Total		36 Units

**Adviser approval is required for all elective selections.*

MASTER OF SCIENCE PROGRAM WITH NYU

Polytechnic has a dual degree transportation program with the Robert F. Wagner Graduate School of Public Service at New York University. Students may pursue an MS in Transportation Planning and Engineering or Transportation Management at Polytechnic and a Master of Urban Planning or a Master of Public Administration at NYU. Because of course waivers or advanced standing, where appropriate, the two degrees may be obtained with some efficiencies in total units and in total time required to earn the two degrees separately.

Those interested in the dual degree program must apply to that program specifically by sending a letter to the Polytechnic Transportation Program or to the NYU Wagner School, accompanied by application forms to both universities.

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 goals 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

1. Completion of a 30-unit major in transportation planning and engineering, including all courses required for the MS in Transportation Planning and Engineering.
2. Completion of two 15-unit minors in related areas, one of which is almost always in quantitative methods. The second often focuses on a particular transportation specialty, such as traffic engineering, transportation planning and transportation economics. The minor areas of study should support the dissertation topic selected.
3. Successful completion and defense of a 30-unit dissertation, which must be an original piece of work that advances the state-of-the-art in a focused area of the transportation profession.

The above are minimum requirements for the PhD. Many students, particularly those entering with advanced degrees in other fields, may require additional courses to support their dissertation research and to aid in successful completion of the PhD qualifying examination in transportation. All applicants to the PhD program are encouraged to make individual appointments with a transportation adviser.

Before registering for dissertation units, candidates must pass a comprehensive PhD qualifying examination. Given once per year, usually in June, July or August, it consists of both written and oral portions. Copies of previous examinations are available on request from the Program Office. Students normally take the qualifying examination after one year of full-time course

work (or the part-time equivalent) is completed. All students seeking to take the examination are permitted to do so once they have expressed their interest to a transportation adviser. Subsequent attempts are at the discretion of the department; in no case are more than three attempts permitted.

There is no foreign language requirement.

The residency requirement for the PhD is 30 units, which must include the dissertation. Thus, students in this program are only required to complete their dissertation at Polytechnic to earn a Polytechnic degree. Any and all graduate courses from other institutions that are relevant to either the major or minors may be transferred, providing that a B grade or better was earned.

In support of dissertation research, a doctoral committee is formed to advise each student. Because of the interdisciplinary nature of transportation research, the committee often includes faculty members from other academic departments. Industrial or other outside committee members with suitable backgrounds are also permitted.

Once students register for dissertation, they must do so continuously until completion. This generally means a minimum of 3 units of registration per semester (not including summers), except in the last semester of work, in which a minimum registration of ½ unit must be maintained. Special permission from the Office of the Dean is required for this. Students are also required to submit and orally defend a formal dissertation proposal after one semester of full-time registration or before going beyond 9 units of dissertation registration on a part-time basis. At the end of each semester of dissertation registration, students must submit a written progress report to their dissertation adviser. After completing their dissertation, students must orally present and defend it before the faculty.

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

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

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 and Economics

TR 609	Transportation Economics and Finance	3
TR 850	Transportation Management	3
TR 851	Transportation Policy	3
TR 852	Urban Public Transportation Systems and Operations	3
MG	Management Elective	3
		15 Units

GRADUATE COURSES

TRANSPORTATION PLANNING, ANALYSIS AND EVALUATION

TR 605 Transportation Demand Forecasting 2/0/0/3

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 2%: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. *Prerequisite: TR 605 or equivalent.*

TR 609 Transportation Economics and Finance 2%: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 2%: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 2%: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.*

TRAFFIC ENGINEERING**TR 681 Traffic Studies and Characteristics** 2%: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 2%: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 2%: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 2%: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** 2%: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 2%: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 2%: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.

TR 855 Intermodal Facilities: Operations and Management 2%:0:0:3

This course offers an introduction and overview of intermodal freight operations and related planning, economic and management issues. The course deals with the physical layout and functional design of intermodal facilities, cargo receiving and delivery operations, storage areas, loading and discharging systems and equipment requirements. The role of information systems and ITS technology in intermodal operations and management is also treated.

INTELLIGENT TRANSPORTATION SYSTEMS

TR 810 Introduction to Intelligent Transportation Systems 2%: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 2%: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 2%: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 Special Topics in Transportation I-IV 2%: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

The Department of Civil Engineering offers a graduate program in Urban Systems Engineering and Management, leading to the Master of Science. The program is currently pending approval from New York State.

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

GENERAL REQUIREMENTS

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, dissertation) are assigned project advisers for each such activity. The project adviser 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 Geotechnics	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



CENTER FOR YOUTH IN ENGINEERING AND SCIENCE (YES CENTER)

Director: Beverly Johnson

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 under-represented in engineering and science, specifically women and minorities. The center directs the following outreach programs: Summer Research Institute, Sci-Tech Summer Enrichment Institute, Ace Mentor Program, College Preview Programs, Introduction to Engineering and BASIS/STRIDE. 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 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.

The institute 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. Students are paid a stipend during this period.

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.

SCI-TECH SUMMER ENRICHMENT INSTITUTE

The Sci-Tech Summer Enrichment Institute gives 10th-grade students educational opportunities in science and mathematics beyond what is normally taught during the academic year, and helps them advance to the next level of study. The six-week program starts in July and ends in August.

The Institute's course work includes:

- Intensive chemistry preparation related to science research
- Intensive mathematics (sequential II) preparation
- Laboratory skills to conduct science experiments
- Computer skills related to science, mathematics and technology
- Writing skills

Critical-thinking and problem-solving skills

- Field trips to science museums and research institutions
- Presentations by guest speakers on science and technology-related careers
- Preliminary SAT and college preparation

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.

INTRODUCTION TO ENGINEERING

EG 101 Introduction to Engineering is designed for 9th- and 10th-grade students interested in engineering. EG 101 examines what engineers do, the tools and technology they use to accomplish their projects, the engineering design process and the design and construction skills needed. The course also teaches students to work in teams, improve writing and public speaking and work with other disciplines.

BASIS/STRIDE (BROOKLYN AND STATEN ISLAND SCHOOLS/SCIENCE TECHNOLOGY & RESEARCH USING INDIVIDUAL DISCOVERY & EXPLORATION)

Created in collaboration with the New York City Board of Education, BASIS/STRIDE sponsors educational and co-curricular activities for 11th- and 12th-grade students to spur their interest in mathematics, science and technology. Students use state-of-the-art resources at Polytechnic and are taught by skilled instructors to solve problems, research effectively and work on independent and group projects. BASIS/STRIDE also sends students on field trips to science and corporate centers for added experience.

By program's end, students submit a finished illustrated or constructed project (model, scrapbook, diagram or drawing) of a scientific or technological concept accompanied by an essay explaining the work. Students receive one high school credit after successfully completing the program.

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.

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

COOPERATIVE EDUCATION PROGRAM

Director: Raina M. Ranaghan

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.

COOPERATIVE EDUCATION PROGRAM

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.

STAFF

BROOKLYN CAMPUS

Raina M. Ranaghan, Director
MS, College of New Rochelle

Robin Ponsolle, Assistant Director
MS, Long Island University

Michele Galella, Cooperative Education Coordinator
MS, Long Island University

Dorothy Adams, Executive Scholars Coordinator
MS, Polytechnic University

JoAnne Davis, Administrative Aide

LONG ISLAND CAMPUS

Raina M. Ranaghan, Director
MS, College of New Rochelle

Martina Higgins, Career Counselor

Dina Kennedy, Administrative Assistant

THE DAVID PACKARD CENTER FOR TECHNOLOGY AND EDUCATIONAL ALLIANCES

Executive Director: Noel N. Kriftcher

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 underrepresented minorities in the use of computers and information-age technology 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 what people discover through publications, multimedia communications, symposia and lectures

COLLEGE AND UNIVERSITY ALLIANCES

Through the Knowledge Workers Educational Alliance, a consortium of six 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 upper-classmen, 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 and management, with more disciplines to be added.

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 hosts a variety of activities on campus that allow 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 Science/Technology Forum; the New York City FIRST! Competition, regional division of a national robotics and design competition for high school students; and the New York City Mathematics, Science and Technology Fair, which qualifies students for the International Science and Engineering Fair.

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.

COMMUNITY ALLIANCES

Through Polytechnic's alliance with United Neighborhood Houses Inc., the University works with New York City's various settlement houses, serving economically disadvantaged populations, to introduce young people to new communications technologies. Select Polytechnic students receive paid internships to serve in settlement houses and work with children, giving them access to the Internet and e-mail, developing their research and writing skills and helping them explore their college and career choices.

The University also works closely with Brooklyn Technical High School to help the high school modernize its engineering curriculum and adopt Polytechnic's unique Introduction to Engineering course to a high school instruction program. The program, called the Brooklyn-Technical Education Partnership, is funded by a grant from Lucent Technologies and is overseen by the Packard Center, in association with the high school's alumni organization.

STAFF

Noel N. Kriftcher, Co-Executive Director
EdD, Hofstra University

Ana Martinez, Co-Director, New York City FIRST!
MPhil, New York University

Everton Barrett, Coordinator, Special Events
MS, New York University

Zaina Mohammed, Administrative Coordinator

HIGHER EDUCATION OPPORTUNITY PROGRAM (HEOP)

Director: Teresina Tam

The Higher Education Opportunity Program (HEOP) is a New York State-funded program. It provides 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. HEOP gives students academic support, counseling and financial aid. HEOP's goal is to retain and graduate students for careers in engineering and technology, areas that are traditionally underrepresented, as well as the liberal studies.

ADMISSION AND APPLICATION PROCEDURES

To qualify for HEOP, students must live in New York State and demonstrate both academic and economic needs. Students must complete a regular application for admission into Polytechnic and indicate on the form their interest in HEOP. An admissions counselor may also refer students to HEOP. Economic eligibility is determined on the basis of income guidelines issued by the New York State Education Department.

Because SAT scores may not thoroughly reflect students' potential for success at Polytechnic, a personal interview is required once economic eligibility is established. During the interview, a counselor will discuss with applicants their academic strengths and background and explain what to expect at Polytechnic. In addition, students must take a math skills assessment test.

HEOP students come from the public and private high schools in New York City and Long Island. To learn more about HEOP, students should call 718/260-3370 or visit www.poly.edu/heop.

TRANSFERS

Students transferring to Polytechnic and wishing to enroll in HEOP must have been in a similar program (HEOP, EOP, SEEK, etc.) at their previous school. Applicants must complete the regular transfer application, obtained from the Office of Admissions. Transfer applicants are reviewed based on individual circumstances, reasons for transferring and program-space availability. The HEOP director reviews the college transcript(s) and recommendations from counselors or professors before sending a recommendation to the Office of Admissions.

ACADEMIC SUPPORT SERVICES

HEOP provides the following academic support services:

- A pre-freshmen summer program, comprising courses in Study Skills, pre-calculus, chemistry, physics and reading/writing
- Exam review sessions
- Individual and group tutoring sessions
- University major/career assessment

COUNSELING

HEOP offers students one-on-one personal, academic, financial and career counseling. Students attend group and individual counseling sessions to help them adjust to college life, and receive continued support throughout their time at Polytechnic.

FINANCIAL AID

HEOP covers a significant portion of eligible students' educational expenses. It is important that students complete, early on, a Free Application for Student Aid (FAFSA) and a Tuition Assistance Program (TAP) application to enable the University to determine their financial need. They are also required to supplement their financial aid packages with minimal student loans.

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

Examines students' expectations and survival skills, note-taking and textbook use and goals and career objectives.

MA 000 Pre-College Math

6:0:NC

Reviews trigonometry, quadratic and absolute value questions and inequalities, limits and differentiation of both algebraic and trigonometric functions.

PH 000 Pre-College Physics

6:0:NC

Covers one-dimensional motion, vectors, two-dimensional motion, Newton's Force Laws, work and energy, momentum, rotations and static equilibrium.

STAFF

Teresina Tam, Director
MS, Wilfrid Laurier University

Jacqueline Bell, Associate Director
MS, State University of New York at Albany

Tara Fitzgerald, Counselor
BS, College of Staten Island

Bonnie Harper, Administrative Aide

PHYSICAL EDUCATION AND ATHLETICS

Director: Maureen Braziel

The Office of Physical Education and Athletics 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 hench 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 scholar-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), ECAC (Eastern Collegiate Athletic Conference), NECVA (North Eastern Collegiate Volleyball Association), the Hudson Valley Conference and the USJI (United States Judo Inc.). The University fields the following men's teams: basketball, baseball, soccer, volleyball, tennis, judo, cross country and indoor and outdoor track. Women's teams include basketball, volleyball, judo, cross country, softball, tennis and indoor and outdoor track.

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, the 3.2-mile run and table tennis. New sports are offered if there is sufficient interest.

COURSES

PE 105A Martial Arts—Judo/Beginner and Advanced

All aspects of Sport Judo from beginner to advanced. Conditioning, drills, mat work, standing techniques and contest rules. Class is offered for recreation or to train for competitions in local tournaments. Students are encouraged to test and advance rank.

PE 105B Martial Arts—Tae Kwon Do/Beginner and Advanced

Taught as a traditional martial art. Lessons include patterns, basic striking and blocking techniques, calisthenics, light sparring, self-defense releases and throws. Students are encouraged to test and advance rank.

PE 106 Aerobics

Basic aerobic steps and conditioning to music. Class consists of warm-up, stretching and low impact aerobics. Floor exercises focus on stomach, legs and buttocks muscles. Strengthening exercises with light weights.

LOCATIONS

BROOKLYN CAMPUS

Fitness Center. Located in basement of Goldsmith Student Activities Union/Wunsch Hall. A variety of exercise equipment is available with extended hours of operation to accommodate student schedules. Equipment includes treadmills, step-pers, bikes and rowing machines for cardiovascular work. Strength equipment includes both single and dual weight machines and free weights, including barbells and dumbbells.

Brooklyn Friends Gym: Located at 375 Pearl Street (one block from campus). Two gyms are available for recreation in the evenings, Monday–Thursday from 7-10 PM.

LONG ISLAND CAMPUS

Gymnasium on campus, with fitness center and game room.

STAFF

Maureen Braziel, Director of Physical Education and Athletics
MS, Hunter College

Everton Barrett, Intramural Director

Jean Sporrer, Women's Athletic Recruiter

John Stalze, Sports Information Director

VARSITY COACHING STAFF

Laddy Baldwin, Men's Basketball

Everton Barrett, Men's and Women's Track

James Barrett, Women's Softball

Maureen Braziel, Men's and Women's Judo

Klavdia Kreig, Women's Volleyball

Rocco Morelli, Men's Soccer

David Mugglin, Women's Basketball

Roger Perez, Men's Baseball

Steve Wen, Men's Tennis

James Zeng, Men's Volleyball

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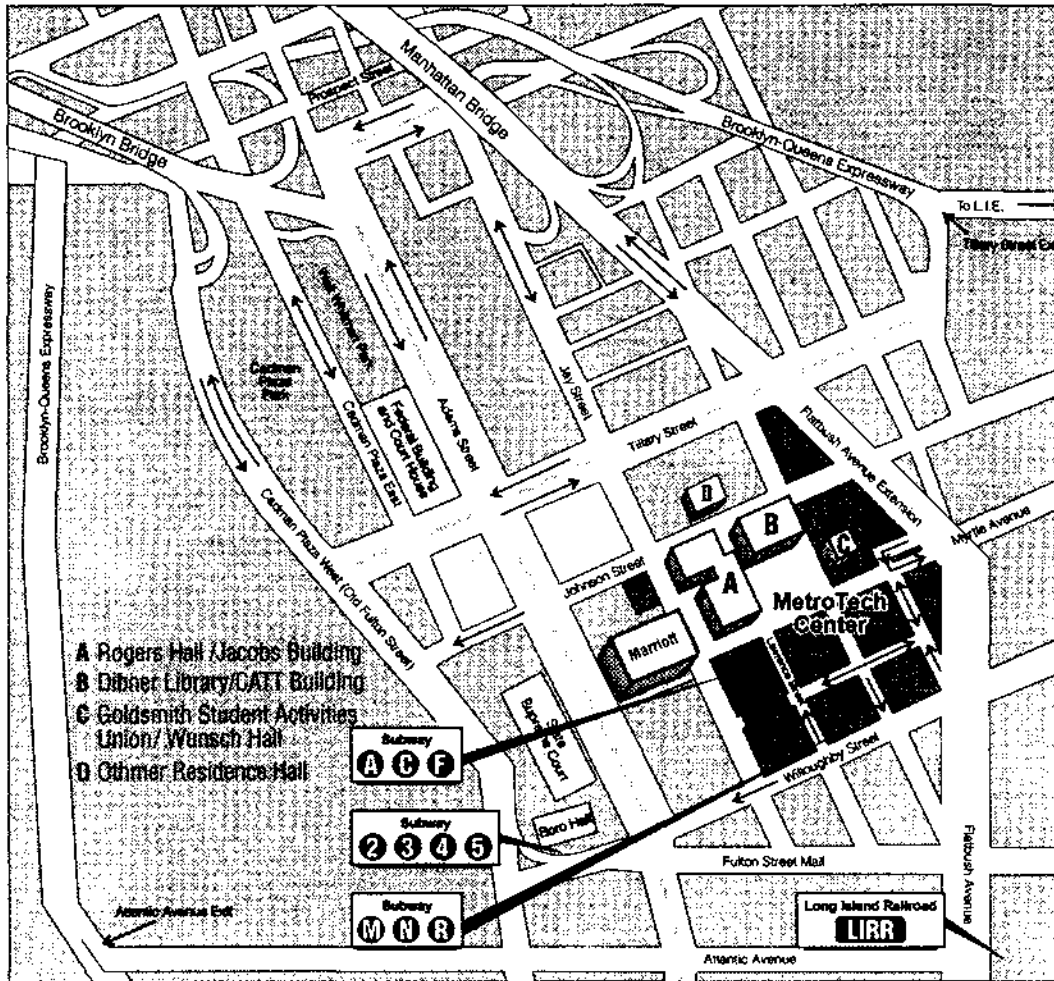
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BROOKLYN CAMPUS



By Subway from all Boroughs

A, C or F train to Jay St.-Borough Hall; or the 2, 3, 4 or 5 subway to Borough Hall (walk to Fulton and make a left onto Jay); or the R or M to Lawrence St.

By Car 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

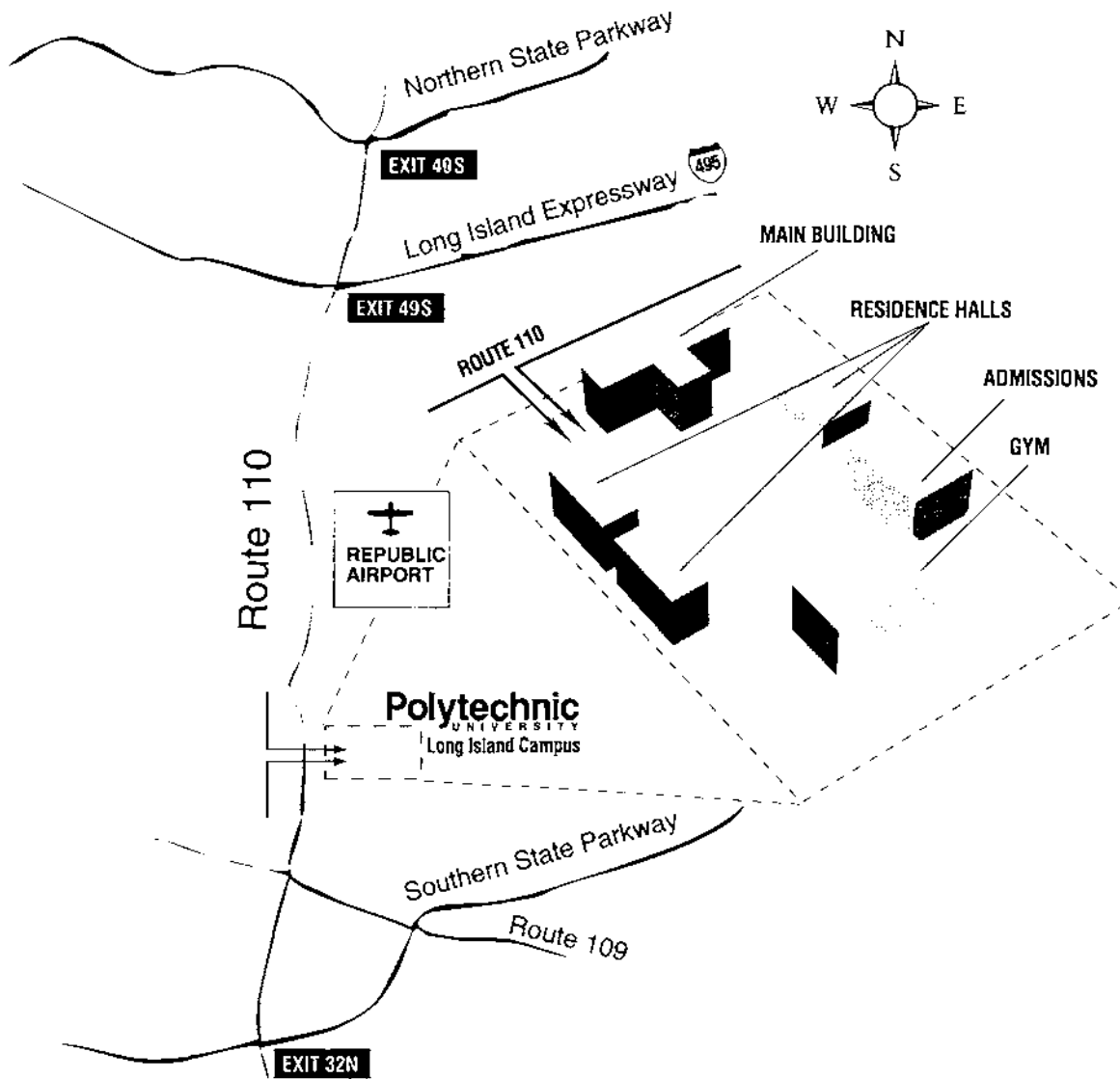
Take Brooklyn-Queens Expwy. to the Tillary St. exit. Go left onto Jay St.

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 on Jay St., across from Polytechnic.

LONG ISLAND CAMPUS AT FARMINGDALE



From New York City

By Train—Take the Long Island Rail Road (LIRR) to the Amityville station—taxi or buses available.

By Car—Take the Long Island Expressway to Exit 49S. Go south on Route 110 four miles to campus on left. Or, Northern State Parkway to Exit 40S then south on Route 110 for five miles to campus on left. You can also take Southern State Parkway to Exit 32N, then north on Route 110 for one mile; campus is on the right.

From New Jersey

By Train—Penn Central, or Commuter Lines to Penn Station, the LIRR, as above.

By Car—Same directions as from New York City.

From Westchester

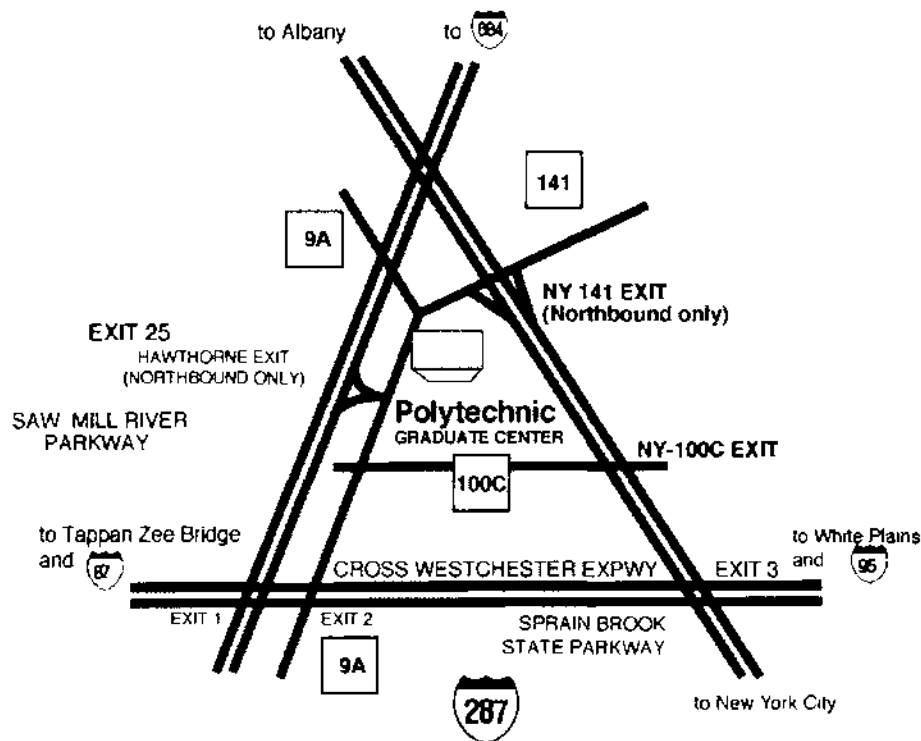
By Train—To Grand Central; take taxi or Shuttle (S) subway train to Penn Station, LIRR as above.

By Car—Whitestone or Throgs Neck Bridge to Cross Island Pkwy. (South) to Long Island Expressway East or Northern State Parkway East (then same as from NYC).

From Eastern Long Island

By Car—Long Island Expressway to Exit 49S which is Route 110; the campus is four miles on the left. Or, take Southern State Parkway to 32 North (Route 110) for one mile; campus is on the right.

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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