Universidad Politécnica de Puerto Rico

GRADUATE CATALOG

Academic Years 2012-13 to 2013-14

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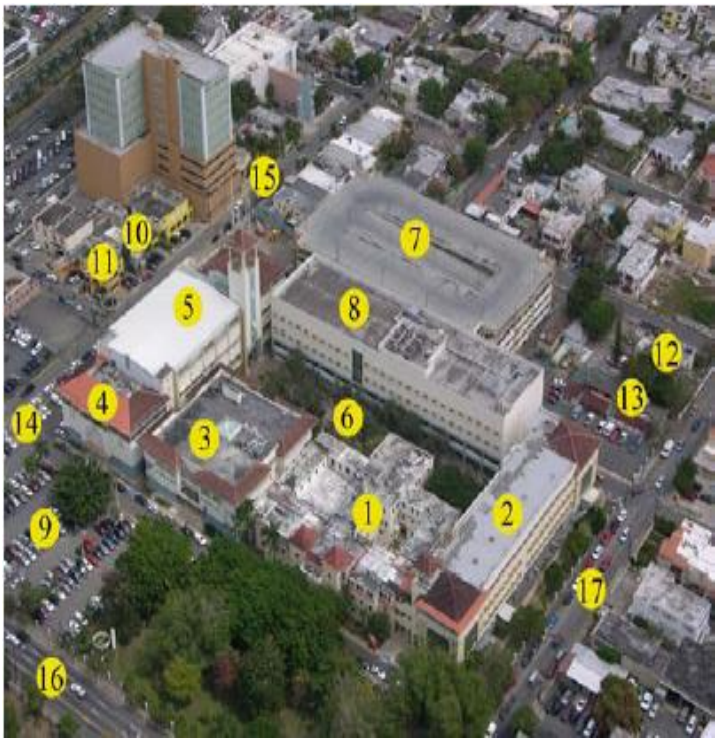

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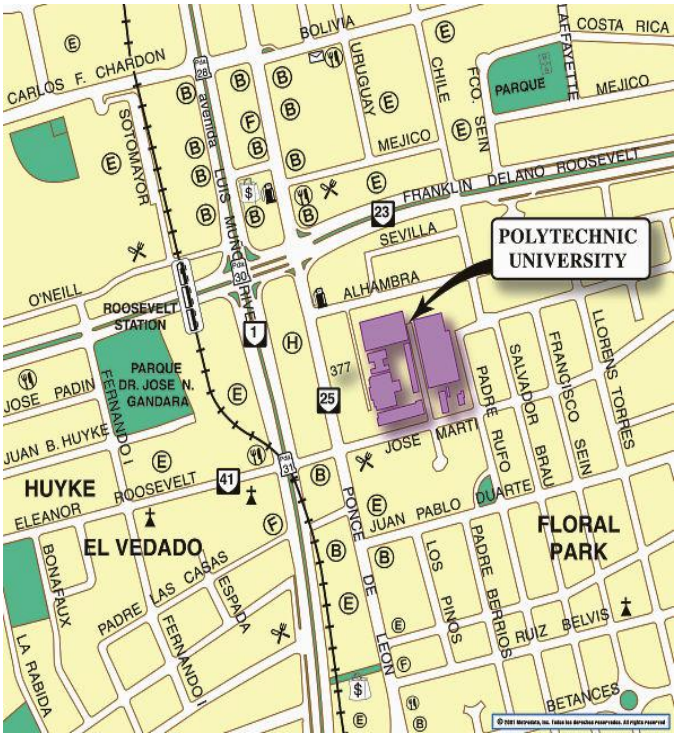

III. ACADEMIC CALENDAR

Academic Year 2008-09 to 2013-2014

TERM	STARTING DATE	LAST DATE
FA/08	August 4, 2008	October 25, 2008
WI/08	November 10, 2008	February 14, 2009
SP/09	March 2, 2009	May 23, 2009
SU/09	June 8, 2009	July 18, 2009
FA/09	August 3, 2009	October 24, 2009
WI/09	November 9, 2009	February 20, 2009
SP/10	March 8, 2010	May 20, 2010
SU/10	June 14, 2010	July 24, 2010
FA/10	August 9, 2010	October 30, 2010
WI/10	November 15, 2010	February 19,2011
SP/11	March 7, 2011	May 28, 2011
SU/11	June 13, 2011	July 23, 2011
FA/11	August 8, 2011	October 29, 2011
WI/11	November 21, 2011	February 21, 2012
SP/12	March 12, 2012	May 26, 2012
SU/12	June 11, 2012	July 21, 2012
FA/12	August 6, 2012	October 27, 2012
WI/12	November 12, 2012	February 16, 2013
SP/13	March4, 2013	May 25, 2013
SU/13	June 10, 2013	July 20, 2013
FA/13	August 5, 2013	October 26, 2013
WI/13	November 18, 2013	February 22, 2014
SP/14	March 10, 2014	May 31, 2104
SU/13	June 9, 2014	July 19, 2014

ACTIVITIES ON THE ACADEMIC CALENDAR

1) Admissions Deadline:
Two weeks before the beginning of the academic term. Deadlines for submission of materials may vary by program. Submission of Late applications require the authorization of the Graduate Affairs Office Supervisor.

2) Orientation and Pre-Registration of New Graduate Students:
Saturday prior to the beginning of the regular registration period.

3) Regular Registration Period:
One week prior to the beginning of the term.

4) Beginning of the Term (Monday):
Classes begin on the Monday after the week of registration. Three credit-hour graduate courses meet once a week with a duration of 4 hours per session for a twelve week period, equivalent to three semester credit-hours.

Courses during the summer term meet twice a week with a duration of 4 hours per session for a six week period.

5) Deadline for Late Registration and Course Changes:
Friday of the first week of each term.

6) Deadline for Completing Pending Projects and to Remove Incomplete Grades:
Eleven (11) weeks after the end of the preceding term are allowed for this purpose (tenth week of the current term).

7) Deadline for the First Partial Examination:
The fourth week of each term (first third of the term).

8) Deadline for the Second Partial Examination:
The eighth week of each term (second third of the term).

9) Deadline for Partial or Total Withdrawal:
Students may withdraw totally or partially until the tenth week of the current term, and receive a grade of "W".

10) Period of Early Registration:
Eleventh week of the current term.

11) Regular Registration Period:
The registration period will be held in the recess period between terms. Active students will be notified in advance of their registration day.

IV. BOARD OF TRUSTEES

Ricardo Jaén Presno, M.D.**, Chairman**
Vice Chairman and Treasurer
Vanessa M. Mullet Sánchez, B.A., J.D., **Secretary**
Francisco Martínez Ubarri, B.S., **Trustee**
Luis E. González Cognet, **Trustee**
Luis Fullana Morales, B.S., **Trustee**
Irving A. Jiménez Juarbe, B.A., M.S.W., J. D. Esq.,
Ernesto Vázquez Barquet, B.B.A., M.B.A., **Ex Officio**

V. INFORMATION DIRECTORY

Mailing Address: P.O. Box 192017
San Juan, Puerto Rico 00919-2017
Street Address: 377 Ponce de León Avenue
San Juan, Puerto Rico 00918
University Switchboard: (787) 754-8000 / (787) 622-8000
Fax (787) 763-8919- Office of the President
Fax (787) 281-8342- School of Engineering
Fax (787) 767-0607- School of Architecture
Fax (787) 754-5931- Dean of Arts and Science
Fax (787) 764-8712- Admissions and Recruitment Office
Fax (787) 756-8647- Department of Science and Math.
Fax (787) 767-2921- Department of Scientific Research
Fax (787) 758-1334- Vice President – Enrollment Management and Student Services
Fax (787) 766-1163- Financial Aid Office
Fax (787) 763-3028- Library
Fax (787) 763-8275- Collector's Office
Fax (787) 753-4465- Accounting
Fax (787) 274-8562- COOP Program
Fax (787) 754-8450- University Progress Center
Fax (787) 753-6569- Human Resources
Fax (787) 764-1902- Registrar's Office
Fax (787) 754-8268- Planning and Development
Fax (787) 758-3383- Student Integrated Service Center
Fax (787) 756-7274- School of Management and Entrepreneurship
Fax (787) 758-7933- Graduate School
Fax (787) 763-6867- Security
Fax (787) 771-0013- Geomatic Sciences
Fax (787) 773-0098- Civil Engineering
Fax (787) 765-9207- Industrial Engineering
Fax (787) 771-0011- Mechanical Engineering
Fax (787) 771-0010- Chemical Engineering
Fax (787) 281-8342- Electrical Engineering
Fax (787) 758-3522- Alumni
Fax (787) 753-1675- Informatics
Fax (787) 754-8520- Educational Services
Fax (787) 751-0545- General Services
Fax (787) 766-4925- Physician
Fax (787) 250-8131- UPADI
Fax (787) 756-8647- Socio-Humanistic
Fax (787) 625-0415- Retention Management
Fax (787) 625-0414- Distance Learning
Fax (787) 294-1816- Continuing Education Center
Fax (787) 771-0012- Compliance: Heath Safety and Environmental
Fax (787) 625-0414- Dean for Academic Support
Fax (787) 754-8821- Purchasing
Fax (305) 418-4325- Miami Campus
Fax (407) 677-5082- Orlando Campus
Internet Home Page: http://www.pupr.edu
Graduate School Home Page: http://www.pupr.edu/gs

VI. ADMINISTRATIVE OFFICIALS

President
Ernesto Vázquez Barquet, BA, MBA
Vice President for Academic Affairs
Miguel A. Riestra, BA, MA, Ph.D.
Vice President for Administration and Finance
Ernesto Vázquez Martínez, BSIE, MBA
Vice President for Enrollment Management and Student Services
Carlos Pérez, BA, MBA
Associate Vice President for Enrollment Management and Student Services
Elsa Zayas, BA, MA
Associate Vice President for Federal and State Grant Funds Administration
Olga C. de Torres, BBA
Dean of Graduate School
Miriam Pabón, BSIE, MEM, Ph.D., PE
Dean of School of Engineering and Geomatic Sciences
Carlos González Miranda, BSIE, MSIE, Ph.D.
Dean of School of Management and Entrepreneurship
José Orlando Rivera; BSIE, MSEM, Ph.D. (Candidate)
Dean of School of Architecture
Carlos Betancourt Llambías, BArch., MArch.
Dean of Arts and Sciences
Catalina Vicéns, BA, MA, Ph.D.
Associate Dean of Engineering and Geomatic Science
Cuauhtémoc Godoy, BSIE, MS Ed., PE
Director, Plasma Laboratory
Ángel González, BSEE, MEE, Ph.D.
Civil and Environmental Engineering Department Head
José Borrageros, BSCE, MSCE, PE
Electrical and Computer Engineering and Computer Science Department Head
Othoniel Rodríguez Jiménez, BSEE, MSEE, CS, Ph.D., PE
Industrial Engineering Department Head (Acting)
Cuauhtemoc Godoy, BSIE, MS Ed., PE
Mechanical Engineering Department Head
Héctor M. Rodríguez Dávila, BSCE, MBA, Ph.D., PE
Chemical Engineering Department Head
Elba Herrera, BSChE, MSChE
Geomatic Sciences Department Head
Marisol Rodríguez, BS, MS
Mathematics and Sciences Department Head
Horacio García Correa, BSEE, MEM
Socio-Humanistic Deparment
Virginia Dessús, BA, MA, Ph.D.
Landscape Architecture Graduate School Director
Marisabel Rodríguez, BA, MLA
Business Administration Department Head
Edwin Dávila Aponte, BBA, MBA, Ph.D.
Library Director
Mirta Colón, BA, MLS
Registrar
Mayra López, BA, MA
Financial Aid Office Administrator
Sergio Villoldo, B.B.A, M.B.A.
Sponsored Research Office
Angel González, BSEE, MSEE, Ph.D.
Honor Program
Wilfredo Torres, BSEE, MEM
Cooperative Education Program
Angie Escalante, BASW, MBA
Faculty Development Coordinator
Heyda Delgado, BA, MA Ed.
Recruitment and Admissions
Teresa Cardona, BBA
Undergraduate Integrated Services Office (CESI) Supervisor
William Peña
Office of Graduate Affairs
Iliciana Cruz
Institutional Advancement
Lourdes Alcrudo, BBA
Outcomes Assessment
Vacant
Student Activities and Sport and Recreation
Roberto Medina
Planning and Institutional Research
Miguel A. Riestra, BA, MA, Ph.D.
Human Resources
Ana E. Castellano, BBA, MBA
Information Technology
Pedro Pérez, MIS
Student Support Services
José L. Mojica
Director Guidance and Counseling
Claribel Díaz
Legal Counselor
Irving A. Jiménez Juarbe, BA, MSW, Esq.
Security Office
Miguel Albarrán
Director Center for Distance Education
Heyda Delgado, BA, MA.Ed.

VII. GENERAL INFORMATION

BRIEF HISTORY

Polytechnic University of Puerto Rico (P.U.P.R.) is a private, non-profit, coeducational, nonsectarian institution founded in 1966. At present it is the largest private Engineering School and the only one in, San Juan, Capital of Puerto Rico. It is also the largest private Hispanic Serving Engineering School in the United States and its territories. PUPR offers the following programs at the graduate level, listed in the order they were created.

LICENSING AND ACCREDITATION

A. The Council of Higher Education of Puerto Rico (CHE-PR)

MASTER PROGRAMS

- Master in Engineering Management (1992)
- MBA in International Enterprises (1997)

- MBA in Management of Technology (1997) **postponed (2001)**
- MBA (General Interdisciplinary) (1997)
- MBA in Computer Information Systems (E-Commerce & Data Base) (1997)
- Master in Environmental Management (1988)
- Master of Science in Manufacturing Engineering (1988)
- Master of Science in Manufacturing Competitiveness (1988)
- Master of Science in Civil Engineering (1998)
- Master in Manufacturing Competitiveness (1998)
- Master of Engineering in Civil Engineering (1998)
- Master of Science in Electrical Engineering (2002)
- Master of Engineering in Electrical Engineering (2002)
- Master of Science in Computer Engineering (2004)
- Master of Engineering in Computer Engineering (2004)
- Master of Science in Computer Science (2005)
- Master in Landscape Architecture (2006)
- MS in Civil Engineering with Specialization in Structures (Sept. 2009)
- MS in Civil Engineering with Specialization in Geotechnology (Sept. 2009)
- MS in Civil Engineering with Specialization in Water Resources (Sept. 2009)
- Master of Engineering in Civil Engineering in Structures (Sept. 2009)
- Master of Engineering in Civil Engineering in Geotechnology (Sept. 2009)
- Master of Engineering in Civil Engineering in Water Resources (Sept. 2009)
- Master of Engineering in Civil Engineering in Water Treatment (Sept. 2009)
- MS in Computer Engineering with Specialization in Internet Engineering (Sept. 2009)
- MS in Computer Engineering with Specialization in Software Engineering (Sept. 2009)
- MS in Computer Engineering with Specialization in Digital Signal Processing (Sept. 2009)
- Master of Engineering in Computer Engineering with Specialization in Software Engineering (Sept. 2009)
- Master of Engineering in Computer Engineering with Specialization in Internet Engineering
- Master of Engineering in Computer Engineering with Specialization in Digital Signal Processing (Sept. 2009)
- MS in Computer Science with Specialization in IT Management and Information Assurance (Sept. 2009)
- MS in Computer Science with Specialization in Knowledge Discovery and Data Mining (Sept. 2009)
- MS in computer Science with Specialization in Computer Graphics and Game Technology (Sept. 2009)
- Master in Computer Science with Specialization in IT Management and Information Assurance (Sept. 2009)
- Master in Computer Science with Specialization in Knowledge Discovery and Data Mining (Sept. 2009)
- Master in Computer Science with Specialization in Computer Graphics and Game Technology (Sept. 2009)
- MS in Electrical Engineering in Communication Systems (Sept. 2009)
- MS in Electrical Engineering in Digital Signal Processing (Sept. 2009)
- Master of Engineering in Electrical Engineering in Communication Systems (Sept. 2009)
- Master of Engineering in Electrical Engineering in Digital Signal Processing (Sept. 2009)
- MS in Manufacturing Engineering with Specialization in Industrial Automation (Sept. 2009)
- MS in Manufacturing Engineering with Specialization in Pharmaceutical Processes (Sept. 2009)
- MS in Manufacturing Engineering with Specialization in Quality Management (Sept. 2009)
- Master of Engineering in Manufacturing Engineering with Specialization in Industrial Automation (Sept. 2009)
- Master Engineering in Manufacturing Engineering with Specialization in Pharmaceutical Processes (Sept. 2009)
- Master of Engineering in Manufacturing Engineering with Specialization in Quality Management (Sept. 2009)
- Master in Manufacturing in Manufacturing Engineering with Specialization in Industrial Automation (Sept. 2009)
- Master Engineering in Manufacturing Engineering with Specialization in Pharmaceutical Processes (Sept. 2009)
- Master of Engineering in Manufacturing Engineering with Specialization in Quality Management (Sept. 2009)
- Master in Manufacturing Competitiveness with Specialization in Pharmaceutical Processes (Sept. 2009)
- Master in Manufacturing Competitiveness with Specialization in Quality Management (Sept. 2009)
- Master of Engineering in Mechanical Engineering with Specialization in Aerospace (2009)
- Master in Geospatial Science and Technology

ONLINE PROGRAMS

• Master of Engineering Management	Sept., 2002
• MS in Manufacturing Engineering	Sept., 2002
• MS in Manufacturing Competitiveness	Sept., 2002
• Master of Engineering in Manufacturing Engineering	Sept., 2002
• Master in Manufacturing Competitiveness	Sept., 2002
• MBA in Computer Information System	Sept., 2002

Most Recent Date of License Renewal

• MBA in Computer Information Systems (E-Commerce & Data Base)	Sept. 2009
• MBA (General and Interdisciplinary)	Sept. 2009
• MBA (International Enterprises)	Sept. 2009
• MBA Management of Technology (postponed)	Dec. 2001
• Master in Computer Science	Sept. 2009
• Master in Engineering Management	Sept. 2009
• Master in Environmental Management	Feb. 1998
• Master in Landscape Architecture	Sept. 2009
• Master in Manufacturing Competitiveness	June, 2001
• Master of Engineering in Civil Engineering	June, 2001
• Master of Engineering in Computer Engineering	Sept. 2009
• Master of Engineering in Electrical Engineering	Sept. 2009

- Master of Engineering in Manufacturing Engineering Sept. 209
- MS in Civil Engineering Sept. 2009
- MS in Computer Engineering Sept. 2009
- MS in Computer Sciences Sept. 2009
- MS in Electrical Engineering Sept. 2009
- MS in Manufacturing Competitiveness Sept. 2009
- MS in Manufacturing Engineering Sept. 2009
- MS in Civil Engineering with Specialization in Structures Sept. 2009
- MS in Civil Engineering with Specialization in Geotechnology Sept. 2009
- MS in Civil Engineering with Specialization in Water Resources Sept. 2009
- MS in Civil Engineering with Specialization in Water Treatment Sept. 2009
- Master of Engineering in Civil Engineering in Structures Sept. 2009
- Master of Engineering in Civil Engineering in Geotechnology Sept. 2009
- Master of Engineering in Civil Engineering in Water Resources Sept. 2009
- Master of Engineering in Civil Engineering Water Treatment Sept. 2009
- MS in Computer Engineering with Specialization in Internet Engineering Sept. 2009
- MS in Computer Engineering with Specialization in Software Engineering Sept. 2009
- MS in Computer Engineering with Specialization in Digital Signal Processing Sept. 2009
- Master of Engineering in Computer Engineering with Specialization in Software Engineering Sept. 2009
- Master of Engineering in Computer Engineering with Specialization in Internet Engineering Sept. 2009
- Master of Engineering in Computer Engineering with Specialization in Digital Signal Processing Sept. 2009
- MS in Computer Science with Specialization in IT Management and Information Assurance Sept. 2009
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- Master in Computer Science with Specialization in IT Management and Information Assurance Sept. 2009
- Master in Computer Science with Specialization in Knowledge Discovery and Data Mining Sept. 2009
- Master in Computer Science with Specialization in Computer Graphics and Game Technology Sept. 2009
- MS in Electrical Engineering in Communication Systems Sept. 2009
- MS in Electrical Engineering in Digital Signal Processing Sept. 2009
- Master of Engineering in Electrical Engineering in Communication Sept. 2009
- Master of Engineering in Electrical Engineering in Digital Signal Processing Sept. 2009
- MS in Manufacturing Engineering with Specialization in Industrial Automation Sept. 2009
- MS in Manufacturing Engineering with Specialization in Pharmaceutical Processes Sept. 2009
- MS in Manufacturing Engineering with Specialization in Quality Management Sept. 2009
- Master of Engineering in Manufacturing Engineering with Specialization in Industrial Automation Sept. 2009
- Master Engineering in Manufacturing Engineering with Specialization in Pharmaceutical Processes Sept. 2009
- Master of Engineering in Manufacturing Engineering with Specialization in Quality Management Sept. 2009
- Master in Manufacturing in Manufacturing Engineering with Specialization in Industrial Automation Sept. 2009
- Master Engineering in Manufacturing Engineering with Specialization in Pharmaceutical Processes Sept. 2009
- Master of Engineering in Manufacturing Engineering with Specialization in Quality Management Sept. 2009
- Master in Manufacturing Competitiveness with Specialization in Pharmaceutical Processes Sept. 2009
- Master in Manufacturing Competitiveness with Specialization in Quality Management Sept. 2009
- Master of Engineering in Mechanical Engineering with Specialization in Aerospace Sept. 2009

ONLINE PROGRAMS

- Master of Engineering Management Sept., 2009
- MS in Manufacturing Engineering Sept. 2009
- MS in Manufacturing Competitiveness Sept. 2009
- Master of Engineering in Manufacturing Engineering
- Master in Manufacturing Competitiveness Sept. 2009
- MBA in Computer Information Systems Sept. 2009

B. Middle States Association of Colleges and Schools (MSACS)

3624 Market St.
Philadelphia, PA 19104-2680
(215) 662-5606
(215) 662-5501 (Fax)

In 2005, the Commission on Higher Education of MSACS extended the accreditation to the institution.

C. Accreditation Board for Engineering and Technology (ABET)

The following Bachelor of Science programs are accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: (410) 347-7700:

- Civil Engineering
- Industrial Engineering
- Electrical Engineering
- Mechanical Engineering
- Environmental Engineering
- Chemical Engineering
- Computer Engineering

D. The following program was accredited by the Applied Science Accreditation Commission of ABET, 111 Market Place Suite 1050, Baltimore, MD 21202-4012. Telephone: (404) 347-7700

- Land Surveying and Mapping (BS)

E. National Architectural Accrediting Board (NAAB)

1735 New York Avenue, NW,
Washington, DC 20006
(202) 783-2007
(202) 783-2822
info@naab.org

In year 2009, NAAB extended accreditation to the School of Architecture .

F. International Assembly for Collegiate Business Education (IACBE)

11374 Strang Line Road
Lenexa, KS 66215 USA
(913) 631-3009
iacbe@iacbe.org

In April, 2006 IACBE accredited the School of Management and Entrepreneurship.

Academic Alliances

Currently, PUPR has academic alliances with the following universities:

a. Instituto Nacional Tecnológico de Santo Domingo (INTEC)
Ave. Los Próceres, Calle Gala,
Postal 342-9 y 249-2, Santo Domingo

b. Fundación Ciudad del Saber
Clayton, Ancón
Ciudad de Panamá

MISSION, VISION AND GOALS

Mission

As an institution of higher education, Polytechnic University of Puerto Rico provides opportunities for individuals from diverse backgrounds in different locations using multiple methods of delivery to cultivate their potential for leadership, productivity and competitiveness with the purpose of providing greater social responsibility toward their communities, through exposure to intellectual, humanistic and technological advancement.

Vision

To be recognized as the leading Hispanic Serving Institution in multiple fields of study, meeting societal and industrial standards in general, in association with public and private enterprise; characterized by an emphatic relationship between faculty and students, and with a culture of client-oriented quality service, empowerment and teamwork. Polytechnic University of Puerto Rico reflects the meeting of the two pervasive cultures of the Americas, thus it is well positioned to interact with the Hispanic and the Anglo worlds inside and outside its geographical borders by providing a cultural and linguistic intermediary link.

Goals

- To contribute to the socio-economic development of Puerto Rico through the formation of well rounded and educated engineers, architects, surveyors, and business managers.
- To provide access to higher education to additional segments of our population other than traditional high school graduates.
- To provide students with the capability to continue graduate education.
- To foster the linkage between PUPR and industry, government, commerce and professional associations.
- To utilize the latest technology to provide, facilitate and manage PUPR's educational offerings.
- To develop in students a profound ethical commitment and a sense of professional competence and social responsibility.
- To promote the linkage among the university and its communities.
- To foster and promote an applied research culture.
- To develop critical thinking and a scientific approach in the analysis and solutions of professional and social problems.
- To promote the dissemination of knowledge through the teaching-learning process and publications.
- To achieve long-term sustainable growth in financial resources.
- To enhance cultural diversity outside PUPR's geographical border.

GRADUATE SCHOOL MISSION STATEMENT

The mission of the Graduate School (GS) is to promote and encourage excellence in graduate education for the students. To accomplish this mission, the GS values integrity, collaboration, efficiency, innovation, and inclusiveness in all that it does. These values are central to the GS's role in encouraging a creative environment for scholarship and research, teaching and learning. The GS develops new concepts and best practices for graduate education, and supports other schools within the Institution in their graduate initiatives and emerging programs. It aims to guarantee that all graduate students regardless of ethnicity, gender, or other individual characteristics are afforded the opportunity to achieve their full potential as professionals.

The Graduate Dean, in collaboration with academic and administrative units of the University, exercises overall review and supervision of graduate programs conducted in the several colleges and provides guidance in the development of new programs as well as the maintenance of standards for existing programs. Each college of the University has developed its graduate programs in accordance with the Council of Graduate Schools national professional standards and the standards of their respective fields.

RECOGNITIONS

BOARD OF EXAMINERS OF ENGINEERS, AND SURVEYORS OF PUERTO RICO – Graduates of Civil Engineering, Industrial Engineering, Electrical Engineering, Mechanical Engineering, Environmental Engineering, Chemical Engineering, and Land Surveying and Mapping curricula qualify to take the examinations required for a professional license.

BOARD OF EXAMINERS OF ARCHITECTS AND LANDSCAPE ARCHITECTS – Graduates of Architecture qualify to take the examinations required for a professional license.

BOARD OF EXAMINERS OF CERTIFIED PUBLIC ACCOUNTANTS – Graduates of BBA in Accounting curriculum are admitted to take their qualifying examinations for the professional license.

VETERANS ADMINISTRATION – Veterans and qualified dependents are permitted to study under the provisions of the G.I. Bill of Rights.

BUREAU OF IMMIGRATION AND CITIZENSHIP SERVICES (FORMERLY INS). Foreign students are permitted to study under BCIS/ Department of Homeland Security.

DEPARTMENT OF SOCIAL SERVICES OF PUERTO RICO – Recipients and beneficiaries of Vocational Rehabilitation are permitted to study under the provisions of the corresponding federal legislation.

DEPARTMENT OF EDUCATION OF PUERTO RICO – Veterans' Eligibility Law 13, 1980.

VIII. GENERAL SERVICES AND FACILITIES

PHYSICAL FACILITIES

The Main Campus of Polytechnic University of Puerto Rico is located in the Metropolitan Area of San Juan at 377 Ponce de León Avenue, nearby the financial and economic center of Puerto Rico. The campus consists of nine acres and six buildings housing classrooms, laboratories, academic offices, library, administrative offices, student center, medical services, athletic and other recreational facilities, and a parking building.
PUPR opened branch campuses at the following cities:

a. Polytechnic University of Puerto Rico, Miami
8180 NW 36 St.; Suite 401,
Miami, Florida, USA 33166

b. Polytechnic University of Puerto Rico, Orlando
4800 Howell Branch Rd. Winter Park,
Orlando, Florida, USA, 32792

LIBRARY

The Library is an academic unit with the mission to offer the university community the information services needed to achieve academic excellence and develop leaders with the knowledge and skills that will help them become professional, responsible and successful citizens. This statement is consonant with the university's mission and all library services are directed towards achieving it.

The Library occupies over 40,000 square feet in a three-story building. The collection is specialized in Engineering, Geomatic Sciences, Architecture, Business Administration, and Landscape Architecture to support the academic programs. The collection also includes nearly 100,000 books and serial volumes which are catalogued and searchable through our on-line catalog. The print resources are organized in open stacks according to the Library of Congress Classification System. In order to deliver the best possible combination of traditional and virtual library services, the library has subscribed to thousands of on-line resources including full text electronic books and periodicals. There are wireless access points throughout the library providing laptop access to electronic and online research resources. In addition, remote access is available through the library's website.

Librarians and library staff offer users specialized information assistance and services such as inter-library loans, information literacy, and bibliographic search, among others. There are also scanning, printing and photocopy services. Carrels and rooms for individual or group studying are distributed throughout the three levels of the building. Library hours include weekends and holidays totaling ninety-three hours weekly. In addition, the library sponsors cultural activities and expositions during the year.

CENTER FOR DISTANCE EDUCATION

The Center for Distance Education at the Polytechnic University of Puerto Rico supports through its human and technological resources the academic programs and online courses offered.

This enable the professors, as well as the students to choose at their convenience the way in which they conduct the teaching – learning process, opening a new door of educational opportunities.

The Center for Distance Education, known in Spanish as *Centro de Educación a Distancia* (*CEDUP*); was established in 2001. Its facilities are located in the 3rd floor of the Library Building. Blackboard (Bb) is the educational platform in use. A Distance Learning Education Policy is in effect.

Courses developed through the educational platform have been incrementing since 2001-2002, when 14 online courses were offered during that academic year; today over 400 courses are taught in one of three ways: web enhance, hybrid or totally online.

INFORMATION LITERACY PROGRAM

Information Literacy is a set of abilities or skills requiring individuals to "recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information."

In order to help students develop these skills the program teach them the processes of finding, organizing, using, producing, and distributing information in print, electronically, and in other formats. Students learn about the flow of information in a variety of disciplines, how to be effective at the research process, how to access information in a variety of formats, and how to formulate effective searches on electronic databases and the Internet. Students become familiarized with practical, social, and ethical issues relating to information.

The Information Literacy program is also located in the third floor of Library Building.

EDUCATIONAL TECHNOLOGY CENTER

The Educational Technology Center (ETC) constitutes the academic computing center. It offers the following services:

1. Provides computer services to the student body and faculty to assist them in the performance of their academic endeavors and projects.
2. Provides training to the Faculty and administrative personnel on computer use.
3. Offers seminars to students about specific software.
4. Offers computer services to the different academic departments as requested.

The ETC is organized in six areas

1. Engineering Graphics Laboratory for computer assisted design.
2. AutoCAD Laboratory for multiple purposes and the use of the latest versions of AutoCAD.
3. Main Computer Area - Laboratory for all the latest Engineering Applications.
4. Computer Classrooms for the different engineering courses.
5. Classroom for the training of students, Faculty and administration.
6. Internet Room- Continuous access to Internet by students. All computers are connected through Ethernet wire scheme using Novell NetWare. The Center provides the latest technology in the industry today.

CONTINUING EDUCATION

The Continuing Education is oriented towards serving the needs of all the Alumni, specially the professional engineers and surveyors. Given the reality of our industrialized society and rapid technological advances, this program provides the resources necessary for renewal of licenses for working professionals. It offers short term non credit seminars, conferences, symposiums, workshops and courses of a technological nature.

COOPERATIVE EDUCATION PROGRAM AND PLACEMENT OFFICE

The Placement Office has the mission to help our students to obtain a professional experience (Temporary or Regular Contract) related to their academic area.

The participants should meet the following requirements:

1. Active students of Polytechnic University of Puerto Rico (third, fourth or fifth year student) or Ex – Alumni.
2. Fill Program Application Form
3. Add the resume to the Application Form (English).
4. Present US citizenship or Visa documentations.
5. Participate in employer's interviews.

IX. STUDENT INFORMATION AND SERVICES

The Graduate School Deanship coordinates a major portion of the services that Polytechnic University of Puerto Rico offers to its graduate students.

OFFICE OF GRADUATE AFFAIRS

The Office of Graduate Affairs offers admission, registration, collection and student financial aid guidance services.

This office is an administrative unit within the Graduate School Deanship. The Deanship is responsible for the facilitation of graduate studies at the Polytechnic University of Puerto Rico. It is the responsibility of the Graduate Affairs Office to see that all pertinent administrative regulations are followed and that proper guidance relative to this topic is provided to all the academic units that offer graduate programs.

For easy access, the Office is located in Alhambra Street #51. Office hours are: Mondays through Thursdays from 8:00am to 8:00pm, Fridays from 8:00am to 12:00 noon and from 1:00pm to 3:00pm, and Saturdays from 8:00am to 12:00 noon. These office hours satisfy the needs of our evening, and Saturday students.

STUDENT ACTIVITIES OFFICE

The Student Activities Office offers the opportunity to participate in organized recreational and sports activities.

The Students Center offers the opportunity to engage in leisure activities such as billiards, dominoes, chess, table tennis, TV Room Area with Cable TV video system and others.

In the sports area, PUPR has an indoor basketball and volleyball court. The institution participates in the Inter-University Sports Organization, the interuniversity league. PUPR participates in several sports such as: Softball (female), Baseball (male), Basketball, Volleyball, Beach Volleyball, Weight Lifting, Tae Kwon Do, Track and Field and Cross Country. There are male and female teams participating in all these sports. In addition PUPR has a male Indoor Soccer team.

In the Intramural Program students, faculty and administration have the opportunity to share in recreational activities and organized sports tournaments such as: Basketball, Volleyball, Dominoes, Billiard and Tennis, Table Tennis, Chess, Softball, and many others.

HEALTH SERVICES

The University requires that all students be covered by some type of health service program. Upon registration, the student must show that he/she is subscribed to a health plan. Students who can not prove that they are subscribed to a health plan, must register in the health services plan sponsored by the Institution. To register for and receive the services sponsored by the institution, the student must pay the corresponding fee for health services stipulated in the Tuition and Fees section of the Catalog.

The Health Services plan sponsored by the Institution is an individually contracted service plan. The service is not a Health Insurance Plan and as such does not include radiology or laboratory services, or medicines. The health services sponsored by the institution are offered by a physician in his private Office located at José Martí Street adjacent to the University campus. Medical services are rendered Monday through Thursday, 8:00 am to 9:00 pm; and Saturday from 8:00 am to 12 noon.

SECURITY OFFICE

Pursuant to Public Law 101-542 "Student Right to Know and Campus Security Act of 1990, PUPR created the Office of Security. This office is responsible of creating, promoting and maintaining academic and working conditions at the campus free of criminal acts. Pacific coexistence among all the university components is essential to achieve a teaching and learning environment free from all kinds of violence. Such atmosphere will benefit students, faculty members, visitors, suppliers and officials from diverse agencies who participate in our operations.

This kind of environment will be monitored on a continuous basis, without interruption, by a closed circuit television network. Cameras are installed in all the common area corridors of al buildings, entrances, exits, all computer rooms, library, laboratory rooms and campus entrances.

All Students, faculty members and employees are provided with an identification card which is required to gain access to the campus and services.

Services that the Security Offices Provides to the University

- Installation and operation of a 24 hours a day, 7 days a week monitoring system
- Implementation of the vehicle access system to the University Campus
- Implementation of the identification card system for employees and students
- Seminars to the students, employees and visitors about the campus security system
- Coordination of diverse activities with the different offices
- Availability of a Security Handbook or manual
- Publication of the annual Statistical Report about Security Information in the campus
- Providing assistance to the student with his vehicle malfunctioning in the campus
- Providing escorts to students if required

IDENTIFICATION CARD

An identification card is issued to students during the registration period. Students are required to present their identification card to gain access to Polytechnic University of Puerto Rico facilities and services.

X. ADMISSIONS

For admission to graduate studies, a student must have obtained a bachelor's degree prior to enrollment. Degree-seeking applicants may sometimes be admitted conditionally. Admission and/or continued enrollment depends on the satisfactory fulfillment of these conditions.

PUPR admits qualified students without regard to gender, sexual orientation, age, race, color, religion, national or ethnic origin, marital status, veteran status or disability.

Active Status

Active Status requires the student to be registered as a Part-Time or Full-Time student. Student can loose this status due to poor academic performance, failure to register for two terms or failure to complete their degree within established time limits.

GRADUATE STUDENT CLASSIFICATION

Full-Time Degree-Seeking Status – The student who intends to complete a graduate degree on a full-time basis must enroll on a minimum of 6 credit-hours per term. To register for more than six credit-hours the student must seek the approval of the Graduate Program Mentor or the Dean of Graduate School.

Part-time Degree-Seeking Status – The student who intends to complete a graduate degree on part-time basis is enrolled in less than 6 credit-hours per term.

GENERAL ADMISSION REQUIREMENTS AND PROCEDURES

For application forms and program information, write to:

Polytechnic University of Puerto Rico, Graduate Affairs Office, PO Box 192017, San Juan, Puerto Rico 00919-2017. Prospective applicants should indicate their preferred academic area when they inquire about admission. Candidates may apply for admission in any academic term.

All applicants must comply with the following requirements:

1. Fill the Application for Admission.
2. Pay a $50.00 Admission Fee (non-refundable).
3. Submit an official academic transcript directly from the university where the applicant obtained his/her bachelor's degree, and a Graduation Certificate that includes the graduation general grade point average to the Graduate Affairs Office.
4. Submit three (3) letters of recommendation from persons who can attest to the applicant's preparation and ability to perform at a graduate level.
5. Aliens must submit a copy of immigration status.

Applicants who are denied admission may request reconsideration by a committee. The Reconsideration committee is composed by the Graduate Program Mentor, Dean of Graduate School and the Vice President for Academic Affairs. The procedures and criteria for reconsideration are established by the Committee taking into account the applicant's job experience, professional licensing and other alternate admission criteria such as results from TOEFL and GMAT among others.

Individual programs may have additional requirements. Applicants are encouraged to consult the catalog's section that describes the graduate program of interest.

An active undergraduate student can only register in graduate courses if he/she has been admitted to the Combined Bachelor's Master's Degree Program. (Refer to Bachelor's Master's Degree Program section of this Catalog).

Upon proper completion of all admission requirements the applicant will, if admitted, be eligible to register. When registration is completed, and all fees are paid, the student will be officially enrolled at the University. The dates for registration are included in the Academic Calendar.

INTERNATIONAL STUDENTS

Applicants who are not United States of America citizens or permanent residents must petition Polytechnic University of Puerto Rico to issue official forms required by the Bureau of Immigration and Citizenship Services (BICS). Upon completion of these forms and acceptance, these applicants will be classified as international students.

An applicant desiring to enroll as an international student must submit the following documents:

International Applicants with Form I-20

1. Fill the Application for Admission.
2. Make payment of Sixty dollars ($60.00) application fee. The application fee is non refundable and will not be applicable toward the student's registration charges.
3. Submit an official transcript certified by the educational institution and validated by the Ministry of Education of the applicant's home country as well as a USA academic equivalence certification for that degree certified by an accredited evaluation firm (World Education Services, Inc.; Educational Evaluation, Inc. etc.). The academic equivalence certification must include the equivalent U.S.A. degree with a detailed evaluation, course by course, of an official transcript from the educational institution in the candidate's home country. The document must be sent directly from the institution to the Graduate Office, Polytechnic University of Puerto Rico.
4. Submit three (3) letters of recommendation from persons who can attest to the applicant's preparation and ability to perform at a graduate level.
5. Demonstrate financial capacity to complete the required program, if personally by means of a funds availability certificate from the candidate's banking institution or:
    a. Submit a sworn statement by the person that will cover the costs of the studies, indicating the annual amount assigned for this purpose and
    b. Submit a copy of the Income Tax return of the person, residing in U.S. territory that will cover the cost of the studies or, if self financed, submit a letter from the applicant's banking institution, certifying availability of funds to cover the studies.
6. Applicants may be required to take the Test of English as a Foreign Language (TOEFL).

The International Student Adviser offers information, counseling, and assistance on Federal Regulations related to maintaining the student status. The adviser is located at the Registrar's Office.

Instructions for the letters of recommendation

The Office of Graduate Affairs will provide the recommendation letters form. These forms must be filled with a typewriter or in block letters by each of the three persons to whom the applicant requests a recommendation. The letters must accompany the application for admission at the time of submission.

NON-DEGREE SEEKING ADMISSION

A non-degree student status is a candidate who would like to take graduate course work for professional development, personal enrichment, or familiarize with the curriculum of a graduate program. Visiting Students, those students that visit PUPR for a term and then transfer the course credit-hours to their degree-granting institution, could also apply as a non-

degree student. Students who are required some pre-requisites courses for a graduate program could take these courses as a non-degree student before being granted full admission to the Graduate School.
A maximum of 12 credit-hours may be completed in the student's graduate program before program admission. Non-degree seeking student must have permission and the signature of the Graduate Program Mentor and Graduate School Dean to register for graduate courses.

Permission to attend PUPR as a non-degree student does not guarantee admission at the undergraduate or graduate level, nor does it guarantee admission into a continuous education program.

The amount of credit-hours taken as a non-degree student will be limited to 12 credit-hours of graduate course work.

If the non-degree student decides to apply for a graduate program (change his/her status as a degree-seeking student) and admission is granted, full credit could be given for courses completed with a grade of at least "B", while having the non-degree student status.

Application Requirements

To apply for admission as a non-degree student, the candidate will be required to provide proof of undergraduate degree by means of an official academic transcript. A one-time non-refundable application fee will be required for the non-degree applicants, and the fee will cover all terms attended as a non-degree student. If later the non-degree student decides to apply for a graduate program, the corresponding non-refundable graduate admission application fee will be waived. Resident applicants must present resident card.

Registration Requirements

A non-degree student must receive permission from both, the Graduate Program Mentor and the Graduate School Dean before registering.

Upon completion or registration of the 12 credit-hours the student may contact the Office of Graduate Affairs for advice on admission into a graduate program.

Restrictions

The following restrictions apply to the non-degree student status:

- A student who is already admitted to PUPR may not register for a non-degree status.
- Financial aid is not available for non-degree students.
- All student, degree and non-degree alike, must meet the requirements as stated in the current PUPR Graduate Catalog. Failure to meet these requirements will subject students to probation or dismissal.

READMISSION POLICY AND PROCEDURES

Students who have been inactive at Polytechnic University of Puerto Rico for two or more regular terms, or who have been suspended academically and wish to be readmitted, must apply for readmission.
Regular students who have discontinued their studies for one year or more will be readmitted under the procedures in effect. The applicable curriculum will be the one outlined in the Catalog in effect at the time of readmission.

The student will receive and submit the readmission application form from the Office of Graduate Affairs and will submit it to the same office. Readmission applications must be submitted at least a month prior to the next registration period. If the student does not register during the period requested, the application will remain active for one (1) additional term.

A student whose readmission application has been denied may appeal to the Readmissions Committee through the Graduate School Deanship. The student will receive instructions regarding the procedure to follow in order to request reconsideration by the committee.

An applicant who is delinquent with the Finance Office may be readmitted conditioned to the full payment of all financial and other debts due to Polytechnic University of Puerto Rico prior to registration.

Validation of courses from other institutions taken before the five-year period prior to readmission may be canceled. A readmitted student may be asked to take such, or other equivalent courses, by his/her Graduate Program Mentor or Dean of Graduate School.

All courses having more than five calendar years of approval at PUPR or elsewhere are considered to be expired. Nevertheless, during the readmission process the Dean of Graduate School will pass judgment of every expired course and determine which ones shall be retaken and which others are waived in writing, if any.

GRADUATE SCHOOL TRANSFER OF CREDIT HOURS

A maximum of 12 credit-hours of graduate-level course work may be transferred from another institution to apply towards a Master's Degree. Acceptance of transfer credit-hours toward program requirements is at the discretion of the program. The student must file a formal petition at the Graduate Affairs Office accompanied with descriptive material such as transcripts, catalog descriptions and listings of textbooks used, among others.

Transfer of credit-hours will be favorably considered if courses were completed with a B or higher grade. Also the courses must be equivalent to those offered in the curriculum of the chosen Graduate Program and they must have been completed within the last five years. No expired courses will be transferred unless there is a waiver in writing by the Dean of Graduate School.

Pre-requisite for a graduate program taken outside PUPR

Students may take undergraduate pre-requisite courses required as part of the Graduate Program Curriculum at Institutions different than PUPR as long as: ① Institution is adequately licensed, ② course content is equivalent to the

course required at PUPR, and ③ a minimum grade of "C" is obtained in the course.

MULTIPLE MASTER'S DEGREES

Completion of an Additional Degree

Students that would like to complete an additional graduate degree (i.e., Graduate School alumni) must: ① complete the admission procedure for the desired additional graduate program, and ② know that only common core courses will be counted towards the additional desired graduate program degree.

Completion of an Additional Specialization

Students could complete an additional specialization in the same graduate program where they are enrolled by completing the number of credit-hours required in the new desired specialization. Courses already approved in the specialization will not be considered towards the required number of credit-hours of the new specialization.

XI. FINANCIAL INFORMATION AND SERVICES

TUITION AND FEES FOR GRADUATE PROGRAMS

The following schedule of tuition and fees applies to all graduate students of the Polytechnic University of Puerto Rico.

Tuition per credit-hour: (Graduate Programs)

• Tuition per graduate credit-hour	$205.00
• Tuition per graduate credit-hour for On-line program	$215.00
• Tuition per graduate credit-hour for Landscape Architecture	$230.00

Registration fees

• Graduate Registration Fee	$50.00
• Graduate Library Fee	$65.00
• Student Activity Graduate	$30.00
• Computer Technology Center Fee	$85.00
• Students Health Services	$20.00

General fees

Application for Graduate Admission (non refundable)	$ 50.00
Application for International Graduate Admission (non refundable)	$ 60.00
Application for Non-Degree Seeking Admission (non refundable)	$ 75.00
Application for Graduate Certificate (non refundable)	$ 75.00
Readmission	$ 25.00
Deferred Payment	$ 40.00
Late Registration	$ 60.00
Drop/Withdrawal Fee Per Course	$ 15.00
Record Analysis	$ 10.00
Change of academic program	$ 15.00
Transcript	$ 8.00
ID-Card	$ 15.00
Duplicate ID-Card	$ 16.00
Access to Parking	$ 60.00
Graduation Fee	$150.00
Late Graduation Fee	$20.00
Certification	$ 5.00
Copy of the Registration Report	$ 3.00
Returned Check Processing	$ 50.00
Collection Fee	$ 20.00
Seminar Fee (SEMI 5500)	$425.00
Graduate Lab Fee	$240.00
Thesis Fee	$230.00
Project Fee	$200.00
Thesis Extension Fee	$230.00
Project Extension Fee	$200.00
Late Charge on pending balances	1.5 % monthly

Note: Tuition and Fees are Subject to Change without notice

PAYMENT OF TUITION AND FEES

Tuition and fees are payable in full during the registration period, and prior to the first day of classes. Students that decide to pay in full during the registration process will receive a 2% discount from the remaining balance that is not covered by financial aid or other sponsorships. Students may opt to defer payment for thirty (30) days at a cost of $40.00 (deferred payment fee), after paying 50% of total cost. The deferred payment will allow the student a grace period after the first day of classes to pay the remaining balance without paying late charges. The registration process is not completed until all fees have been paid or proper arrangement for deferred payment has been made.

In case the student cannot fully satisfy his debt prior to registration, the University's collection policy is as follows:

a. Tuition and fees due from previous terms of study must be paid in full, prior to the student registering for the new term.
b. Any balance remaining after 30 days will be subject to a 1.5% monthly surcharge.
c. Balances remaining unpaid after 180 days will be subject to an additional collection fee.

Students who request loans or veteran benefits must consult either the Director of Student Financial Aid or the Institution's Veterans Representative in the Registrar's Office, before their registration can be completed.

Payment of fees can be made either in money order, personal check, a bank manager's check, a certified check, Automatic Teller (ATM), Visa, MasterCard or American Express. Failure to pay any University fees when due may result in administrative withdrawal or withholding copies of student's academic records or other documents by the appropriate University officials. Students with pending balances on their accounts are not permitted to enroll in subsequent terms.

VETERANS' BENEFITS

Students eligible for Veterans benefits are required to make their financial arrangements in line with the policies of the University for all students.

REFUND POLICY

The Finance Office is responsible for complying with the refund policy established by the Institution. The procedure to apply for a refund must be submitted in writing, and in accordance with the academic term calendar.

INSTITUTIONAL REFUND POLICY

	Percentage of Refund
During week of regular registration	100 %
During first week of classes in each term	100%
During second week of classes in each term	33% Tuition and Laboratory Fees
During third week of classes thru the last date to withdraw form a course	0.00%

Registration fees are non refundable.

FINANCIAL DELINQUENCY

Students failing to pay their debt to the University on or before the day payment is due may be excluded from graduation. The University may also withhold grades, the issuance of transcripts, degrees, diplomas, and the granting of certificates of good standing to any student whose account is in arrears. Inactive students with debts will have the opportunity to pay the pending balances. Their payment plan agreement with Polytechnic University of Puerto Rico is held in association with the United Credit Bureau Service. If the students fail to comply with the payment plan, they are referred to a collection agency. Students referred to an agency for collection will be charged an additional fee.

STUDENT CONSUMER INFORMATION

The University conforms to the Student Consumer Information Requirements established by the United States Department of Education, and hereby serves notice that the Director of Student Financial Aid and office staff are the persons designated under those requirements to assist the student or prospective student in obtaining information regarding student financial assistance.

FINANCIAL AID

The University participates in the Federal Stafford Loan Program and State Grant (Programa de Asistencia Económica para Estudiantes Graduados Fondo Especial de Oportunidades Educativas). This program has the following requirements:

1. Be enrolled at least half-time in an eligible program.
2. Be a U.S.A. citizen or eligible alien.
3. Make satisfactory academic progress[1].
4. Have financial needs.
5. Sign a statement of Educational Purpose and Certification on refunds and default, also sign an Anti-Drugs Abuse Act Certification, a statement of update information and Selective Service registration status.
6. Have a valid social security number.
7. Not in default.

The student who requires a financial aid loan must file the U.S. Department of Education Federal Student Aid Application Form used to determine the family contribution (FC), and the financial needs of the student. Also, the student has to file an application for the loan and bring it to the Financial Aid Office with the required documentation. The application will be processed by the office and sent to the lender if the student is eligible.

For more information or additional Financial Aid opportunities, students should visit the Financial Aid Office of PUPR, located on the first floor of the Administration Building.

XII. ACADEMIC INFORMATION AND SERVICES

The student should be thoroughly familiar with: (1) this section of the Catalog, (2) the section containing the academic requirements for the degree he/she plans to earn, (3) the offerings of his/her major program of study, and (4) any changes published after the publication of this Catalog. A degree will be awarded only to a student who has satisfied all the academic and administrative requirements of Polytechnic University of Puerto Rico.

PROGRAM SEQUENTIAL CONTINUITY

The Polytechnic University of Puerto Rico will provide the student a program curriculum sequential aligned with the academic time length and course prerequisites. The student is responsible to follow the sequential to accomplish the graduation requirements within the corresponding time schedule. If the student is not able to follow the sequential, he/she will be responsible to develop the most effective program sequential with his/her mentor to minimize the program completion time. The department is responsible to offer the courses based on the program sequential to insure the student completion time. An annual offering plan is prepared based on the sequential timing and course prerequisites. If the course has a low enrollment, the department will develop alternatives to provide the course for the student that are in compliance with the program curriculum sequential.

ACADEMIC PROGRAM CONTINUITY

The Polytechnic University of Puerto Rico will reserve the right to close or postpone an academic program based on low enrollment figures. To insure that the enrolled student is not affected by this decision, the institution will provide the

[1] The student has to maintain satisfactory academic progress in the course of studies he or she is pursuing, according to the standards and practices of the institution in which he or she is enrolled in order to receive aid under the Student Financial Assistance Program.

necessary course offering alternatives to complete the program curriculum for the in progress students.

GRADUATE ACADEMIC SCHEDULE

Registration for all students is held prior to the beginning of each term on designated days as specified in the Academic Calendar. Completion of registration for each term is a prerequisite of class attendance. The academic year consists of three terms, and one summer session. Fall, Winter, and Spring classes are scheduled from Monday through Thursday from 6:30 pm to 10:30 pm; Saturday from 8:00 am to 5:00 pm or through On-line courses. On-line courses may have on-campus requirements. Depending upon the term, students may be required to make-up class contact hours lost due to days observed as holidays.

CHANGES IN CLASS SCHEDULE

During the first week of classes a student may add, or drop from, courses by completing a Change of Program Form at the Graduate Affairs Office.

Add Policy: A student may add a course during the official Add/Drop period; a class which has been dropped will not appear in his/her permanent record. Some academic programs may require approval of the Program Mentor before any course change is made. For withdrawal after the Add/Drop period, consult the Withdrawal Policy.

ACADEMIC LOAD

The regular or normal load per term is six (6) credit-hours. Additional credit-hours require the approval of the Graduate Program Mentor or the Graduate School Dean. Credit-hours will not be awarded for courses in which the student is not properly registered.

DEFINITION OF CREDIT-HOUR

A credit-hour for Federal programs, including the Federal student financial assistance program, is defined as follows: (34 CFR 600.2 of financial regulations) - An amount of work presented in intended learning outcomes and verified by evidence of student achievement that is an institutionally established equivalent that reasonably approximates not less than:

1. One hour of classroom or direct faculty instruction and a minimum of two hours of out of class student work each week for approximately fifteen weeks for one semester or trimester hour of credit, or ten to twelve weeks for one quarter hour of credit, or the equivalent amount of time; or
2. At least an equivalent amount of work as requited in paragraph (1) of this definition for other academic activities as established by the institution, including laboratory work, internship, practice, studio work, and other academic work leading to the award of credit-hours.

Credit Hour at PUPR system:

One credit-hour corresponds to 15 contact hours per term for a lecture course, and thirty (30) to forty five (45) contact hours per term for a laboratory or practicum course. Additionally includes a minimum of 2.5 hours of out of class student work each week for the twelve week term. The exception is each one of the Architecture (ARCH) courses which requires twelve (12) contact hours per week.

DEFINITIONS RELATED TO CREDIT-HOURS

Other definitions related to credit-hours are:

1. Attempted credit-hours - all credit-hours in which the student enrolls at the graduate level at the Polytechnic University of Puerto Rico, for which a grade of I, A, B, C, D, F, W, NS, S, NP, or P is given, including all the number of times the student has enrolled in the same course.
2. Transfer credit-hours - graduate credit-hours approved with a grade of "A", "B" or its equivalent at an accredited institution of higher learning, and are accepted by the Graduate School in accordance with the prevailing norms at the PUPR. Transfer credit-hours will not be taken into consideration in qualitative evaluation. These credit-hours will be considered to determine the level or year of study of the student at the graduate level. A maximum of six (6) credits will be accepted in transfer from other accredited institutions of higher learning.
3. Approved credit-hours – credit-hours attempted at the PUPR by students admitted to the Graduate School and approved with a grade of "A", "B", "C", "S" or "P".
4. General average - measure used to evaluate the academic performance of the graduate student. This measure is computed by dividing the total number of credit-hours accumulated by the total number of credit-hours in which the student has received final grades, including "F,s" that have not been removed. Courses in which grades of "S", "NS", "P" or "NP" will not be included for computing the measure.
5. Repetition of courses - practice under which the graduate student is allowed to repeat only a course in which he (she) obtained a grade of "C", "D", "F", "NS", or "NP". In accordance with this practice, only the highest grade will be considered to determine the general average.

RESIDENCE REQUIREMENTS

Residence requirements are not mandatory for the Master's degrees offered at Polytechnic University of Puerto Rico.

WITHDRAWAL FROM COURSES

The Polytechnic University of Puerto Rico does not encourage withdrawal from courses. The withdrawal form must be approved by the Graduate Affairs Officer and Finance Officer by the stated deadline. Students may withdraw from courses two weeks before ending a term, or on the date specified in the academic calendar.

TOTAL WITHDRAWAL

Students needing to withdraw from the University for personal reasons, must secure a Withdrawal Form from the Graduate Affairs Office. This type of withdrawal must be signed by the Graduate Affairs Officer. The application shall be submitted by the stated deadline.

GRADING SYSTEM

The Polytechnic University of Puerto Rico utilizes an alphabetic grading system. The grades that must appear in the midterm and final reports are as follows:

A	Excellent (4 honor points per credit-hour)
B	Good (3 honor points per credit-hour)
C	Satisfactory (2 honor points per credit-hour)
D	Deficient (I honor point per credit-hour)
F	Failure (0 honor points per credit-hour)
I-Grade	Incomplete
WF	Non Authorized Withdrawal

GRADE POINT AVERAGE OR GRADE INDEX

A student's grade point average is the measure of academic achievement and computed as follows:

a. The total number of credit-hours corresponding to all courses taken, counted once, and having a grade of A,B,C,D, or F, is obtained (T).
b. The credit-hours of each course is multiplied by 4,3,2,1 or 0 according to grades of A,B,C,D or F, respectively.
c. These products are added (S); and identified as honor points.
d. S is divided by T to obtain the grade-point average.

In computing the grade point average or grade-index, the highest grade obtained in a repeated course will be used whenever it is higher than the original grade. If the grade obtained in the repeated course is lower than the original grade, the original grade will prevail.

SYMBOLS

T	Transferred
AU	Audit (class audited only)
R	Repeated course
W	(Withdrawal) Indicates that the student was permitted to withdraw from a course without penalty. It indicates that authorization of the officers previously mentioned was obtained
P	Pass, only for specified courses
NP	Not passed, only for specified courses
E	Expired course (course no longer offered)
S	Satisfactory, only for specified courses
NS	Not satisfactory, only for specified courses
CE	Course Exception

NORMS AND PROCEDURES FOR THE EVALUATION OF STUDENT ACADEMIC PROGRESS AT THE GRADUATE LEVEL

Purpose

This document includes the norms and procedures of student academic progress at the graduate level. The purpose of these norms and procedures is to define the parameters to be used in the retention, probation, suspension, and academic dismissal of students. They establish the mechanisms to be followed in the evaluation of student academic progress. These norms and procedures apply to every student admitted or readmitted to pursue graduate studies.

Norms and Procedures

The PUPR requires that all graduate students demonstrate academic progress through the general average.

A. **Definitions**

1. Attempted Credit-Hours- Credit-hours the student has registered at PUPR, and in which he/she has obtained I, A, B, C, D, F or W, including all repetitions.
2. Transferred Credit-Hours -Credit-hours taken at other accredited institutions, which the student has passed with A, B, or C grades, and that are accepted by the Department Director or the corresponding Dean, in accordance with PUPR policy.
3. Passed Credit - hours Attempted credit-hours taken at PUPR in which A, B, C, or D grades are obtained, except in those specific cases defined by the departments.
4. Grade Point Average - The measure of academic merit achieved by the student; it is calculated by dividing the total accumulated honor points by the number of credit-hours in which the student has received final grades, including outstanding F's.
5. Repeated Courses - is a practice under which the student is allowed to repeat courses. In accordance with this authority, the highest grade is the only grade considered for the overall average. Repeated courses will be considered in the quantitative and the qualitative.
6. Suspension for Academic Deficiency - separation of the student from UPPR for academic reasons which takes into consideration the qualitative element, and the time on probation.
7. Academic Year and Term- Academic year consists of three consecutive academic periods called terms from August 1 to July 31 of the following year. The Summer academic period is optional and the grades will be added to the previous academic period of study.

B. **Norms of Academic Progress to be followed by the Registrar Office for the evaluation of students**

1. **Retention Index**

The institution adopts the required index as presented in Table A, in accordance with the number of credits completed and transferred credits. (The student must have a general grade point average of 3.00 or more, both concentration courses and general average, for the granting of the degree).

Table A
Retention Index

Transfer Credit-hours (1)	Credit-hours Passed at PUPR (2)	Total Credit-hours Accumulated at PUPR	Minimum Grade Point Average
		0-9	2.50
		10-18	2.80
		19 or more	3.00

2. **Probation and Suspension**

2.1 All students whose academic progress does not comply with part II, paragraph B.1, will enter a period of probation (P1) which shall not exceed one academic year.

2.2 If the student does not surpass the probation (P1) and fails to comply with the qualitative element, the student will be suspended (S1) for a term of one year. At the end of the period of suspension, the student should request readmission if he/she wants to continue his/her studies. When readmitted, the student will enter a probation (P2) status for one academic year. If fails probation (P2), and does not comply with the general average, the student will be expelled from the Institution without the right to appeal.

3. **Incomplete Grades**

If the professor gives an incomplete in a course, the student must complete the requirements thereof within the date indicated in the next academic term. The professor should remove the incomplete within the date set in the academic calendar. If the incomplete is not removed at the established date, it becomes the final grade linked to the incomplete grade. These incomplete grades are considered in the calculation of the qualitative measure.

C. **Procedure**

The academic progress of all eligible students not receiving financial aid will be measured in the following way:

1. The qualitative part shall be verified once a year during the summer period. The retention rate refers to the general average that the student must accumulate in comparison with the total number of credits accumulated according to Table A (qualitative part). The general average will be calculated using only the credits approved in the UPPR. In this calculation, all courses in which the student is enrolled and that belong to his/her degree at the Graduate School until the last period of study will be considered. The condition of the student shall be determined using the following procedure:

    a. When the cumulative index is less than the established in table A, probation (P1) shall be granted for a period of one academic year. The Registrar's Office will notify such probation (P1) to the student in a certified letter. At the same time, it shall notify the academic Department for the corresponding follow-up.

    b. at the end of the period of probation (P1), The student must achieve an academic index equal to or greater than that provided in Table A,.

    b.1 During the period of probation (P1) the student will be responsible for preparing its own program of study with the advice and help of his Mentor or academic Director, repeating, firstly, all courses taken which have rating "C", "D", "F" or "WF".

    b.2 If the student requests a total withdraw or leaves the University during his period of probation (P1), it will be located on probation when he returns, in the event that he/she returns.

        a. If after completing one year of probation (P1) the student does not comply with the conditions laid down in paragraph 2 and does not surpass the academic deficiencies, will be suspended (S1) for one academic year. The Office of the Registrar will notify the suspension in a certified letter. At the end of the period of suspension, if the student wants to continue studying, he/she shall request readmission. When readmitted, he/she will enter probation (P2) for one academic year. If it fails probation (P2) the student will be expelled from the institution. The student will be expelled from the institution without right to appeal.

        b. Any student who is suspended for academic deficiency will need to remain separated academically from the UPPR for one academic year before qualifying for readmission, and courses taken at another institution will not be transferred.

D. **RIGHT TO APPEAL**

The student may appeal this decision under the following conditions:

a. Any student who considers that a mistake has been made in the application of these policies and procedures used to evaluate academic progress may send a written request for reconsideration to the Academic Achievement Committee within ten (10) working days after notification of the decision.

b. The request for reconsideration should state clearly the mistake he/she understands has been made, give a brief statement of facts, state and justify the basis for the requested change or restitution.

c. Each request for reconsideration must be submitted to the Registrar's Office.

d. Presentations before the Academic Achievement Committee by persons who are not members of the Committee will be permitted in special cases. The Committee's decision will be final.

Effective Date

These rules and regulations are in effect since August 1, 2012. Any student affected by norms and procedures eliminated by these new rules and regulations may apply for reconsideration of his/her case.

APPLICATION FOR GRADUATION

An official academic evaluation is required prior to applying for graduation. The graduation application must be completed and a graduation fee paid no later than the date specified in the academic calendar. Academic and Graduation applications are obtained at the Graduate Affairs Office. The graduation application should be returned to this Office after clearance by Library, Financial Aid and Finance Offices confirming non existence of debts and payment of the non-refundable graduation fee. Any alleged error in the analysis of an academic record should be reported to the attention of the Academic Evaluator, Graduate Affairs Office within a week after it has been received by the student.

GENERAL GRADUATION REQUIREMENTS

The Polytechnic University of Puerto Rico reserves the right to make changes in the different curricula and degree requirements at its discretion. As a rule, a student is entitled to graduate under the curriculum requirements in force at the time of admission to the Institution. However, students who fail to fulfill the graduation requirements within the regular period of time assigned to their corresponding curricula, and students who re-enroll after a period of one year of absence or more, are governed by the existing curricular requirements at the time of graduation.

To receive a graduation diploma from the Polytechnic University of Puerto Rico, candidates must meet the following conditions or requirements:

1. Apply for graduation after the completion of about 80% of the credit-hours required by filing an application form at the Graduate Affairs Office on the day the student registers in the fall term of the last year of studies.
2. Pay the graduation fee and satisfy all other financial obligations to the University no later than the date specified in the academic calendar.
3. Students must have been recommended for the degree by the Dean of Graduate School to the President of PUPR and to the Board of Trustees.
4. Students completing requirements during any one of the different three academic terms are invited to do their best and participate in the summer commencement exercises.
5. Students should have taken the final credit-hours for the degree at the PUPR with the understanding that these credit-hours correspond to the total credit-hours of the last year of the program as specified and described in the Catalog.
6. The student must attain a minimum cumulative grade point average of 3.00.
7. In general, the acceptable grades in an academic record to enable graduation include A, B, or C. However, a student is only allowed two courses with grade C to be eligible for graduation.
8. When a student receives a grade of D, F, NS or NP in a course, the student must enroll in the same course and obtain an acceptable grade.
9. If a student has three courses with grade C, the student must enroll in one of these course and obtain a minimum grade of B.
10. From the term of first registration, graduate students have five years to complete their degree. The time limit for completing a graduate degree can be extended from the term of first registration up to seven years via: a formal petition issued by the graduate student to the Graduate School Dean and the corresponding approval by the Dean.
    Note: Time limit extensions are subjected to verification of caducity of certain courses.
11. The student must satisfy all credit-hours specified for the degree within a period equivalent to five years. After the expiration of said period, all expired courses must be repeated, unless otherwise authorized by the Graduate School Dean.
12. The University celebrates Commencement Exercises once every academic year during the Summer term, at which time all degrees and certificates are awarded.

CURRICULAR CHANGES

When the curriculum of a graduate program is revised, this curriculum will apply to (1) new students admitted to the program and (2) inactive students who have been out of the Institution for at least one academic year.

Active students who would like to adopt the curriculum change in his/her program must complete the specific form at the Graduate Affairs Office.

VETERANS' SERVICES

Polytechnic University of Puerto Rico offers recruiting, guidance, and referral services to veterans who wish to study at the institution. The guidance and counseling officer at the Registrar's Office assists veterans in the solution of their individual problems and serves as liaison with other offices, as needed. Veteran's academic records are under the custody of the Registrar's Office and are available for student's review.

CERTIFICATIONS AND TRANSCRIPTS

Whenever a student files an application with the Registrar's Office for a certification of his program of study, transcripts or any other official statement, the same will usually be issued by the Registrar within two weeks after filing of the request. However, when a request is made at the beginning or the end of a term, a longer period of time for issuance may be required. To

transfer credit-hours to other colleges and universities and to supply information to certifying agencies and prospective employers, official transcripts are issued in a confidential manner. These are mailed directly to the addresses designated by the students and are never given to the student or any other individual. Students may also obtain an official copy of the transcript of credits marked Student Copy. Any alleged errors in the transcript should be reported to the Registrar within ten days of receiving it. A transcript and certification fee is charged for each transcript. All services are denied to debtor students.

DIPLOMAS

Diplomas must be claimed by graduates at the Registrar's office no earlier than three weeks following the graduation ceremony.

CHANGE OF ADDRESS

When a student submits an application for admission, he/she is required to submit a mailing address. After admission, changes of address should be reported immediately to the Graduate Affairs Office. If change of the address is not indicated, the University will not be responsible for correspondence it sends which is not received by the student. Any notice, official or otherwise, mailed to a student's address as it appears on the records shall be deemed sufficient notice.

CHANGE IN GRADUATE PROGRAM

A student that would like to change from his/her current graduate program to a new program must: ① complete the change in graduate program form and pay the required fees, ② be in good academic standing, ③ have approved at least 3 credit-hours and ④ comply with the specific graduate program requirements.

CHANGE IN SPECIALIZATION

Student must complete the change in specialization form available at the Graduate Affairs Office.

CLASS ATTENDANCE

The fact that classes are scheduled is evidence that attendance is important. Students should maintain regular attendance if they are to attain maximum success in the pursuit of their studies. Students who have not attended any classes during the first two weeks of the academic term, are automatically disqualified to charge tuition fees to federal funds and are responsible for their payment. The instructor, after receiving the class lists, will submit, in writing, the names of all such students to the Office of the Registrar.

It is recognized that the record of class attendance may vary according to the student, the instructor, or the course. On occasions, it may be necessary for the student to be absent from scheduled classes or laboratories. The student is responsible for contacting the instructor and for all work, completed or assigned. Instructors in charge of courses in all programs of study are required to include in their mid term and final grade reports the total number of absences of all students. The Registrar will not accept reports if this condition is not met by the instructor.

APPOINTMENT OF GRADUATE SCHOOL RESEARCH ASSISTANTSHIPS (RAs) AND TEACHING ASSISTANTSHIPS (TAs)

Graduate School publicizes assistantships, screens applications and submits recommendations to the Graduate Council for its final approval regarding RAs and TAs.

General guidelines and applications for RAs on TAs can be obtained at the Graduate School Deanship or Graduate School Website, www.pupr.edu/gs.

XIII. GENERAL GRADUATE ACADEMIC INFORMATION

DEGREES OFFERED

Master Degrees in Engineering

Master of Science in Civil Engineering
Master of Science in Computer Engineering
Master of Science in Computer Science
Master of Science in Electrical Engineering
Master of Science in Manufacturing Competitiveness
Master of Science in Manufacturing Engineering
Master of Engineering in Civil Engineering
Master of Engineering in Computer Engineering
Master of Engineering in Electrical Engineering
Master of Engineering in Manufacturing Engineering
Master in Computer Science
Master in Geospatial Science and Technology
Master in Manufacturing Competitiveness
Master in Mechanical Engineering

Master Degree in Landscape Architecture

Master of Landscape Architecture

Master Degrees in Management

Master of Business Administration
Master in Engineering Management
Master in Environmental Management

PHILOSOPHY AND OBJECTIVES

Polytechnic University of Puerto Rico, being deeply committed to serve the private sector, as well as the government and engineering profession, proclaims that graduate studies is one of the most effective ways to satisfy one and all of these constituents. The economic growth strategy promoted by the Government of Puerto Rico depends heavily on product design and development, as part of an ambitious science and technology initiative.

Graduate Programs at Polytechnic of University of Puerto Rico provide excellent opportunities and academic resources for the continuing development of advanced studies and research in Engineering, Management and Landscape Architecture. The most important objective of these programs is that the graduate student develops a mastering knowledge of his/her field of study and of the resources and techniques that will enable

him/her to carry out independent professional work or research. The second most important objective is to contribute to the development of an environment capable of nourishing the science and technology initiative of the Government of Puerto Rico. These two objectives, will contribute in many ways to the development of the student, the University, and the community at large.

While the provisions of this Catalog will ordinarily be applied as stated, PUPR reserves the right to change, without previous notice to individual students, any provisions listed in it, including, but not limited to, academic regulations and requirements. Every effort will be made to keep students advised on any changes. Information on changes will be available at the Graduate School. Notification of changes will be posted on PUPR's Web Page. It is especially important to note that it is the responsibility of the student to keep abreast of current graduation requirements for a particular degree program. A student is normally required to satisfy the degree requirements of the Catalog in effect at the time of his/her initial registration.

A degree will be awarded only to a student who has satisfied all the academic and administrative requirements of PUPR.

ORGANIZATION OF GRADUATE STUDIES

Polytechnic University of Puerto Rico offers Graduate Programs in Engineering, Management, and Landscape Architecture. Graduate studies at PUPR are organized around the Graduate School and the academic departments. The student is normally admitted to study the master's degree in the field in which his or her undergraduate degree was conferred when the student record indicates ability to do advanced work in the field. When the student decides to do graduate work in a different field, however, the department may require him/her to establish additional background by taking certain undergraduate courses.

GRADUATE COURSES NUMBERING SYSTEM

All graduate courses in Engineering are codified by a number between 6000 and 7999. Some graduate programs in Engineering allow the graduate student to take undergraduate advanced courses, codified by the level 5000. All graduate courses in Management are codified by a number between 5500 and 7999. All graduate courses in Landscape Architecture are codified by a number between 6000 and 7999. 5000 level courses will only be counted as graduate course credit-hours if the graduate program curriculum provides for it.

GRADUATE PROGRAM MENTORS

The Graduate Program Mentors are faculty members who verify that administrative and academic requirements are met by all graduate students. Also these faculty members are responsible of establishing more detailed academic requirements for their programs.

The functions and responsibilities of the Graduate Program Mentors include, among others: curriculum advising, general academic advising, consideration of proposed changes on the student's plan of graduate work, thesis/design project general advising, and the preparation of qualifying examinations (when applicable).

GRADUATE SCHOOL DEADLINES

Specific deadlines are published by the Graduate School each term to inform the graduate student regarding due dates related to the specific master's programs.

PLAN OF STUDY

A Plan of Study could be required by an academic program. In such cases, the student must submit the Plan of Study to the Graduate Program Mentor for his/her approval.

XIV. REQUIREMENTS FOR THE MASTER'S DEGREE

There are several academic options to complete a Master's degree. The applicant should seek information on the program of interest to determine which options are available in that program.

Option I. Thesis Requirement

In addition to all other graduation requirements, the student shall:

1. Pass all required credit-hours.
2. Present a Thesis proposal of the research that the student will carry out, to his/her Graduate Committee. The student must comply with his/her Graduate Program research requirements.
3. Prepare a Thesis document following the Graduate School Thesis Writing Procedures.
4. Prepare and present to his/her Graduate Committee a defense of the Thesis research.

Students must enroll for one thesis course and at least one thesis extension to comply with the thesis option graduation requirement. Additional thesis extensions are optional to complete his/her academic work. It is important to mention that by definition the Thesis Extension course count as 0 credit-hours but it is equivalent to the academic load of a 3 credit-hours graduate course. In addition, students pursuing the Thesis option can only register in the extension course for up to five consecutive regular trimesters. If the student has not completed the thesis work by the fifth extension course, he/she will have to register the thesis course again. Registering the thesis course again will allow him/her to continue the thesis work.

In the event that the student fails the defense, he/she will have the opportunity to defend his/her work for a second time in the following term. The result of the second defense shall be final.

Master's Thesis Policy

The following Graduate School policies apply to the Thesis-based Master Degree programs:

1. The Thesis Committee consists of three persons.
2. The Thesis Chairperson must be a faculty member of the Graduate School. The other two members of the Committee (the readers) can either be Institution faculty members or one faculty member from the Institution and the other, a professional within a field of study related to the Thesis.
3. The Thesis Chairperson must have a Doctor's Degree, related to the contents of the Thesis' research. The second member must have a Doctor's Degree. The third member must have either a Doctor's or Master's Degree, with the exception of Master's Degrees recognized as the first professional degree in the field.
4. Under no circumstances shall the external person be a re**l**ative of the student. This policy is put in place to avoid any conflict of interest.
5. The Graduate Program Mentor will ensure that the composition of the Committee meets the minimum requirements.
6. It is the prerogative of the student to choose the Thesis Chairperson. The Chairperson can either accept or reject the student's request. The Chairperson may suggest, and negotiate with the student the other two members of the committee. The student may accept or reject the Chairperson's suggestion.
7. The Student's Thesis Committee will accept guests to the Thesis Defense. Guests, however, cannot participate in the evaluation of student's work.
8. Thesis Defense will be given a grade of Pass (P) or No Pass (NP). However, if the Committee determines that the student must continue working on his or her Master's Thesis by means of a Thesis Extension, a Satisfactory (S) grade may be granted. The student must refer to the Continuous Enrollment Policy.

Research topics that change from a Thesis to a Design Project level

Students whose research topics changed, by recommendation and approval of their Graduate Committee, from a Thesis level to a design project level must register at least the Design Project course and comply with the Design Project requirements to complete his/her academic work.

Option II. Design Project Requirement

In addition to all other graduation requirements, the student shall:

1. Pass all required credit-hours.
2. Prepare a Project document following the Graduate School Guidelines for the Design Project Article.
3. Present the Project work and outcomes at the Graduate School Project Design Expo.

Students must enroll for one design project course to comply with the design project option graduation requirement. Design Project Extension is optional to complete his/her academic work. It is important to mention that by definition the Design Project Extension course count as 0 credit-hours but it is equivalent to the academic load of a 3 credit-hours graduate course. In addition, students pursuing the Design Project option can only register in the extension course for up to two consecutive regular trimesters. If the student has not completed the Design Project work by the second extension course, he/she will have to register the Design Project course again. Registering the Design Project course again will allow him/her to continue the thesis work.

In the event that the student fails the defense, he/she will have the opportunity to present his/her work for a second time in the following term. The result of the second presentation shall be final.

Research topics that change from a Design Project to a Thesis level

Students whose research topics are develop, by recommendation and approval of their Graduate Committee, from a design project level to a thesis level (innovation) must register at least the Thesis course and comply with the Thesis requirements to complete his/her academic work.

Option III. Comprehensive Exam Requirement

1. Pass all required credit-hours.
2. Pass a written examination on the material covered in the major field courses. If the student fails, he/she may take a second exam in the next term. The result of the second exam shall be final.

Option IV. Without Thesis, Project or Comprehensive Exam Requirement

In addition to the general requirements, the student shall:

1. Pass all required credit-hours.

CONTINUOUS ENROLLMENT

Continuous Enrollment is only required when a student is pursuing academic work/research necessary to complete a degree. Continuous Enrollment applies to students who have started the research phase of their graduate degree by either enrolling the thesis or design project course. Continuous Enrollment allows students to maintain active status with his/her advisor by registering extension courses. It is the responsibility of the student to maintain Continuous Enrollment status. In the event that the student does not comply with the Continuous Enrollment policy, he/she will have to register the thesis or design project course; the Graduate School will not permit extension courses without the thesis or design project course.

RULES FOR THE PREPARATION OF THESIS DOCUMENT AND PROJECT ARTICLE

Student must refer to the Graduate School Publications entitled Thesis Writing Procedures or Guidelines for the Design Project Article when writing either the thesis document or the project article. These documents contain specific information regarding the sections of the thesis or project article documents. Compliance with the rules described in those

guidelines is mandatory to all graduate students submitting thesis or project article documents to the Graduate School.

The Graduate School offers support services regarding the writing procedures for the thesis or project article through the Graduate School Deanship personnel.

XV. PROGRAMS OF STUDY

MASTER IN CIVIL ENGINEERING

The Graduate Program of Civil Engineering offers two degrees: Master of Science in Civil Engineering (MSCE) and Master of Engineering in Civil Engineering (MECE). Currently, students can select one of the four major areas of interest offered for these degrees: Structural Engineering, Geotechnical Engineering, Water Resources & Water Treatment, and Construction Engineering. By choosing appropriate courses at the graduate level, the student can tailor the program to his/her specific interests or research focus. The Civil Engineering Graduate Program Mentor will work closely with the student to carefully choose the elective courses that fulfill the student's professional expectations in breadth as well as in depth.

PROGRAM PHILOSOPHY

Experience and professional practice are essential elements in the formation of an engineer, but an in-depth knowledge of the foundations of the different Civil Engineering (CE) areas, and the development of strong analytical skills based on state of the art knowledge, methodologies, and techniques are also necessary. The professional experience would complement and strengthen the study through applications, but they cannot substitute the experience acquired through an academic graduate level degree.

The CE graduate program seeks to promote advanced studies and research at the Polytechnic University of Puerto Rico. Moreover, it seeks to involve graduate students in this process and to instill in them an intense desire for knowledge.

Civil Engineers are responsible for providing the world's infrastructure facilities, which are basic to the existence of modern society. These facilities can be large and complex, thus requiring the civil engineers to be broadly trained and able to deal with the latest technologies. The goals of the Graduate Program in Civil Engineering at PUPR are to provide comprehensive training in the Civil Engineering area chosen by the students, to offer instruction in the methods of independent investigation, and to foster the spirit of research scholarship.

The Graduate Program in Civil Engineering has the following objectives:

1. Adequately prepare Civil Engineers in the most advanced technological and scientific aspects of their chosen area of interest.
2. Convey into students the skills and knowledge that will enable them to occupy positions in industry, academia, the public or private sector, or in their own enterprises.
3. Offer Civil Engineers the opportunity to grow professionally in the essential aspects of design and research of their chosen area of interest.
4. Prepare Civil Engineers capable of:
    a. Employing the latest technology to analyze and design safe structures. (Specific to the Structural Engineering area.)
    b. Using their best judgment to analyze data and predict soil properties. (Specific to the Geotechnical Engineering area.)
    c. Applying hydrologic and hydraulic models to the analysis and design of water systems. (Specific to the Water Resources area.)
    d. Assessing and give recommendations to improve the quality of water. (Specific to the Water Treatment area.)
    e. Managing and inspecting the construction of infrastructural projects. (Specific to the Construction Engineering area.)

GRADUATE PROFILE AND OUTCOMES

CE graduates should be able to keep abreast of the latest developments in their chosen area of interest (Structural Engineering, Geotechnical Engineering, Water Resources, Water Treatment and Construction Engineering) by being capable of doing the following:

1. Read and analyze journal papers from their chosen area of interest.
2. Conduct independent research in their chosen area of interest (Thesis Option).
3. Develop engineering solutions of the common problems in their chosen area of interest.
4. Be able to find solutions to comprehensive situations in their chosen area of interest.
5. Write papers or technical reports.
6. Conduct technical and scientific presentations within a conference environment.
7. Use mainstream engineering software applications related to their area of interest.

Graduates in the area of Structural Engineering will be able to:

1. Analyze and design statically indeterminate structures.
2. Analyze and design of structural systems.
3. Use advanced computer tools to analyze the behavior of structural systems.
4. Apply the finite element method to structural systems, plates and shells, plane frame elements and elastic foundations.
5. Understand the behavior of structures under time-dependent loads, vibration analysis, and design for earthquake and impact loadings.
6. Apply advanced concepts to design more economical structures.
7. Apply fundamental concepts within the theory of elasticity and plasticity.
8. Perform analysis to predict and prevent the buckling of

trusses, frame elements, shell structures and beams.
9. Apply the principles of soil mechanics to the design of foundations for complex situations.
10. Analyze and design concrete and steel bridges.

Graduates in the area of Geotechnical Engineering will be able to:

1. Fully understand soil shear strength behavior and its application to the engineering practice.
2. Use computer programs to evaluate the properties of soils.
3. Determine the appropriate type of soil shear strength to be used for analysis and design of geotechnical structures.
4. Be able to select the most suitable type of foundation for a specific site.
5. Estimate and control the distribution of consolidation settlement with time.
6. Understand the behavior of soils under dynamic load.
7. Understand the mechanisms of earthquakes and measurement of strong ground motions.
8. Perform back analysis of slope failures and stabilization techniques.
9. Apply the analytical and experimental approach to the design of earthworks involving seepage and seepage control measures.
10. Recognize potential applications for retention structures used in civil engineering applications.

Graduates in the area of Water Resources & Water Treatment will be able to:

1. Select and apply appropriate hydrologic and hydraulic models for analysis and design.
2. Apply probability and statistics principles in the solution of hydrologic problems.
3. Analyze statistical procedures for the evaluation of hydrologic events.
4. Apply groundwater concepts in the solution of hydrologic and water supply problems.
5. Apply tools for the analysis and management of fluvial systems.
6. Design urban drainage systems.
7. Become a productive member of a team involved in the design or management of dams and reservoirs.
8. Assess water quality for any case related to treatment and distribution of potable water, and collection, treatment and disposal of runoff and wastewater.
9. Perform physical-chemical, biological and bench-scale testing of untreated water, potable water, and wastewater samples.
10. Identify and account for the change in contaminant characteristics during each treatment process.
11. Evaluate the efficiency of the different processes in the water and wastewater treatment.
12. Model, design, and evaluate processes in water and wastewater treatment.
13. Identify the best treatment alternative for each contaminant in subsurface environments.

Graduates in the area of Construction Engineering will be able to:

1. Use the administration of contracts as a first step in reducing costs and ease the burden of dispute resolution.
2. Plan the construction of a project taking into account budget and cost.
3. Apply an effective safety program to construction projects.
4. Identify and analyze construction scheduling problems.
5. Manage successfully the finances of construction projects.
6. Manage efficiently construction equipment and materials.
7. Apply adequate inspection techniques to construction projects.
8. Design and supervise the construction of safe temporary structures used for construction.
9. Apply local building laws and regulations for site development and design.

CAREER OPPORTUNITIES

CE Graduates could primarily work in engineering consulting firms, in construction companies and in government agencies that deal with public infrastructure. They could work in the design of civil engineering works or in the inspection and supervision of construction projects. Graduates of this master program can also teach at the undergraduate or technical level, or can pursue a doctoral degree.

PROGRAM REQUIREMENTS

Admission Requirements

Students with undergraduate preparation in Civil or Environmental Engineering programs are encouraged to apply for admission. Applicants must have completed a bachelor's degree at an accredited university with a minimum Grade Point Average (GPA) of 2.75/4.00. Applicants not meeting these requirements may request reconsideration by a committee.

Graduation Requirements

Students may pursue their master degree according to three program alternatives. One conducts to the Master of Science in Civil Engineering degree and the other two lead to the Master of Engineering in Civil Engineering degree. Following are the requirements for each of the three alternatives. All alternatives require a minimum GPA of 3.00/4.00.

<u>Alternative 1: Master of Science Degree - Thesis Requirement</u>

- Approve a minimum of 24 credit-hours in graduate courses (Level 6000) in the major area. Two of the courses must be CE 6900 - Introduction to Research in Civil Engineering and a mathematical oriented course as required by the major area of interest selected by the student.
- Approve a minimum of 6 credit-hours in graduate

courses (Level 6000) out of the major area. These courses may be replaced major area courses.
- A maximum of 6 credit-hours advanced under-graduate courses (Level 5000) can be used to replace graduate courses (Level 6000) as recommended by the Civil Engineering Graduate Program Mentor.
- Carry out a research program as specified in his/her program of study and prepare a thesis. The thesis consists of 6 credit-hours. Pass an oral exam (defense) on the thesis subject.

Alternative 2: Master of Engineering Degree - Master Project Requirement

- Approve a minimum of 27 credit-hours, in graduate courses (Level 6000) in the major area. One of the courses must be a mathematical oriented course as required by the major area of interest selected by the student.
- Approve a minimum of 6 credit-hours in graduate courses (Level 6000) out of the major area. These courses may be replaced major area courses.
- A maximum of 6 credit-hours advanced under-graduate courses (Level 5000) can be used to replace graduate courses (Level 6000) as recommended by the Civil Engineering Graduate Program Mentor.
- Carry out a special project as specified in his/her program of study and prepare the project report. The project consists of 3 credit-hours. Give an oral presentation on the master project.

Alternative 3: Master of Engineering Degree - Comprehensive Exam Requirement

- Approve a minimum of 30 credit-hours, in graduate courses (Level 6000) in the major area. One of the courses must be a mathematical oriented course as required by the major area of interest selected by the student.
- Approve a minimum of 9 credit-hours in graduate courses (Level 6000) out of the major area. These courses may be replaced major area courses.
- A maximum of 6 credit-hours advanced under-graduate courses (Level 5000) can be used to replace graduate courses (Level 6000) as recommended by the Civil Engineering Graduate Program Mentor.
- Pass an oral and written comprehensive exams on the topics covered in the major area.

Thesis, Master Project and Comprehensive Exam Requirements

The thesis or project required in the Civil Engineering Graduate Program is intended to test the ability of the Master's candidate to engage in original research or complex projects, and to organize and evaluate themselves creatively in the area of Civil Engineering.

Thesis

The student must prepare a research proposal, after completion of a minimum of twelve (12) credit-hours. The proposal has to be approved by the student advisor and the graduate committee. The graduate committee will be constituted by a minimum of three professors, including the chairperson. The student must conduct the research under the direct supervision of the chairperson and with the mentoring of the rest of the graduate committee. The final report must include original contributions to the specific area of knowledge.

At completion of the thesis project, an oral examination will be administered to test the candidate not only on his/her research topic, but also in the Civil Engineering areas and related fields that are relevant for the thesis development. This examination (defense) is administrated by the graduate committee, under the supervision of the chairperson and with the presence of the Civil Engineering Graduate Program Mentor.

A copy of the final version of the thesis report with the signature approval of the graduate committee must be delivered to both, the Civil Engineering Graduate Program Mentor and the Graduate School.

Master Project

In the Master Project alternative, the student must prepare a project proposal. The proposal has to be approved by the project advisor. The project advisor is a faculty member. The project has to be a challenging case-study that may include the evaluation, analysis and/or design of a specific situation within the student's area of interest.

At completion, the project will be presented at the Graduate School Design Project Expo. As a final requirement of the Graduate School, the student must submit a technical article of the Master Project.

Comprehensive Exam

The comprehensive examination will be designed to test the candidate in the Civil Engineering areas and related fields covered in his/her program of study. This examination is administered by the graduate committee, under the supervision of the student advisor, after the completion of a minimum of 33 credit-hours.

DEGREES OFFERED

The Department of Civil and Environmental Engineering offers graduate instruction leading to the degrees of Master of Science in Civil Engineering (MSCE) and Master of Engineering in Civil Engineering (MECE). Students must select a major area of interest from the following:

- Structural Engineering
- Geotechnical Engineering
- Water Resources & Water Treatment
- Construction Engineering

CURRICULAR STRUCTURE AND SEQUENCE

Required Course for MSCE (3 credit-hours)

Course	Title	Credit-Hours
CE 6900	Introduction to Research in Civil Engineering	3

Major Area

Students must select one of the four available Major Areas: (1) Structural Engineering, (2) Geotechnical Engineering, (3) Water Resources & Water Treatment, and (4) Construction Engineering. The total number of credits in Major Area courses varies depending on the degree and option selected. For the Master of Science degree, student must take a minimum of 18 credit-hours in their Major Area. For the Master of Engineering degree with the Project Option, student must take a minimum of 24 credit-hours in their Major Area. For the Master of Engineering degree with the Comprehensive Exam Option, students must take a minimum of 27 credit-hours in their Major Area.

Structural Engineering Courses

Required Course

Course	Title	Credit-Hours
CE 6370	Finite Element Methods in Engineering	3

Other Courses

Course	Title	Credit-Hours
CE 6300	Structural Engineering Laboratory	3
CE 6305	Simulation Engineering Laboratory	3
CE 6315	Analysis of Plates and Shells	3
CE 6320	Advanced Strength of Materials	3
CE 6323	Design of Composite Materials	3
CE 6325	Principles of Structural Stability	3
CE 6330	Advanced Topics in Structural Engineering	3
CE 6335	Advanced Foundations	3
CE 6340	Advanced Bridge Design	3
CE 6345	Design of Reinforced Masonry Structures	3
CE 6350	Dynamics of Structures	3
CE 6355	Advanced Earthquake Engineering	3
CE 6357	Wind Engineering	3
CE 6360	Bridge Inspection, Rehabilitation, Repair, and Management	3
CE 6375	Advanced Finite Element Methods in Engineering	3
CE 6378	Advanced Reinforced Concrete Design	3
CE 6380	Nonlinear Behavior of Concrete Structures	3
CE 6385	Advanced Steel Design	3
CE 6390	Lateral Load Distribution in Multistory Buildings	3
CE 6395	Nonlinear Analysis of Soil-Structure Interaction	3

Geotechnical Engineering Courses

Required Course

Course	Title	Credit-Hours
CE 6174	Finite Element Methods for Geotechnical Engineering	3

Other Courses

Course	Title	Credit-Hours
CE 6100	Soil Shear Strength	3
CE 6105	Advanced Geotechnical Engineering Applications	3
CE 6110	Earth Retaining Structures	3
CE 6114	Shallow Foundations	3
CE 6116	Consolidation Theory and Applications	3
CE 6120	Deep Foundations	3
CE 6125	Soil Dynamics	3
CE 6130	Geotechnical Earthquake Engineering	3
CE 6140	Slope Stability	3
CE 6150	Seepage & Drainage	3
CE 6335	Advanced Foundations	3
CE 6395	Nonlinear Analysis of Soil-Structure Interaction	3

Water Resources and Water Treatment Courses

Required Course

Course	Title	Credit-Hours
CE 6210	Probability & Statistics in Water Engineering	3

Other Courses

Course	Title	Credit-Hours
CE 6220	Meteorology	3
CE 6230	Groundwater Hydrology	3
CE 6240	Urban Drainage	3
CE 6250	Advanced Hydrologic and Hydraulic Models	3
CE 6260	Analysis and Restoration of Fluvial Systems	3
CE 6270	Sedimentation Engineering	3
CE 6280	Reservoir Analysis and Design	3
CE 6410	Water and Wastewater Treatment Applications	3
CE 6420	Fate and Transport of Contaminants in Soils	3
CE 6430	Remediation in Contaminated Subsurface Environments	3
CE 6440	Physical and Chemical Treatment Processes of Water and Wastewater	3
CE 6450	Biological Wastewater Treatment Processes	3
CE 6460	Water Quality Control and Management	3

Construction Courses

Required Course

Course	Title	Credit-Hours
CE 6532	Construction Cost Control	3

Other Courses

Course	Title	Credit-Hours
CE 6512	Value Engineering	3
CE 6520	Construction Contracting and Procurement	3
CE 6530	Schedule Impact Analysis	3
CE 6540	Construction Equipment Administration	3
CE 6542	Construction Material Management	3
CE 6544	Hazardous Material Management	3
CE 6550	Construction Inspections	3
CE 6560	Construction Safety and Regulations	3
CE 6570	Modern Construction Materials	3
CE 6580	Temporary Structures in Construction	3
CE 6585	Site Planning and Design	3

Out-of-Major Area

An Out-of-Major Area course is any CE course not listed in the student's Major Area. In addition, students in the Water Resources and Water Treatment major area of interest may take as Out-of-Major Area elective any course labeled as MEM 69XX and EPM 6XXX, while students in the Construction Engineering major area of interest may take as Out-of-Major Area elective any course labeled as MGM 5XXX, MEM and EPM 6XXX. The total number of credits in out-of-major area courses varies depending on the degree and option selected. For the Master of Science degree and the Master of Engineering with the Project option, students could take a maximum of 6 credit-hours in elective courses. For the Master Degree with the Comprehensive Exam option the maximum is 9 credit-hours in elective courses. Students are allowed to replace Out-of-Major Area courses with Major Area courses.

Thesis, Project and Comprehensive Exam courses

Course	Title	Credit-Hours
CE 6901	Master's Thesis Dissertation	6
CE 6902	Extension of Master's Thesis Dissertation	0
CE 6905	Master Project, "Final Project"	3
CE 6906	Extension of Master Project, "Final Project"	0
CE 6910	Comprehensive Examination	3

LABORATORIES

The Civil and Environmental Engineering Department has the following laboratory facilities on campus: Structural Engineering Laboratory, Construction Materials Laboratory, Mechanics of Materials Laboratory, Geotechnical Engineering Laboratory, Environmental Engineering Laboratory, Transportation Laboratory, and Civil Engineering Simulations Laboratory. These laboratories have been designed to perform a wide range of experiments in each of the areas.

Structures and Mechanics of Materials Laboratory – This laboratory is prepared to support undergraduate and graduate courses of Civil Engineering, as well as some extracurricular activities of the students, such as a competitions sponsored by the student chapters of professional societies. Among the major equipment of the laboratory are a test frame with two hydraulic jacks with capacity of 50 KN (11.5 kips) each; small-scaled structures to support the theory of structural lectures with experiments; a plate for analysis of a two-way slab; models of a gable and flat frame; data acquisition system to obtain the data electronically.

Construction Materials Laboratory – This laboratory can be used to develop an understanding of the physical and mechanical properties of construction materials as well as the loads that each construction material can withstand. The laboratory has several equipments to test aggregates, concrete, wood, reinforcing steel and asphalt.

Geotechnical Engineering Laboratory – This laboratory has multiple sets of equipment meeting or exceeding industry standards and used to measure the engineering properties of soils with an acceptable rate of accuracy. The laboratory facilities provide enough space for four fully equipped workstations.

Environmental Engineering Laboratory – In this laboratory, students can conduct tests to determine the main physical, chemical and biological characteristics of water and wastewater, to monitor the quality of water and wastewater, and to conduct measurements for air contaminants, solid waste physical properties, metals and dissolved components in wastewater, pH of soil suspensions in water, and adsorption of organic chemicals to activated carbon.

Highway and Transportation Laboratory – This laboratory is focused in data collection techniques and use of equipment and computer software associated with different types of transportation studies in which application of statistics and probability to analyze, interpret, manage and present transportation data is required.

Civil and Environmental Engineering Simulations Laboratory - This laboratory is equipped with 30 computers. It is commonly used as a classroom for professors to teach essential Civil Engineering software and as a computer center for civil and environmental engineering for students to use for their class projects.

CIVIL ENGINEERING
COURSE DESCRIPTIONS

CE 6100 - Soil Shear Strength

Three credit-hours. Prerequisite: None. One four hours session per week.

The Mohr Circle, failure theories and stress paths. Behavior of saturated sands during drained and undrained shear. Liquefaction and cyclic mobility. Stress-deformation and strength characteristics of saturated cohesive soils. Use of triaxial testing and stress paths in engineering practice.

CE 6105 - Advanced Geotechnical Engineering Applications

Three credit-hours. Prerequisite: None. One four hours session per week.

Fundamentals of geotechnical engineering laboratory instrumentation. Measurement of the relative density of sands. Direct shear testing of loose and dense and dry and saturated sand. Unconfined compression test. Evaluation of soil/structure interface friction angle. CU Triaxial test with pore pressure measurement.

CE 6110 - Earth Retaining Structures

Three credit-hours. Prerequisite: None. One four hours session per week.

Retaining Structures. Stability of retaining walls. Waterfront structures. Sheet piling wall analysis and design. Wales and tie rods. Deadman capacity. Methods for reducing lateral pressure. Relieving platforms. Energy, absorbing capacity of dolphins. Design of braced cofferdams. Lateral pressure and stability.

CE 6114 - Shallow Foundations

Three credit-hours. Prerequisite: None. One four hours session per week.

Shallow foundations. Ultimate bearing capacity theories under centric vertical, inclined, and eccentric loads. Special cases of shallow foundations. Settlement and allowable bearing capacity. Dynamic bearing capacity and settlement. Shallow foundations on reinforced soil. Uplift capacity of shallow foundations.

CE 6116 - Consolidation Theory and Applications

Three credit-hours. Prerequisite: None. One four hours session per week.

Compressibility of soils. Consolidation test. Consolidation settlement calculations. Time rate of consolidation. Determination of coefficient of permeability. Evaluation of secondary settlement. Vertical drains. Design of surcharge monitoring program.

CE 6120 - Deep Foundations

Three credit-hours. Prerequisite: None. One four hours session per week.

Characteristics and capabilities of deep foundations. Sheet pile walls on sandy and clayey soils. Estimation of pile length. Load transfer mechanism. Estimation of pile capacity. Settlement of piles. Pullout resistance. Pile driving formulas. Group capacity and elastic settlement. Negative skin friction. Drilled-Pier and Caisson foundations.

CE 6125 - Soil Dynamics

Three credit-hours. Prerequisite: None. One four hours session per week.

Fundamentals of vibrations. Waves in elastic medium. Properties of dynamically loaded soils. Foundation vibration. Dynamic bearing capacity of shallow foundations. Liquefaction of soil.

CE 6130 - Geotechnical Earthquake Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

The principles, theories and methods of Geotechnical earthquake engineering. Principles of wave propagation and their applications for the development of local site effects, liquefaction and slope stability under seismic conditions.

CE 6140 - Slope Stability

Three credit-hours. Prerequisite: None. One four hours session per week.

Subsoil exploration and sampling for slope stability. Shear strength for slope stability analysis. Factor of safety. Procedures for computations, Ordinary, Bishop, Jambu and Spencer methods. Water pressures and unit weight. Short and long-term conditions. Pseudo-static analysis. Common problems in computer analysis. Back analysis of slope failures. Computer applications. Slope stabilization and monitoring program.

CE 6150 - Seepage and Drainage

Three credit-hours. Prerequisite: None. One four hours session per week.

Permeability. Seepage principles. Flow nets. Quick conditions. Filter and drain design. Geosynthetics applications. Seepage control in earth dams and levees. Cutoff walls. Foundation dewatering and drainage. Slope stabilization with drainage. Instrumentation.

CE 6174 – Finite Element Methods for Geotechnical Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Review of Theory of Elasticity. Variational Principles. Domain discretization. Displacement approximation. Shape functions and generalized coordinates approach. Finite Element Stiffness Matrix. Isoparametric elements. Consistent load vector. Bar elements applied to pile analysis. Plane strain elements applied to slope and earth gravity dam analysis. Plate elements applied to analysis of mats on elastic foundations. Commercial packages. Advanced topics in geotechnical computational mechanics.

CE 6210 - Probability and Statistics in Water Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Probability and statistical principles applied to the solution of hydrologic problems. Application of probability distributions to the rainfall and runoff process. Field analysis using random distributions and functions. Determination of confidence intervals and hypothesis. Analysis of annual and partial hydrologic time series.

CE 6220 - Meteorology

Three credit-hours. Prerequisite: None. One four hours session per week.

Composition of the atmosphere. Temperature and air mass. Atmospheric pressure and occurrence of winds. Precipitation and condensation processes. Climate zones. Weather prediction. Atmospheric pollution. Instrumentation and measurement.

CE 6230 - Groundwater Hydrology

Three credit-hours. Prerequisite: None. One four hours session per week.

Description of the occurrence of groundwater and its relation to the hydrologic cycle. Study of the mechanics of flow in a porous media, groundwater movement and well hydraulics. Quality and pollution of groundwater. Saline water intrusion. Groundwater management and artificial recharge.

CE 6240 - Urban Drainage

Three credit-hours. Prerequisite: None. One four hours session per week

Studies of storm water management in urban areas emphasizing storm drainage systems associated with transportation facilities and urbanized watersheds. Basic topics: a) Surface drainage systems design parameters and regulations, b) Flow in gutters, c) Drainage inlet and median channels analysis, d) Detention and retention storage facilities analysis.

CE 6250 - Advanced Hydrologic and Hydraulic Modeling

Three credit-hours. Prerequisite: None. One four hours session per week.

Methods of modeling hydrologic and hydraulic systems are examined. Basic topics: a) Particular models, b) Model selection, c) Model calibration procedures, d) Model application to real cases.

CE 6260 - Analysis and Restoration of Fluvial Systems

Three credit-hours. Prerequisite: None. One four hours session per week.

This is a practical course, which describes the characteristics, management and restoration of fluvial systems and their associated estuary and wetland habitats. It provides an integrated overview of the morphology, ecology, hydrology, hydraulics and sediment dynamics of both artificial and natural channels and their associated floodplains. Tools are presented to observe, sample, and interpret basic problems that affect fluvial systems, and to define and analyze restoration alternatives.

CE 6270 - Sedimentation Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Sediment transport Analysis and management in the fluvial environment. A practical course on the characteristics and management of fluvial sediments including: sediment characteristics, origin and transport of sediments, sampling and measurements of both coarse and fine sediment, initiation of motion, channel hydraulics and stability, numerical and physical modeling concepts, design of fixed and live bed channels. Includes practical applications in the area of reservoir design and management, bridge scour, intake design, and streambank erosion and design of naturalized channels.

CE 6280 - Reservoir Analysis and Design

Three credit-hours. Prerequisite: None. One four hours session per week.

Physical characteristics of reservoirs: yield, capacity, reliability, sedimentation. Types of reservoirs. Forces on dams, gravity dams, arch dams, earth dams. Failure, safety and rehabilitation of dams. Spillways, gates and outlet structures.

CE 6300 - Structural Engineering Laboratory

Three credit-hours. Prerequisite: None. One four hours session per week.

Experimental determination, and correlation with theoretical predictions of behavior of basic structures under static and dynamic loading conditions. Tests include tension, compression, fatigue, and strain gauge measurements.

CE 6305 - Simulation Engineering Laboratory

Three credit-hours. Prerequisite: None. One four hours session per week.

The development of numerical structural system models. Applications of software system to design and analysis. Interactive design techniques of optimal design and structural element configuration. Experimental stress analysis using computer tools.

CE 6315 - Analysis of Plates and Shells

Three credit-hours. Prerequisite: None. One four hours session per week.

Bending of flat plates. General theory. Folded plates. Slab action and beam behavior. Shear flow at plate intersections. Membrane stresses and displacement of shells of revolution. Bending stresses in circular domes. Synclastic surfaces. Cylindrical shells. Antiplastic surfaces. Hyperbolic paraboloid shells. Edge geometry and support conditions. Prestressing in plates and shells.

CE 6320 - Advanced Strength of Materials

Three credit-hours. Prerequisite: None. One four hours session per week.

Theories of stress and strain, linear stress-strain. Temperature relations, inelastic material behavior, nonsymmetrical bending of straight beams, torsion, beams oil elastic foundations. Applications to cylindrical shells. Two-dimensional theory of elasticity. Matrix formulation.

CE 6323 - Design of Composite Materials

Three credit-hours. Prerequisite: None. One four hours session per week.

Fibers and polymers. Pultrussion process. Micro and macro mechanics of a lamina. Lamination analysis. composite structures: beams, columns and plates. Mechanical testing of composites. Failure analysis. Viscoelastic analysis. Stability analysis. Sensitivity analysis.

CE 6325 - Principles of Structural Stability

Three credit-hours. Prerequisite: None. One four hours session per week.

Integration of the neutral equilibrium differential equation in columns. Energy method. Principle of stationary total potential energy. Second order strains. Stress stiffness matrix in flexural members. Eigenvalue problem. Buckling of trusses and frames. Computer program. Torsional and torsional-flexural buckling of beams. Stress stiffness matrix plate elements. Local buckling. Inelastic effects.

CE 6330 - Advanced Topics in Structural Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Advanced matrix analysis methods. Applications to bar-element structures, with particular emphasis on the stiffness method application, computer implementation, and the usage of spreadsheets and analysis packages.

CE 6335 - Advanced Foundations

Three credit-hours. Prerequisite: None. One four hours session per week.

The applications of the principles of soil mechanics to the design of foundations. Subsurface investigation. Design of footings, retaining walls, pile foundations, flexible retaining structures, anchor tie-backs, bridge piers, abutments, dewatering system, and underpinning. Case studies.

CE 6340 - Advanced Bridge Design

Three credit-hours. Prerequisite: None. One four hours session per week.

Introduction to modern highway bridges. Design of concrete, steel and timber superstructures. Design of bridge substructure, including: piers, abutments and bearings. Bridge seismic analyses. Introduction to bridge inspection and maintenance.

CE 6345 - Design of Reinforced Masonry Structures

Three credit-hours. Prerequisite: None. One four hours session per week.

Design of Masonry building structures using working stress and ultimate strength. Design methods. Lateral load distribution to shear walls. Design of shear and bearing masonry walls subjected to lateral and gravity load conditions. Quality control and construction of masonry structures. Reinforced masonry, system behavior state analysis.

CE 6350 - Dynamics of Structures

Three credit-hours. Prerequisite: None. One four hours session per week.

Analysis and design of structures under time-dependent loads. Response of elastic damped and undamped structural systems. Vibration analysis for single and multiple lumped mass systems and continuous systems. Lagrange's equation. Design for earthquake and impact loadings.

CE 6355 - Advanced Earthquake Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Earthquake characteristics and hazard. Overview of earthquake resistant design. Behavior of buildings. Design of moment resisting frames, walls, dual system, diaphragms. Design of foundation structures. Safety evaluation and strengthening of existing structures.

CE 6357 - Wind Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Introduction to Wind Engineering. Prediction of design wind speed and structural safety. Strong wind characteristics and turbulence. Basic bluff-body aerodynamics. Resonant dynamic response and effective static load distribution. Internal pressures. Laboratory simulation of strong winds and wind loads. Wind tunnel experiments. Wind loads in low-rise buildings, tall buildings, bridges and other types of structures.

CE 6360 – Bridge Inspection, Rehabliltation, Repair and Management

Three credit-hours. Prerequisite: None. One four hours session per week.

Overview of the bridge engineering process: from the origins of bridge project through its design and the eventual maintenance and rehabilitation of a structure.

CE 6370 - Finite Element Methods in Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Generation of finite element stiffness matrix. Shape functions and generalized coordinates approach. Consistent load vector and thermal effects. Programming techniques. Plane elasticity. Isoparametric elements. Assumed stress hybrid approach. Rectangular, triangular and quadrilateral elements. Conforming and non-conforming plate bending elements. Stiffness matrix contribution of elastic foundation. Displacement constraints. Lagrange multipliers. Development of computer programs.

CE 6375 - Advanced Finite Element Methods in Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Semi-analytical finite element processes. Use of orthogonal functions and "finite strip" methods. Non-linear plasticity, creep, viscoplasticity. Non linear geometrically covering the large displacement and structural instability.

CE 6378 - Advanced Reinforced Concrete Design

Three credit-hours. Prerequisite: None. One four hours session per week.

Advanced analysis and design of reinforced concrete structures. Short and slender columns and beam-columns. Torsion, shear in short elements. Bearing and shear walls. Two-way floor systems. Composite structures.

CE 6380 - Non Linear Behavior of Concrete Structures

Three credit-hours. Prerequisite: None. One four hours session per week.

Geometrically non-linear and mechanically non-linear behavior of reinforced concrete elements. The moment-curvature responses and relationships. Mechanics fracture of concrete elements.

CE 6385 - Advanced Steel Design

Three credit-hours. Prerequisite: None. One four hours session per week.

Behavior of elements subjected to tensile, bending, and compression forces. Design of connections. Design of plate-girders.

CE 6390 - Lateral Load Distribution in Multistory Buildings

Three credit-hours. Prerequisite: None. One four hours session per week.

Stiffness matrix of frame elements. Shear wall representation as wide column. Coupling beams. Reduction of the building stiffness matrix to horizontal floor displacements. Floor center of rigidity and principal axes. Transformation of reduced stiffness matrix to principal displacements at shear centers. Lateral load vector as per current code. Diaphragm displacements and loads on parts of the lateral force resisting system. Detailed discussion of a special purpose computer software. Applications.

CE 6395 - Nonlinear Analysis of Soil-Structure Interaction

Three credit-hours. Prerequisite: None. One four hours session per week.

Nonlinear stress-displacement relationship at soil-structure interface. Discussion of differences between granular and cohesive soils. Refined beam-column with five (5) degrees of freedom to allow distributed load between nodes. Element stiffness matrix and geometric non-linearity expressed by corresponding stability matrix. Analytical procedure to take into account the non-linear soil response by means of a corrective force vector. Discussion of computer software for calculation of ultimate pile lateral load capacity considering non-linear soil behavior and second order effects. Studies of bridge pile bent subjected to large lateral forces caused by extreme ground motion during earthquakes.

CE 6410 - Water And Wastewater Treatment Applications

Three credit-hours. Prerequisite: None. One four hours session per week.

Development of sampling programs and experimental procedures to evaluate untreated water sources, and the treatment performance of potable water and wastewater unit processes. The results can be used to improve the operation and maintenance of existing facilities and the design of new facilities with confidence based on field data.

CE 6420 - Fate and Transport of Contaminants in Soils

Three credit-hours. Prerequisite: None. One four hours session per week.

Engineering principles applied to the study of contamination and remediation of soils. Basic topics: a) Characteristics of soils, b) Origin and nature of soil contamination, c) Fate and Transport of contaminants in the subsoil, d) Remediation of soil contamination.

CE 6430 - Remediation in Contaminated Subsurface Environments

Three credit-hours. Prerequisite: None. One four hours session per week.

Remediation engineering: design and applications to emphasize the engineering aspects of using remediation process for the treatment of contaminated soils, sludge, and groundwater.

CE 6440 - Physical and Chemical Treatment Processes of Water and Wastewater

Three credit-hours. Prerequisite: None. One four hours session per week.

Physical and chemical characteristics of water and wastewater. Analysis of the theory and applications of physical and chemical processes to the treatment of water and wastewater: screening, sedimentation, thickening, dissolved air flotation, coagulation, chemical precipitation, mixing, flocculation, filtration, electrodialysis and pressure membranes, adsorption, aeration, absorption and stripping, water softening, water stabilization, ion exchange, and disinfection. Design criteria and evaluation techniques for these processes. Chemical requirements and sludge production calculations.

CE 6450 - Biological Wastewater Treatment Processes

Three credit-hours. Prerequisite: None. One four hours session per week.

Fundamentals of biochemical operations for wastewater treatment. Modeling of ideal suspended growth reactors. Techniques for evaluating kinetic and stoichiometric parameters. Design and evaluation of suspended growth processes: activated sludge, biological nutrient removal processes, aerobic digestion, anaerobic processes, and lagoons. Modeling of ideal attached growth reactors. Biofilm modeling. Design and evaluation of attached growth processes: trickling

filters, rotating biological contactors, and submerged attached growth bioreactors.

CE 6460 - Water Quality Control and Management

Three credit-hours. Prerequisite: None. One four hours session per week.

Study of the water quality control framework, based on the Clean Water Act (CWA) and the Safe Water Drinking Act (SDWA). Basic topics: a) Clean Water Act b) Safe Drinking Water Act, c) Detection and Monitoring, d) Treatment and Quality Control.

CE 6512 - Value Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

Fundamentals of value engineering Project Budgeting. Budgeting techniques. Cost control. Cost models. Planning for value engineering. Human factor. Case studies.

CE 6520 - Construction Contracting and Procurement

Three credit-hours. Prerequisite: None. One four hours session per week.

Project delivery methods. Contract participants and roles. Contract forms and clauses. Contract documents interpretation and modifications. Construction Contract Administration. Alternative Dispute Resolution.

CE 6530 - Schedule Impact Analysis

Three credit-hours. Prerequisite: None. One four hours session per week.

Scheduling specifications. Time Impact Analysis Techniques. Construction delay claims. Damages quantification. Schedule claims preparation/presentation/defense.

CE 6532 - Construction Cost Control

Three credit-hours. Prerequisite: None. One four hours session per week.

Construction financial management. Accounting for construction financial resources. Managing costs and profits. Managing cash flows. Managing assets and debt. Financial decisions.

CE 6540 - Construction Equipment Administration

Three credit-hours. Prerequisite: None. One four hours session per week.

Construction Equipment Management. Organizational Structures for EM. Economics / Operation / Mechanics of Construction Equipment Systems. Performance and Productivity Measures. Automation in Equipment Management (EM).

CE 6542 - Construction Material Management

Three credit-hours. Prerequisite: None. One four hours session per week.

Material Management Systems. Total Material Costs. Materials requirements planning. Total Quality Management. lust-in-Time concept. Vendor evaluation. Purchasing. Expediting. Field control. Automation in Material Management.

CE 6544 - Hazardous Material Management

Three credit-hours. Prerequisite: None. One four hours session per week.

This course covers the safety, health and transportation regulations of hazardous materials according to Federal and Local Agencies Regulations, such as: Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and Department of Transportation (DOT).

CE 6550 - Construction Inspections

Three credit-hours. Prerequisite: None. One four hours session per week.

Fundamentals of engineering construction inspections. Specifications writing. Contracts. Qualifications & requirements. Inspections procedures. Roles, duties and allocations of responsibilities. Project coordination. Project location. Standards and codes. Guidelines for inspectors. Field inspections. Structural inspections. Geotechnical inspections.

CE 6560 - Construction Safety Planning & Regulations

Three credit-hours. Prerequisite: None. One four hours session per week.

Fundamentals of safety in construction industry. Construction accidents. Safety plan development. Safety management during construction project. OSHA regulations and compliance. Jobsite assessment. Safety record keeping. Safety meetings. Subcontractors.

CE 6570 - Modern Construction Materials

Three credit-hours. Prerequisite: None. One four hours session per week.

This course discusses the production, properties, and performance of modern construction materials and their application on special construction environments.

CE 6580 -Temporary Structures in Construction

Three credit-hours. Prerequisite: None. One four hours session per week.

Fundamentals of temporary structures in construction industry. Technical, business, and legal aspects to build and maintain different temporary support and access structures. Erection and earthwork equipment. Dewatering. Underground support. Construction ramps, runways and platforms. Concrete formwork. False work. Protection of site.

CE 6585 - Site Planning and Design

Three credit-hours. Prerequisite: None. One four hours session per week.

Introduction to the process of site analysis, environmental issues, building laws and regulations related to land

development. Geographical, topographical, climatic, and ecological issues are approached to complement the understanding of site analysis and design. Surveying, grading, water spply systems, stormwater and sanitary sewer systems design principles are issues to be presented.

CE 6900 - Introduction to Research in Civil Engineering

Three credit-hours. Prerequisite: None. One four hours session per week.

This course introduces students to the different stages of a formal research process in engineering sciences. Emphasis is given to the first steps of the process, that lead to the development of a thesis (project) proposal: topic selection, formulation of preliminary objectives, development of a comprehensive literature review, and definition of the research project objectives, scope, methodology, and schedule of activities.

CE 6901 - Master's Thesis Dissertation

Six credit-hours. Prerequisite: Graduate Program Mentor Approval. One four hours session per week.

Experimental and/or theoretical research to be presented in thesis for degree requirements.

CE 6902 - Extension of Master's Thesis Dissertation

Zero credit-hours. Prerequisite: Graduate Program Mentor Approval. One four hours session per week.

Extension to complete the experimental and/or theoretical research to be presented in thesis for degree requirements.

CE 6905 - Master Project, "Final Project"

Three credit-hours. Prerequisite: Graduate Program Mentor Approval. One four hours session per week.

Development of a design project covering all relevant aspects and using advanced analysis and design techniques.

CE 6906 - Extension of Master Project, "Final Project"

Zero credit-hours. Prerequisite: Graduate Program Mentor Approval. One four hours session per week.

Extension to complete the development of a design project covering all relevant aspects, and using advanced structural analysis and design techniques.

CE 6910 - Comprehensive Examination

Zero credit-hours. Prerequisite: Graduate Program Mentor Approval. One four hours session per week.

Written and oral comprehensive exams on the major field of study.

CE 6999 - Special Topics in Civil Engineering

Three credit-hours. Prerequisite: Graduate Program Mentor Approval. One four hours session per week.

Special topics in any areas of civil engineering.

PROGRAM FACULTY

Alsaadi, Balhan Altayeb – Professor, **Ph.D.** in Civil Engineering, Polytechnic University of Madrid, Spain, 1988; **M.S.C.E.** and **B.S.C.E.**, Trian Vuia Polytechnic Institute, Timisoara, Romania, 1984.

Coll Borgo, Manuel – Lecturer II, **Ph.D**. in Civil Engineering, University of Puerto Rico, Mayagüez Campus, 2001; **B.S.C.E.**, University of Puerto Rico, Mayagüez Campus; 1994; P.E.

Collazos Ordóñez, Omaira – Professor, **Ph.D.** in Civil Engineering, University of Missouri – Columbia, 2003; **M.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1993; **B.S.C.E.**, University of Cauca, Colombia , 1989.

Cruzado Vélez, Héctor J. – Professor, **Ph.D.** in Wind Science and Engineering, Texas Tech University, 2007; **M.S.C.E.**, Massachusetts Institute of Technology, 1998; **B.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1996; P.E.

Cuevas Miranda, David – Lecturer II, **Ph.D.** in Geological Oceanography, University of Puerto Rico, Mayagüez Campus, 2010; **M.S.** in Geology, Saint Louis University, 2003; **B.S.** in Geology, University of Puerto Rico, Mayagüez Campus, 1998.

Delgado Loperena, Dharma – Professor, **Ph.D.** in Human Environmental Sciences, University of Missouri – Columbia, 2004; **M. Arch.**, University of Puerto Rico, Río Piedras Campus, 1983; **B.A.** in Environmental Design, University of Puerto Rico, Río Piedras Campus, 1981.

Deschapelles Duque, Bernardo – Professor, **Ph.D.** in Civil Engineering, California Western University, 1983; **M.S.C.E.**, California Western University, 1981; **B.S.C.E.**, University of Havana, Cuba, 1954; B.S.Ch.E., University of Havana, Cuba, 1952; P.E.

Elías Rivera, Johnny – Professor, **LL.M.**, Catholic University of Puerto Rico, 1983; **J.D.**, University of Puerto Rico,1974; **Ph.D.** in Civil Engineering, University of California, 1964; **B.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1959, P.E., Esq.

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González Miranda, Carlos J. – Professor, **Ph.D.** in Industrial Engineering, North Carolina State University, 1995; **M.M.S.E.**, North Carolina State University, 1990; **B.S.I.E.**, University of Puerto Rico, Mayagüez Campus, 1987.

Guzmán De La Cruz, Alberto – Professor, **Ph.D.** in Civil Engineering, University of Puerto Rico, Mayagüez Campus, 1998; **M.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1994; **B.S.C.E.**, Institute of Technology of Santo Domingo, Dominican Republic , 1990; P.E.

Malaver Muñoz, Roger – Associate Professor, **Ph.D.** in Chemical Engineering, University of Sherbrooke, Canada, 1999; **M.S.Ch.E.**, University of Puerto Rico, Mayagüez Campus, 1993;

B.S.Ch.E., National University of San Marcos, Perú, 1990; **B.S.** in Food Technology Engineering, Villareal University, Perú, 1987.

Mueses Pérez, Auristela – Professor, **Ph.D.** in Civil Engineering, University of Florida; **M.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1992; **B.S.C.E.**, Technological Institute of Santo Domingo, Dominican Republic, 1987; P.E.

Pabón González, Miriam – Professor, **Ph.D.** in Industrial Engineering, University of Massachusetts, 2001; **M.E.M.**, Polytechnic University of Puerto Rico, 1995; **B.S.I.E.**, University of Puerto Rico, Mayagüez Campus, 1990; P.E.

Pacheco-Crosetti, Gustavo – Professor, **Ph.D.** in Civil Engineering, University of Puerto Rico, Mayagüez Campus, 2007; **M.S.** in Finite Element Method, UNED, Spain, 1996; **M.S.C.E**., University of Puerto Rico, Mayagüez Campus, 1993; **B.S.C.E.** and **M.S.C.E.**, National University of Córdoba, Argentina, 1988; P.E.

Pimenta De Oliveira, Aluisio – Associate Professor, **Ph.D.** in Environmental Engineering, Rensselaer Polytechnic Institute, New York, 2001; **M.S.Ch.E.**, University of Maryland, 1983; **B.S.Ch.E.**, University of Maryland, 1976; P.E.

Torres Rivera, Reinaldo – Associate Professor, **M.Arch.**, University of Puerto Rico, Río Piedras Campus, 1987; **B.** in Environmental Design, University of Puerto Rico, Río Piedras Campus, 1983.

Villalta Calderón, Christian A. – Assistant Professor, **Ph.D.** in Civil Engineering, University of Puerto Rico, Mayagüez Campus, 2009; **M.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 2004; **B.S.C.E.** University of Costa Rica, 2001.

MASTER PROGRAM IN COMPUTER ENGINEERING

The Electrical and Computer Engineering and Computer Science Department at the Polytechnic University of Puerto Rico offers graduate programs in Computer Engineering, in Computer Science, and in Electrical Engineering. For the Master in Computer Engineering, the Thesis option leads to a Master of Science in Computer Engineering (M.S.Cp.E) degree and the non-Thesis option leads to a Master of Engineering in Computer Engineering (M.Eng.Cp.E.) degree. Currently, there are three areas of specialization for the M.S.Cp.E or the M.Eng.Cp.E; Software Engineering, Internet Engineering, and Digital Signal Processing. By choosing appropriate elective courses at the graduate level the student can tailor the program to his/her specific interests or research focus. An advisor will work closely with the student to carefully choose the elective courses that fulfill the student's professional expectations in breadth as well as in depth.

PROGRAM PHILOSOPHY

Our program is flexible enough to be tailored to the student interests while providing sufficient breadth and depth to accommodate the rapid changes taking place in the field. This program aims to enable graduates to pursue further studies at the doctoral level, enter the industrial workforce, create technological new ventures, be self-employed, or work in a research and development environment. This graduate program offers engineers, or scientists with appropriate background, a unique opportunity to become more productive by acquiring knowledge of advanced technologies in the Computer Engineering field. This also includes the exploration of projects with a technical venture, or entrepreneurial focus.

GRADUATE PROFILE AND OUTCOMES

Our graduates should be able to keep abreast of the latest developments in their areas, read and analyze journal papers from their field, conduct independent research in their areas of interest (Thesis Option), write papers or technical reports, conduct technical and scientific presentations within a conference environment, and explore technological venture opportunities with an entrepreneurial mind-set.

We also promote in our students awareness of the need to actively pursue continuing education and professional development in order to remain actualized in the computer engineering field.

CAREER OPPORTUNITIES

The computer industry in Puerto Rico and the United States should be a primary source of employment for engineers and scientists holding Masters in Computer Engineering. The federal and local government, as well as the high technology companies in the U.S. and Puerto Rico offer additional opportunities for engineers and scientists holding master degrees. Graduates of this master program can also teach at the undergraduate or technical level, or can pursue a doctoral degree.

PROGRAM REQUIREMENTS

Admission Requirements

Applicants must meet the general requirements for admission to the graduate program outlined by the Graduate School. In addition applicants are expected to have a Bachelor of Science in Computer Engineering, preferably from an ABET-accredited institution, or a Bachelor of Science in Computer Science, and a minimum general GPA of 2.8, and a GPA of 3.00 in the computer related courses. After a revision of the student's credit transcript the department may require him/her to take certain developmental or pre-requisite courses.

The student is normally admitted to the master's degree program in the field in which his or her undergraduate degree was conferred. When the student decides to do graduate work but his background is from a different field, the department, at its discretion, may require him/her to establish additional background by taking a number of undergraduate courses. These requirements must be fulfilled as early as possible in the student's program. Courses taken to remedy deficiencies cannot be used to fulfill course requirements for the master's degree.

Graduation Requirements

A candidate for a master's degree in Computer Engineering must:

- Complete the plan of study with at least the minimum number of credit-hours specified by the M.S.Cp.E. (15 credits of core courses, 6 credit-hours of thesis and 12 credit-hours in elective courses) or the M. Eng. Cp.E. (15 credit-hours of core courses, 21 credit-hours of elective courses, and 3 credit-hours for a project), with a minimum GPA of 3.0 points.
- Present and defend an independently written, single author, thesis (for students enrolled in the thesis option).
- Pursue a plan of study that will lead to the completion of all requirements, including those of the department, within a maximum number of years established by the Graduate School.
- Satisfy all other institutional requirements for graduation.

DEGREES OFFERED

The Thesis option leads to a Master of Science in Computer Engineering (M.S.Cp.E.) degree and the non-Thesis option leads to a Master of Engineering in Computer Engineering (M.Eng.Cp.E.) degree.

Thesis Option:

This option provides a significant element of independent research through the completion of a thesis. This option is recommended, but not limited, to the student either seeking to pursue a doctoral degree or planning to work in a research and development environment. It consists of 15 credit-hours of core courses, 6 credit-hours of Thesis work and 12 credit-hours of elective courses for a total of 33 credit-hours. Students enrolled in this track will receive a Master of Science in Computer Engineering (M.S.Cp.E.).

The thesis research shall be directed by a member of the faculty, which also acts as the student's advisor and graduate committee chairperson. The purpose of the thesis is to expose the student to a reasonably independent research experience that enhances his/her academic development. The student should prepare, carry out and report a structured and methodical study of importance. Publication of this work in journals, conference proceedings, and/or poster presentations is strongly encouraged.

Thesis Requirements:

1. Thesis Topic: The thesis topic must be approved in writing by the student graduate committee. The topic should be of sufficient relevance to illustrate the student's ability to conduct independent research to the extent described above.
2. Thesis Exam (Defense): The student will make an oral presentation followed by a session of question and answers. Students must approve an oral thesis examination before his/her graduate committee.
3. Continuous Enrollment: Once the graduate committee has accepted the student's topic the student can receive authorization to enroll in the Thesis course. It is recommended that the student maintains continuous enrollment through the Thesis Extension course.
4. Thesis Copies: The student will be required to submit copies of the thesis in a format approved by the Graduate School. After approval and correction, a final version of the copies will be maintained in the library.

Non-Thesis Option:

The non-thesis option also provides for some degree of exposure to independent research through class projects, literature search and paper reviews. Because of the additional course load required by this alternative the student can select to specialize further in his/her area or to add more breadth to his program. This option is recommended, but not limited, to students who are not interested in seeking a higher degree (Ph.D.), but rather have an entrepreneurial bent. Its completion requires 15 credit-hours of core courses, 21 credit-hours of elective courses, and a 3 credit Project course, for 39 credit-hours. Students enrolled in this option will receive a Master of Engineering in Computer Engineering (M.Eng.Cp.E.). This option does not require a comprehensive examination but requires a final project which the program encourages to be the exploration of an opportunity for an entrepreneurial technological venture through the development of a prototype for the proposed new product or service, the hardware aspects and environment for the project should be discussed.

CURRICULAR STRUCTURE AND SEQUENCE

The Master of Science program is a flexible program that can be tailored to the student's interest while providing solid grounding through 15 credit-hours of core courses on some of the key concepts and tools related to the Computer Engineering field. For each area of interest the required undergraduate courses are defined as the minimum background or prerequisites necessary to enter the field. The students will have to enroll in these courses if they did not take them as part of their undergraduate studies.

Further remedial courses could be determined, at the discretion of the department, on an individual student basis depending on the student's background and chosen field of study. If further remedial courses are prescribed they will not counted towards the degree, and must be approved with the minimum specified grade.

Software Engineering Area

This area seeks to develop professionals with a strong background in the development of large software systems. Upon graduation the student should be able to go into industry, government, or academia, or pursue doctoral studies. A variety of courses are offered such as: Object Oriented Design, Software Engineering I and II, Data Communication Networks, Computer Security, Advanced DataBase System, Data Mining and Data Warehousing, Special Topics in Software Engineering, Human Computer Interface, Software Testing, Advanced Software

Architecture, and the Software Engineering Project course. New courses are added periodically. In addition to the courses that focus on the Software Engineering methods, techniques, and tools, emphasis is also placed on opportunity identification with a view toward the establishing of new technological ventures in this area, the Technology-Based Startups course, and the Project Course support this aim.

Internet Engineering Area

The purpose of this area of specialization is to prepare professionals that can lead their enterprises in leveraging the Internet and in developing new uses for the information search, dissemination, social and networking collaboration potential of this global infrastructure. Graduates may also pursue further graduate studies leading to a doctoral degree. A diversity of courses are offered such as: Data Communication Networks, Internet Engineering I and II, e-Commerce and Web Information Systems, Computer Security, Object Oriented Design, Human Computer Interfacing, Network Security, Advanced DataBase Systems, Data Mining and Data Warehousing, Special Topics in Internet Engineering, and the Internet Engineering Project course. These cover current and future architectural, human accessibility, and technological aspects of the Internet, providing adequate breadth and depth in the field. In addition to the courses that focus on Internet Engineering, additional emphasis is also placed on opportunity identification with a view toward the establishing of new technological ventures in this area, the Technology-Based Startups course, and the Project Course support this aim.

Digital Signal Processing Area

This area seeks to prepare professionals with a strong background in Digital Signal Processing and its applications. Graduates of this area can be employed by industry, government, academia, or pursue doctoral studies. A variety of courses cover the theory and the application of Digital Signal Processing concepts, including: Linear Systems, Digital Signal Processing, Stochastic Processes, Advanced Mathematics for Signal Processing, Speech Processing, and Image Processing, among others. In addition to the courses that focus on Digital Signal Processing, emphasis is also placed on opportunity identification with a view toward the establishing of new technological ventures in this area, the Technology-Based Startups course, and the Project Course support this aim.

Prerequisite Courses or Equivalents

Course	Title	Credit-Hours
CECS 6000	Computer Science and Engineering Problem Solving	3
CECS 6001	Programming with Objects, Structures and Algorithms (POSA)	3
CECS 6002	Discrete Structures	3
CECS 6003	Logic Circuits	3
MGM 5700	Probabilities and Statistical Methods	3

Core Courses

The student program must include 15 credit-hours of core courses for each area as specified below.

Digital Signal Processing Core (15 credit-hours)

Course	Title	Credit-Hours
EE 5720	Digital Signal Processing	3
EE 6010	Mathematical Methods for Signal Processing	3
EE 6020	Stochastic Processes	3
EE 6030	Linear Systems	3
CECS 6120	Computer Architecture	3

Software Engineering Core (15 credit-hours)

Course	Title	Credit-Hours
CECS 6120	Computer Architecture	3
CECS 6130	Data Communication Networks	3
CECS 6150	Object Oriented Design	3
CECS 6510	Software Engineering I	3
CECS 6605	Advanced Database Systems	3

Internet Engineering Core (15 credit-hours)

Course	Title	Credit-Hours
CECS 6120	Computer Architecture	3
CECS 6130	Data Communication Networks	3
CECS 6150	Object Oriented Design	3
CECS 6605	Advanced Database Systems	3
CECS 6760	Internet Engineering I	3

Elective Courses

Even though all areas of studies have overlapping topics the elective courses are loosely classified into three sections only for organizational purposes but students from each area are free to choose from the whole pool of electives as long as they comply with pre-requisites. The three sections of electives are: Digital Signal Processing-oriented electives, Software Engineering-oriented electives and Internet Engineering-oriented electives.

The area-oriented electives give support, as deemed necessary by the student and his counselor, to the student's chosen field of work.

Each area features a Special Topics Course, a Project Course and/or a Thesis.

The appropriate mix of electives will depend on the chosen field of study and will be carefully decided by the student, working closely with his advisor, in order to fulfill his professional interest in depth as well as in breadth.

Elective courses at the graduate level

(The student may complete the remaining number of required credit-hours by selecting, in agreement with his advisor, courses from this list).

Digital Signal Processing Oriented Electives

Course	Title	Credit-Hours
CECS 6240	Technology-Based Start-Up	3
EE 7712	Image Processing	3
EE 7740	Algorithms for Digital Signal Processing	3
EE 7780	Special Topics in Signal Processing	3

Software Engineering Oriented Electives

Course	Title	Credit-Hours
CECS 6750	Software Testing	3
CECS 7510	Software Engineering II	3
CECS 7802	Special Topics in Software Engineering	3

Internet Engineering Oriented Electives

Course	Title	Credit-Hours
CECS 7230	Network Security	3
CECS 7560	Internet Engineering II	3
CECS 7804	Special Topics in Internet Engineering	3

Electives Related to more than one Area of Studies

Course	Title	Credit-Hours
CECS 6005	Principles of Information Security	3
CECS 6015	IT Auditing & Science Operations	3
CECS 6035	Contingency Planning	3
CECS 6045	Law, Investigation, and Ethics	3
CECS 6240	Technology-Based Start-Up	3
CECS 6430	Advanced Software Architecture	3
EE 6720	Pattern Recognition	3
CIS 6715	E-Commerce and Web Information Systems	3
CECS 7010	Computer Graphics	3
CECS 7020	Advanced Computer Graphics	3
CECS 7130	Advanced Computer Networks	3
CECS 7240	Database Security	3
CECS 7235	Computer Forensics	3
CECS 7520	Human Computer Interaction	3
CECS 7530	Data Mining and Data Warehousing	3
CECS 7550	Artificial Intelligence	3
CECS 7570	Computer Security	3

Thesis and Project Courses

Course	Title	Credit-Hours
CECS 7971	Thesis	6
CECS 7972	Thesis Extension	0
CECS 7900	Project for Master in Computer Engineering	3
CECS 7901	Project Extension for Master in Computer Engineering	0

MASTER IN COMPUTER SCIENCE

The Computer Science Program of the Electrical and Computer Engineering and Computer Science Department at the Polytechnic University of Puerto Rico offers a Master Degree in Computer Science. There are two options: the Thesis option and the non-Thesis option. The Thesis option (33 credit-hours) leads to a Master in Science in Computer Science (MS CS) degree. The non-Thesis option (39 credit-hours) leads to a Master in Computer Science (MCS) Degree. The three main areas of interest to be offered in this program are: IT Management and Information Assurance (ITMIA), Knowledge Discovery and Data Mining (KDDM), and Computer Graphics and Game Technology (CGGT). Combining core courses with recommended electives provides students with an opportunity for advancement throughout the program that can be tailored to their personal needs, research focus, and time limitation.

PROGRAM PHILOSOPHY AND OBJECTIVES

Computer Science is a dynamic field where the fast pace of innovation leads to a need for continuous actualization of knowledge. The emphasis on standard practices, tools and methodologies will provide graduates with empirical knowledge. The program seeks to develop skills in decision-making, leadership, and collaboration. Graduates will possess in-depth engineering and technological knowledge that will allow them to further develop these skills while performing successfully at strategic levels. This know-how is obtained through the development of technical, analytical, and project management/leadership skills and initiatives, acquired throughout the program. The program also prepares graduates for academic careers that can fill the demand for professors in related areas of instruction.

The main objective of the program is to prepare students for a professional career that broadly spans industrial, governmental and academic settings. The program is committed to impart to students the leadership and professional requirements needed in the computer science environment (in all sectors), enabling them to participate in research, and in the development of new systems and components. The program aims to prepare graduates with a desire and capacity for life-long learning and self-development.

GRADUATE PROFILE AND OUTCOMES

Students completing the Master in Computer Science degrees will be professionally prepared and qualified to: apply knowledge of mathematics and computer science to identify, formulate and solve scientific problems, manage capital and intellectual property assets, implement computer security, understand ethical and legal aspects of computing, participate as a team member/leader or project manager. Additionally, provide technical direction in the development of high-level architectural specifications, understand human factors that impact human computer interaction, analyze and interpret data for decision-making, integrate computer systems from components that perform a wide range of tasks and meet user needs, perform as entrepreneurs and consultants, understand

the impact of scientific solutions in a global/societal context, and recognize the need to engage in life-long learning.

CAREER OPPORTUNITIES

The federal and local governments, as well as high-technology companies in PR and the US, represent the main employers of engineers and scientists holding master degrees. The most common categories of occupations that need to have a background in Computer Science are: system software engineers, application software engineers, network/database/system administrators, information security managers, computer system analysts, computer scientists, computer support specialists, game developers, database administrators, specialists in data mining, software publishers, project leaders, Web developers, Internet and Intranet developers, computer science teachers, information managers and others. Graduates may be employed in the computer industry to lead team projects related to hardware and software system design and/or research. Opportunities for employment increase greatly with a Master's Degree in Computer Science.

Advancement leads towards management and administrative positions: Project Manager (PM), Manager of Information Systems (MIS), Chief Information Officer (CIO), Chief Information Security Officer (CISO), Knowledge Engineer (KE), Chief Knowledge Officers (CKO), Database Administrator (DBA), Network Administrator (NA), among others. Some of these may require experience, which also leads to lucrative opportunities as system designers, independent consultants or computer consulting firm owners. The service industry is growing steadily, and is recognized as one of the most promising occupational groups for computer scientists for the next decade.

PROGRAM REQUIREMENTS

Admission Requirements

Applicants must meet the general requirements for admission to the graduate program outlined by the Graduate School. In addition, applicants are expected to have a Bachelor of Science in Computer Science, a minimum general GPA of 2.8.

The student is normally admitted to the master's degree program in the field in which his or her undergraduate degree was conferred. When the student decides to do graduate work but his background is from a different field, the department, at its discretion, may require him/her to establish additional background by taking a number of undergraduate courses. The student has to earn a grade of C or better in his undergraduate work. These requirements must be fulfilled as early as possible in the student's program. Courses taken to remedy deficiencies cannot be used to fulfill course requirements for the master's degree. The program adopts the Polytechnic University guidelines for Combined Bachelor's Master's Degree Program by allowing students who have accumulated a minimum of 85% from their total credit-hours towards the Bachelor degree to begin taking graduate courses from the Master in Computer Science (MSCS/MCS) programs.

Graduation Requirements

A candidate for the Master Degree in Computer Science (MCS) or the Master in Science in Computer Science (MS CS) is required to complete a plan of study with a minimum number of credit-hours specified by the selected option:

M.C.S. (Non-Thesis Option)

Core: 15 credit-hours; Electives: 21 credit-hours; Project Course: 3 credit-hours; Total: 39 credit-hours.

M.S.C.S. (Thesis Option)

Core: 15 credit-hours; Electives: 12 credit-hours; Thesis: 6 credit-hours; Total: 33 credit-hours.

Students should present and defend an independently written, single author thesis (for thesis option), pursue a plan of study that will lead to the completion of all requirements including those of the department and satisfy other institutional requirements for graduation.

CURRICULAR STRUCTURE AND SEQUENCE

Areas of Interest

The three main areas to be offered in this program are: IT Management and Information Assurance (ITMIA), Knowledge Discovery and Data Mining (KDDM), and Computer Graphics and Game Technology (CGGT).

IT Management and Information Assurance (ITMIA) Area of Interest

The ITMIA specializes in training graduates to become leaders in IT groups in the financial industry, including knowledge in security, operations, off-shoring and financial terminology. There is a shortage of skilled computer security professionals capable of reducing vulnerabilities in computing systems.

Knowledge Discovery and Data Mining (KDDM) Area of Interest

The KDDM are relevant in various industries such as finance or pharmaceutical where there are vast amount of data to be analyzed and leveraged for new business ideas. Graduates will be knowledgeable in applying algorithms and building systems to work with real-world data.

Computer Graphics and Game Technology (CGGT) Area of Interest

The CGGT addresses the gaming industry by focusing on technology needed to be successful in that growing industry. Graduates will be knowledgeable in applying advanced AI techniques for commercial computer games, the use of commercial game technology for training and education, product development methodologies, and entrepreneurship.

Thesis Option Degree Requirements (for a total of 33 credit-hours)

The thesis option requires a minimum GPA of 2.8 from baccalaureate studies in Computer Science or related fields.

Degree requirements for this option include the completion of twenty-seven (27) credit-hours of coursework and six (6) credit-hours of approved thesis work. Fifteen (15) credit-hours of core courses at the 6000-6900 are required for the degree. Twelve (12) credit-hours of 6000-7900 level elective courses must be approved. Six (6) additional credit-hours must be completed through the development of a thesis in a subject related to the MS in Comp. Science program. The thesis subject matter is to be approved by the student's graduate advisor and the thesis committee. The total of thirty-three (33) credit-hours is required for the thesis option.

Non-Thesis Option Degree Requirements (for a total of 39 credit-hours)

The non-thesis option requires a minimum GPA of 2.8 from baccalaureate studies in Computer Science or related fields. Degree requirements for this option total thirty-nine (39) credit-hours that include thirty-six (36) credit-hours of coursework and three (3) credit-hours of project courses. Fifteen (15) credit-hours of core courses at the 6000-6900 level are required for the degree. Twenty (21) credit-hours of 6000-7900 level elective courses must be approved and three (3) credit-hours of project courses. The project subject matter is to be approved by the student's graduate advisor. The program encourages, promotes and will give preference to projects with an entrepreneurial scope. The entrepreneurial focus derives from the desire to meet the goals advanced by the Puerto Rico Industrial Development Corporation (PRIDCO) who funded the startup of this program.

Rational for Business Electives

Regardless of industry sector, business application development requires know-how of the application domain. The ability to communicate effectively with the business side is essential to contain development costs and meet the business needs. Furthermore, economics are an increasingly important aspect of strategic technical decisions. As computer scientists with advanced skills graduate into leadership positions in the industry, need to round up their technical skills with relevant business electives.

Prerequisite Course or Equivalents

Course	Title	Credit-Hours
CECS 6000	Computer Science and Engineering Problem Solving	3
CECS 6001	Programming with Objects, Structures and Algorithms (POSA)	3
CECS 6002	Discrete Structures	3

Core Courses
(6000-6900 Level Courses)
(3 credit each) (15 credits)

Course	Title	Credit-Hours
CECS 6010	Advanced Design and Analysis of Algorithms	3
CECS 6030	Computational Theory	3
CECS 6230	IT Operations	3
CECS 6430	Advanced Software Architecture	3
CECS 6750	Software Testing	3

IT Management and Information Assurance (ITMIA)

Course	Title	Credit-Hours
CECS 7230	Network Security	3
CECS 7235	Computer Forensics	3
CECS 7570	Computer Security	3

Knowledge Discovery and Data Mining (KDDM)

Course	Title	Credit-Hours
CECS 6605	Advanced Database System	3
CECS 7530	Data Mining and Data Warehousing	3
CECS 7550	Artificial Intelligence	3

Computer Graphics and Game Technology (CGGT)

Course	Title	Credit-Hours
CECS 7010	Computer Graphics	3
CECS 7020	Advanced Computer Graphics	3
CECS 7550	Artificial Intelligence	3

Additional Elective Courses

Student must complete the remaining number of required credit-hours by selecting courses from this list of electives or those strongly recommended for another area of interest:

Course	Title	Credit-Hours
CECS 6005	Principles of Information Security	3
CECS 6015	IT Auditing and Secure Operations	3
CECS 6035	Contingency Planning	3
CECS 6045	Law, Investigation and Ethics	3
CECS 6240	Technology-Based Start-Up	3
CECS 6760	Internet Engineering I	3
CECS 7130	Advanced Computer Networks	3
CECS 7240	Database Security	3
CECS 7410	Parallel and Distributed Processing	3
CECS 7420	Modeling and Simulation	3
CECS 7510	Software Engineering II	3
CECS 7520	Human-Computer Interaction (HCI)	3
CECS 7760	Internet Engineering II	3
CIS 6715	E-Commerce and Web Inf. Systems	3
CECS 6120	Computer Architecture	3
CECS 6130	Data Communication Networks	3
CECS 6150	Object Oriented Design (OOD)	3
CECS 6510	Software Engineering I	3

Additional Elective Courses

Student must complete the remaining number of required credit-hours by selecting courses from this list of electives.

Thesis option should choose one (1) course; Non-thesis option should choose four (4) courses.

- KDMM or CGGT Courses can be electives for the ITMIA Area.
- ITMIA or CGGT Courses can be electives for the KDDM Area.
- KDDM or ITMIA Courses can be Electives for the CGGT Area.

Requirements for the Thesis and Non-thesis options

Thesis or Project

Course	Title	Credit-Hours
CECS 7980	Thesis	6
CECS 7990	Thesis Extension	0
CECS 7950	Project for Master in Computer Science	3
CECS 7951	Project Extension for Master in Computer Science	0

MASTER IN ELECTRICAL ENGINEERING

The Master Degree in Electrical Engineering offers two options. The Thesis option leads to a Master of Science in Electrical Engineering (M.S.E.E) degree and the non-Thesis option leads to a Master of Engineering in Electrical Engineering (M.Eng.E.E.) degree. Currently there are two areas of interest for the M.S.E.E or the M.Eng.E.E: Digital Signal Processing and Communication Systems. By choosing appropriate elective courses at the graduate level the student can tailor the program to his/her specific interests. A counselor will work closely with the student in order to carefully choose the elective courses that fulfill the student's professional expectations in breadth as well as in depth.

PROGRAM PHILOSOPHY

Our program is flexible enough to be tailored to the student interest while providing sufficient breadth and depth to accommodate the rapid changes taking place in the field.

This program aims to enable graduates to pursue further studies at the doctoral level, enter the industry workforce or work in a research and development environment.

This program intends to offer electrical engineers an opportunity to become more productive by acquiring knowledge of advanced technologies in the Electrical Engineering field. This includes exposing the student to state of the art engineering application software.

The program also seeks to stimulate students to actively pursue continuing education and professional development options in order to stay on the cutting-edge of Electrical Engineering Science and technology.

GRADUATE PROFILE AND OUTCOMES

Graduates should be able to keep abreast of the latest developments in their areas, read and analyze journal papers from their field, conduct independent research in their areas of interest (Thesis Option), write papers or technical reports, conduct technical and scientific presentations within a conference environment, and use mainstream engineering software applications.

CAREER OPPORTUNITIES

The telecommunication industry in Puerto Rico and the United States should be a primary source of employment for engineers holding Masters of Engineering with coursework in Communications Systems and Digital Signal Processing. The federal and local government, as well as the high technology companies in the U.S. and Puerto Rico offer additional opportunities for engineers holding master degrees. Master of Engineering graduates can also teach at the undergraduate or technical level and can pursue a doctoral degree.

PROGRAM REQUIREMENTS

Admission Requirements

Applicants must meet the general requirements for admission to the graduate program outlined by the Graduate School. In addition, applicants are expected to have a Bachelor of Science in Electrical Engineering, preferably from an ABET-accredited institution, a minimum general GPA of 2.8, and a GPA of 3.00 in the electrical engineering courses. After a revision of the student's credit transcript the department may require him/her to take certain remedial courses.

The student is normally admitted to the master's degree program in the field in which his or her undergraduate degree was conferred. When the student decides to do graduate work in a different field, the department, at its discretion, may require him/her to establish additional background by taking a number of undergraduate courses. The student has to earn a grade of C or better in his undergraduate work. These requirements must be fulfilled as early as possible in the student's program. Courses taken to remedy deficiencies cannot be used to fulfill course requirements for the master's degree.

Graduation Requirements

A candidate for a master's degree in Electrical Engineering must:

- Complete the plan of study with at least the minimum number of credit hours specified by the M.S.E.E. (9 credit-hours of core courses, 6 credit-hours of thesis and 15 credit-hours in elective courses) or M.Eng.E.E. (9 credit-hours of core courses and 30 credit-hours of elective courses), with a minimum GPA of 3.0 points (no more than six credit-hours are accepted in transfer courses and no more than six credit-hours of advanced undergraduate courses are allowed).
- Present and defend an independently written, single author thesis (for students enrolled in the thesis option).
- Pursue a plan of study that will lead to the completion of all Graduate School requirements, including those of the department, within a maximum of five years.

- Satisfy all other institutional requirements for graduation.

DEGREES OFFERED

The Thesis option leads to a Master of Science in Electrical Engineering (M.S.E.E) degree and the non-Thesis option leads to a Master of Engineering in Electrical Engineering (M.Eng.E.E.) degree.

Thesis Option:

This option provides a significant element of independent research through the completion of a thesis. This option is recommended, but not limited, to the student either seeking to pursue a doctoral degree or planning to work in a research and development environment. It consists of 9 credit-hours of core courses, 6 credit-hours of Thesis work and 15 credit-hours of elective courses for a total of 30 credit-hours. Students enrolled in this track will receive a Master of Science in Electrical Engineering (M.S.E.E.).

The thesis research shall be directed by a member of the faculty, which also acts as the student's graduate committee chairperson. The purpose of the thesis is to expose the student to a reasonable independent research experience that enhances his/her academic development. The student should prepare, carry out and report a structured and methodical study of importance. Publication of this work in journals, conference proceedings, and /or poster presentations is strongly encouraged.

Thesis Requirements:

1. Thesis Topic: The thesis topic must be approved in writing by the student graduate committee. The topic should be of sufficient relevance to illustrate the student's ability to conduct independent research to the extent described above.
2. Thesis Exam (Defense): Students must approve an oral thesis examination before his graduate committee. The student will make an oral presentation followed by a session of questions and answers.
3. Continuous Enrollment: Once the graduate committee has accepted the student's topic it is mandatory that the student maintains continuous enrollment with the thesis extension course until graduation.
4. Thesis Copies: The student will be required to submit copies of the thesis in a format approved by the Graduate School. After approval and correction, a final version will be maintained in the library.

Non-Thesis Option:

The non-thesis option also provides for some degree of exposure to independent research through class projects, literature search and paper reviews. Because of the additional course load required by this alternative the student can select to specialize further in his/her area or to add more breadth to his program. This option is recommended, but not limited, to students who are not interested in seeking a higher degree (Ph.D.). Its completion requires 9 credit-hours of core courses and 30 credit-hours of elective courses for 39 credit-hours. Students enrolled in this option will receive a Master of Engineering in Electrical Engineering (M.Eng.E.E.). This option does not require a comprehensive examination or final project. If a student desires to tackle a specific project, it can do so under the "Design Project for Master in Electrical Engineering" course.

CURRICULAR STRUCTURE AND SEQUENCE

The Master of Science program is a flexible program that can be tailored to the student's interest while providing solid grounding, through 9 credit-hours of core courses, on some of the key concepts and tools related to the electrical engineering field. For each area of interest required undergraduate courses are defined as the minimum background or prerequisite necessary to enter the field. The students will have to enroll in these courses if they did not take them as part of their undergraduate studies. Background courses are advanced undergraduate courses and count (up to 6 credit-hours) toward the degree.

Further remedial courses could be determined, at the discretion of the department, on a one to one basis depending on the student's background and chosen field of study. If further remedial courses are prescribed they will not count toward the degree and will have to be approved with a grade of C or better.

Communication Systems

The purpose of this area is to prepare professionals with a strong background in Communication Systems. Upon graduation the engineer should be able to enter the telecommunication industry or pursue doctoral studies. Besides Digital, Satellite and Wireless Communications Systems, there are several courses in Antenna and Electromagnetism so that the interested student can specialize further in those areas. A variety of courses are offered such as Digital Communication, Wireless Communication, Satellite Communication Systems, Data Communication and Computer Networks, Digital Signal Processing, Stochastic Processes, Antenna Theory, RF Design, and Engineering Electromagnetic Field Theory.

Digital Signal Processing

The purpose of this area is to prepare engineers that can either enter into the DSP industry or that can pursue further graduate studies leading to a Doctoral degree. A diversity of courses such as Digital Signal Processing, Image Processing, Stochastic Processes, Pattern Recognition, Speech Processing, Algorithms for Signal Processing, Satellite Remote Sensing of the Oceans, Digital Communication and Neural Networks cover coding, compression and information extraction providing adequate breadth and depth in the field.

CURRICULAR STRUCTURE

These courses should be completed during undergraduate studies, or should be taken at the beginning of the graduate studies, prior to (or at the same time than) the core courses.

Digital Signal Processing Area

Course	Title	Credit-Hours
EE 5720	Digital Signal Processing	3

Communication Systems Area

Course	Title	Credit-Hours
EE 5714	Digital Communication Systems	3
EE 5720	Digital Signal Processing	3

Core Courses

The student program must include 9 credit-hours of core courses as specified below.

Digital Signal Processing Core

Course	Title	Credit-Hours
EE 6010	Mathematical Methods for Signal Processing	3
EE 6020	Stochastic Processing	3
EE 6030	Linear Systems	3

Communication Systems Core

Course	Title	Credit-Hours
EE 6010	Mathematical Methods for Signal Processing	3
EE 6020	Stochastic Processes	3
EE 6760	Digital Communications	3

Elective Courses

Even though areas of interest have overlapping topics, the courses are loosely classified in three sections for organizational purposes: Digital Signal Processing oriented electives, Communication Systems oriented electives and Computer Engineering oriented electives.

The Computer Engineering oriented electives give support, as deemed necessary by the student and his counselor, to the student's chosen field of work.

The appropriate mix of electives will depend on the chosen field of study and will be carefully decided by the student, working closely with his advisor, in order to fulfill his professional interest in depth as well as in breadth.

Elective courses at the advanced undergraduate level

(The student may include up to 6 credit-hours selected from this list).

Communication Systems Oriented Electives

Course	Description	Credit-Hours
EE 5730	Radio Frequency Circuit Design	3

Elective courses at the graduate level

(The student may complete the remaining number of required credit-hours by selecting, in agreement with his advisor, courses from this list).

Digital Signal Processing Oriented Electives

Course	Title	Credit-Hours
EE 6632	Non-Linear Control	3
EE 6660	Advanced Robotic Manipulators	3
EE 6720	Pattern Recognition	3
EE 6740	Intelligent Control	3
EE 7712	Image Processing	3
EE 7714	Satellite Remote Sensing	3
EE 7716	Computer Vision	3
EE 7730	Speech Processing	3
EE 7740	Algorithms for Digital Signal Processing	3

Communication Systems Oriented Electives

Course	Title	Credit-Hours
EE 6012	Advanced Engineering Mathematics	3
EE 6760	Digital Communications	3
EE 6770	Satellite Communication Systems	3
EE 7772	Wireless Communication	3

Electives Related to both Areas of Studies

Course	Title	Credit-Hours
EE 7780	Special Topics Digital Signal Processing	3
EE 7790	Design Project for Master in Electrical Engineering	3
EE 7791	Design Project Extension for Master in Electrical Engineering	0
EE 7800	Thesis	6
EE 7801	Thesis Extension	0

Computer Engineering Science Oriented Electives

Course	Title	Credit-Hours
CECS 6120	Computer Architecture	3
CECS 6130	Data Communication Networks	3
CECS 6150	Object Oriented Design	3
CECS 6510	Software Engineering I	3
CECS 6010	Advanced Analysis and Design of Algorithms	3
CECS 6240	Technology based Startups	3
CECS 7550	Artificial Intelligence	3

Note: EE 5720 Digital Signal Processing and EE 5714 Digital Communication Systems are required courses for the Communication Systems track and therefore are requisites for all the courses offered within this area.

If the required courses are not part of the student background, then these courses should be taken prior to admission to the program or during the first two terms of the program.

COMPUTER AND ELECTRICAL ENGINEERING, AND COMPUTER SCIENCE LABORATORIES

Networking Laboratory - This laboratory is equipped with a broad variety of networking appliances including repeaters, switches, routers, firewalls, and servers, plus wireless access points, and wired interconnection panels housed in various cabinets and racks. There are also twenty (20) dual-processor hyper-threading workstations, where the student can configure a variety of protocol stacks and network management software.

Configurable Hardware Laboratory - This laboratory has 15 ML-5001 Evaluation Platform boards for Xilinx Virtex-5 reconfigurable gate arrays. These are connected to PC workstations that are configured with the Xilinx Integrated Software Environment which allow the creation of VHDL models for hardware-implemented functionality of substantial complexity. These models and other intellectual property modules are then compiled, simulated, debugged, synthesized and downloaded into the Evaluation Platform boards, where they can be embedded into the application environment.

Learning Objects Research Collaborative Atelier (LORCA) eLearning Research Laboratory - This laboratory provides space, laptop computers, and several servers to support the development of eLearning and educational support tools. This laboratory is available to students conducting work on eLearning as part of their undergraduate research course, capstone course, graduate thesis course, or graduate project course.

High Performance Computing Center - This laboratory provides a high performance, loosely coupled, parallel computing facility that was established with a grant provided by the Air Force Office of Research of the Department of Defense in 2004 for $101,089. This lab has two Beowulf PC Clusters with 64 processors each and one SGI PC Cluster with 256 processors from a grant from the NSF for $160,000. It also houses an Altix 350 supercomputer with four processors from a grant by PRIDCO. All are used to support scientific and engineering research for graduate and undergraduate students.

Turing Laboratory for Graduate Studies - This laboratory provides faculty members and graduate students state-of-the-art equipment to support their research. The PUPR was recently awarded a grant from PRIDCO for the establishment of the Master in Computer Science (first in Puerto Rico) of $450,000 and for the acquisition, installation, and maintenance of the PCs and workstations, housed in the Turing lab. It includes 24 state of the art Dell Pc's, 10 SGI power workstations, 4 Apple G5 and 4 50" Plasma Monitors.

"Window to the Caribbean" Laboratory - This laboratory creates a virtual environment that connects Puerto Rico to the rest of the world. Its main function will be to participate in collaborative academic and research projects with students, professors, industries and others entities from around the globe. The lab was financed by a grant from the Air Force Office of Research Science of the Department of Defense (AFORS DoD) in 2005 for $181,000.

Virtual Wireless Lab for Information Security - In September 2007 the Army Research Office of the Department of Defense (ARO DoD) awarded a grant for $193,800 for a virtual wireless lab for information security.

Digital Forensics Signal Processing Laboratory - This laboratory is equipped with high performance Workstations with 1 GByte of RAM, flat panel monitors and a heavy duty HP Color Laser Printer. All workstations have a research license of MATLAB and Internet access.

COURSE DESCRIPTIONS

Computer Engineering, Computer Science, and Electrical Engineering

CECS 6000 - Computer Science and Engineering Problem Solving

Three credit-hours. Prerequisites: None. One four hours session per week.

This course provides a mathematical background that is fundamental for problem solving ability at the graduate level in computer science. Review of limits, derivatives and transcendental functions. Indefinite, definite and improper integrals. Sequences, series, power series and Taylor series. Differential equations. Lines and planes in space, surfaces, partial derivatives, the gradient and directional derivatives.

CECS 6001 - Programming with Objects, Structures, and Algorithms (POSA)

Three credit-hours. Prerequisites: None. One four hours session per week.

This course is a practical synthesis of concepts from Structured Programming, Abstract Data Types, Object Oriented Programming, Data Structures and Algorithms. A rationed introduction to Objects, and Object Oriented Programming, is followed by an in depth discussion of the most common Data Structures, and the way these are used to simplify and make more understandable and flexible an application modeling and programming.

CECS 6002 – Discrete Structures

Three credit-hours. Prerequisites: Calculus 1. One four hours session per week.

This course provides a mathematical background that is fundamental for problem solving ability at the graduate level in computer science. The first half of the course will provide an introduction to the Formal Logic and Proof techniques, set theory, combinatory, probability, relations, functions and matrices. The second half of the course will cover graphs, trees and graph algorithms. The course will conclude with an overview of Boolean algebra, computer logic, computation and languages.

CECS 6003 – Logic Circuits

Three credit-hours. Prerequisites: None. One four hours session per week.

This course provides a background that is fundamental for graduate level students in electrical engineering, computer science, and computer engineering. In this course students learn about Binary Systems, Boolean algebra and Logic gates, Digital Circuits, Gate Minimization, Combinational and Sequential logics, Counters, Memories, among others. One of the main goals in this course is to study the process of digital circuit design. A review of the basics of binary system operation and the Boolean algebra, the details of binary logic gates and the concepts of logic minimization, is provided. The MAP methods to simplify the Product-of-Sum will be covered. Techniques for design and analysis of combinational and synchronous sequential circuits will be studied, as well as combinational circuits such as: Adder/Subtractor, Decoder, Encoder, Magnitude Comparator, and Multiplexer. An overview of sequential elements: latches and flops will be provided. Memories and memory addressing will be covered. Other topics that will be covered are: asynchronous sequential logic design techniques, HDL description languages, functional verification, test, design-for-test, Integrated circuit packaging. Future trends will also be observed.

CECS 6005 – Principles of Information Security

Three credit-hours. Prerequisites: Graduate Program Mentor approval. One four hours session per week.

This course is an introduction to the various technical aspects of information security and assurance to understand computer, data, and communications security issues. It provides the foundation for understanding the key issues associated with protecting information assets, determining the levels of protection and response to security incidents, and designing a consistent, reasonable information security system, with appropriate intrusion detection and reporting features.

CECS 6010 - Advanced Design and Analysis of Algorithms

Three credit-hours. Prerequisites: Data Structure. One four hours session per week.

This course emphasizes the computational complexity of a problem, the efficiency of an algorithm for solving a problem, technique for designing algorithms, and the inherent intractability of certain problems. Problems in a number of applications are covered.

CECS 6015 - IT Auditing and Secure Operations

Three credit-hours. Prerequisites: Graduate Program Mentor approval Required. One four hours session per week.

The course will give students the know-how they need to implement an effective Information Technology (IT) audit. The course covers principles and practice related to the evaluation of secure operations in existing and new information technologies. Core concepts related to security auditing and accountability will be discussed using the standard IT audit approach and contemporary information system auditing concepts. Internet and e-commerce security auditing issues will also be addressed.

CECS 6030 - Computational Theory

Three credit-hours. Prerequisites: Calculus II, Discrete Structure. One four hours session per week.

This course provides an introduction to formal languages. Regular languages: regular expressions, finite automata, minimization, closure properties, decision algorithms, and non-regular parsing theory, and no context-free languages. Computable languages: Turing machines, recursive functions, Church's thesis, un-decidability and halting problem.

CECS 6035 - Contingency Planning

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This course addresses the managerial issues associated with planning for, and reacting to events, incidents, disasters and crises. It covers organizational awareness, incident response, contingency strategies, disaster recovery, business continuity operations planning, and crisis management. Students will learn the skills to secure current information systems and networks, recognizing and planning for threats and vulnerabilities present in the existing systems.

CECS 6045 - Law, Investigation, and Ethics

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This course is intended for students of computer science and other related fields of study who are interested in the IT social and ethical issues that arise from computationally intense environments in the workplace and in society. It addresses computer crime laws and regulations, the measures and technologies used to investigate computer crime incidents and the ethics involved in the use of computers, information systems and technology. Controversies and alternate points of view are addressed on social, legal, philosophical, political, constitutional and economic issues related to computers.

CECS 6230 - IT Operations

Three credit-hours. Prerequisites: None. One four hours session per week.

The course covers all relevant tasks for the day to day life of an IT Manager. It will cover user support as well as change management and strategic planning in a heterogeneous environment. The goal is to give an upcoming IT manager all relevant skills in order to successfully run an IT Department for medium and large companies.

CECS 6240 - Technology-Based Start-Up

Three credit-hours. Prerequisites: None. One four hours session per week.

This course provides an introduction to the concepts and activities applicable to launching and managing technology-based ventures. Course readings, case studies and discussion

will highlight key issues and concepts. Throughout the course of the semester, students will create a technology-based enterprise with all the essential dements concerning technology viability, competitive positioning, sales channel analysis, business plan, and investor pitch. Students will work in teams to launch companies, working through issues as they arise. Successful team-building for a technology-based start-up and product life-cycle planning are addressed as part of the strategic considerations for creating companies that can quickly define and dominate a new sector or die easily.

CECS 6430 - Advanced Software Architecture

Three credit-hours. Prerequisites: Object Oriented Programming. One four hours session per week.

The course introduces Pattern Languages of program design, which represent a recently defined major abstraction level after Object Oriented Programming. Then follows up with an introduction to the two major component architectures in use today: Sun's Java Beans (EJB), and Microsoft's COM and .NET architectures in their several incarnations. The course then explores Web Services and several proposals for the assembly of applications from network-accessible, centrally published, and publicly discoverable services. Finally we end up with a close look at more recent developments in Model Driven Architectures, including their potential for platform independent application models, and for back annotation of implementation level customizations.

CECS 6605 - Advanced Database System Design

Three credit-hours. Prerequisites: None. One four hours session per week.

Methodologies and principles of database systems are covered: database architectures, logical modeling, the relational model, data normalization, database design process and techniques, relational algebra, relational calculus, integrity constraints, views, and SQL language. Advanced topics include: non-first normal-form databases, database security, query optimization, indexes generation, security issues, distributed databases, object-relational and object-oriented databases, internet databases, parallel databases and XML databases. Projects on theoretical aspects of databases and on application development will be required.

CECS 6750 - Software Testing

Three credit-hours. Prerequisites: Object Oriented Programming. One four hours session per week.

This course covers topics of software testing methodologies for development and maintenance for object-oriented, component-based business and web applications. Approaches to automatic testing and supporting tools are covered. Topics include structural and functional techniques, code inspection, peer review, test verification and validation, statistical testing methods, regression tests, preventing of errors, metrics, plans, formal models and software quality. Students who finished this course will be able to analyze a given software life cycle for improvements as well as design and implement testing strategies within their companies.

CECS 6760 - Internet Engineering I

Three credit-hours. Prerequisites: EE 6130. One four hours session per week.

This course presents current and emerging technologies for the World Wide Web. The emphasis is on understanding the operation of the World Wide Web at many different architectural levels, including its protocols, programming languages, history and future.

CECS 6824A - Special Topics in CS (ITMIA)

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This course is designed to offer the students additional insight on topics related to the Information Technology Management (ITMIA) and Information Assurance (IT) area of interest. Topics discussed include the fundamental tools and techniques for IT management, computer security and information assurance. General models of computer security and intrusion detection techniques are also discussed.

CECS 6824B - Special Topics in CS (KDDM)

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This course is designed to offer the students additional insight on topics related to the Knowledge Discovery and Data Mining (KDDM) area of interest. The course discusses special topics related to Data Warehousing as one of the main mechanisms for practical storage of historical data derived from the enterprise operational databases. Several models for organizing and re-factoring databases along various dimensions, as used in Data Warehouses, are discussed, and justified. Data Mining and Data Warehousing tasks, techniques and different tools for implementation are discussed. The most representative commercial tools for data mining incorporating these techniques will be reviewed.

CECS 6824C - Special Topics in CS (CGGT)

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This course is designed to offer the students additional insight on topics related to the Computer Graphics and Game Technology. This course is intended for graduate students who are interested in special topics on modeling systems with sculptured curve and surface geometry. Methods of geometric modeling for integral and rational curves and surfaces and their application to computer aided design problems will be studied.

CECS 7010 - Computer Graphics

Three credit-hours. Prerequisites: Calculus II. One four hours session per week.

This course is an introduction to computer graphics for students who wish to learn the basic principles and techniques

of the field and who in addition want to write substantial graphics applications themselves.

CECS 7020 - Advanced Computer Graphics

Three credit-hours. Prerequisites: CECS 7010. One four hours session per week.

This course is intended for graduate students who are interested in modeling an engineering system with sculptured curve and surface geometry. Methods of geometric modeling for integral and rational curves and surfaces and their application to computer aided design problems will be studied.

CECS 7130 - Advanced Computer Networks

Three credit-hours. Prerequisite: EE 6130. One four hours session per week.

The course covers the latest trends in computer networking and the related applications that depend on those advances. Study of wireless networks, value added networks (van), virtual private networks (vpn), satellite networks, cable, fiber and other wide-area networking technologies. The impact of new networking technologies and the new business modalities that they facilitate is covered. The course emphasizes on the integration of networking concepts and protocols into comprehensive solutions for the enterprise or business. Discussion of performance, reliability, expandability, relevance, and the economic aspects of planning and implementing practical computer networks is also covered. Analysis of the trade-offs between equipment costs, performance, reliability, long-term expandability, and operational and human management costs. Analysis of tariff and legal constraints that bear on the adoption of particular technologies are considered.

CECS 7230 – Network Security

Three credit-hours. Prerequisite: Graduate Program Mentor approval required. One four hours session per week.

The fundamental tools and techniques for network security are discussed in the context of the pervasive role and impact that the internet has over the individual, the enterprise and on society-at-large. Major topics covered are symmetric encryption (DES and AES), public key encryption (RSA and Diffie-Hellman), message authentication and hash functions. A general introduction to number theory, prime numbers and discrete logarithms is provided as mathematical background. The course concludes by illustrating these techniques in network security applications including electronic mail, IP security and web security.

CECS 7235 – Computer Forensics

Three credit-hours. Prerequisite: Graduate Program Mentor approval required. One four session per week.

This course is an introduction to digital forensics in the context of the microsoft windows operating system. Overview of evidence collection and archiving (rfc 3227), order of volatility and Locards Exchange Principle. Preservation of volatile and non-volatile data. Analysis of data including windows memory and registry analysis, log file and executable file analysis. The course will use case studies and open source tools.

CECS 7240 - Database Security

Three credit-hours. Prerequisite: Graduate Program Mentor approval required. One four session per week.

This course will focus on issues related to the design and implementation of secure data stores. Emphasis will be placed on access control, multilevel security in systems, covert channels, inference problem and security measures for relational and object-oriented database systems. Also, secure distributed and heterogeneous databases systems as well as data mining for security applications are addressed.

CECS 7410 - Parallel and Distributed Processing

Three credit-hours. Prerequisite: None. One four hours session per week.

This course provides a graduate-level introduction to parallel and distributed systems programming. The foundations of the creation of systems on distributed environments will be discussed. The main characteristics of a distributed and parallel system will be presented emphasizing how they can be used to outline new applications.

CECS 7510 - Software Engineering II

Three credit-hours. Prerequisites: EE 6510. One four hours session per week.

The course discusses recent trends in Software Engineering theory and practice. Explores new paradigms in the conceptualization of software such as Pattern Languages and Aspect Oriented Programming and their impact in the creation of re-usable and evolvable software. Covers increasingly important software topics such as Software Testing, Software System Validation, Software Reliability, and Software Security. Choosing from the techniques learned in Software Engineering I, we can now fully concentrate on going through several development cycles and improving techniques and know-how of tools. We will discuss limitations and advantages of using metrics, creating artifacts and how to maintain planning, deliverables and documentation in synch.

CECS 7520 - Human Computer Interaction

Three credit-hours. Prerequisite: Object Oriented Programming. One four hours session per week.

The course presents issues on effective human-computer interaction. The role of software engineering and the human factors is considered in the design, implementation and evaluation of software. User interface and software design principles, guidelines, methodologies and strategies are explored. Specific topics covered include: basic elements, procedures, tools, development environments, user experience levels, interaction styles and collaborative systems technology. Additional topics on multidisciplinary dynamics of human-computer interaction as a field of study, current developments in HCI research and usability engineering are covered. The course reviews principles and guidelines so as to move on to

advanced subjects on rapid development and application in computer engineering.

CECS 7530 - Data Mining and Data Warehousing

Three credit-hours. Prerequisite: CECS 6605. One four hours session per week.

The first part of the course discusses Data Warehousing as one of the main mechanisms for practical storage of historical data derived from the enterprise operational databases. Several models for organizing and re-factoring databases along various dimensions, as used in Data Warehouses, are discussed, and justified. Data warehouses represent just one, but perhaps the most readily available source of data within an enterprise, for performing data mining. Additional data sources for mining are discussed, including governmental and commercial sources. The second and third parts of the course discuss data mining tasks, techniques and the tools that implement these. Major data mining tasks include classification, clustering and diagramming. These generic tasks are supported through a set of techniques that include decision trees, self-organizing maps, neural networks, and other visual representation techniques. The most representative commercial tools for data mining incorporating these techniques will be used by students to mine some publicly available data sets and report their findings.

CECS 7550 - Artificial Intelligence (AI)

Three credit-hours. Prerequisite: Data Structure. One four hours session per week.

This course offers a broad overview in the field of artificial intelligence and Knowledge Based Expert Systems (KBES). A basic background in computer science and programming in structured languages is assumed. The course surveys the major topics in Artificial Intelligence (AI). It begins with an overview of what constitutes AI and an introduction to intelligent agents. This is followed by a series of traditional AI topics such as logic, predicate calculus, knowledge representation, reasoning, planning, inference, heuristic and adversary search, artificial neural networks, machine learning, genetic algorithms, fuzzy logic and logic programming.

CECS 7560 - Internet Engineering II

Three credit-hours. Prerequisites: CECS 6770. One four hours session per week.

The students will learn advanced Internet technologies and how to use them to design the overall structure of secure systems and e-commerce sites. Techniques for integrating legacy back-end systems and additional software components will be discussed. The use of W3C standards such as XML and other emergent technologies will be emphasized.

CECS 7570 - Computer Security

Three credit-hours. Prerequisites: EE 6130. One four hours session per week.

The fundamental tools and techniques for computer security are discussed in the context of the pervasive role and impact that computer technology has over the individual, the enterprise and on society-at-large. Mathematical cryptography fundamentals are covered followed by a set of services built on these techniques, which are then used to provide security at the system and network levels. General models of computer security and intrusion detection techniques are also covered.

CECS 7802 - Special Topics in Software Engineering

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This course seeks to allow the inclusion into the curriculum of newly developing trends and special areas of interest or research. The format of the course will vary, including student and lecturer presentations, and discussion and reporting on recent research results.

CECS 7804 - Special Topics in Internet Engineering

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This course seeks to allow the inclusion into the curriculum of newly developing trends and special areas of interest or research. The format of the course will vary, including student and lecturer presentations, and discussion and reporting on recent research results.

CECS 7900 – Project for Master in Computer Engineering

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

Two project alternatives are offered in the student's area of specialization: a research study or development of a software application. The project topic needs to be approved by the course instructor. The research study requires a thorough review of literature relevant to a current problem in the student's specialization area. The research project should present a solution to the problem in the form of a research paper of publishable quality. For the software application development alternative a real-life problem amenable to a solution that leverages the computer engineering methodologies should be selected.

Preference will be given to the development of tools. The analysis and design phases should be applied to the problem using appropriate modeling techniques to describe the system before and after the proposed solution. Conceptual and physical model design and documentation should be done using computer engineering tools.

This course seeks to develop the research and/or application development skills of students at a graduate level scope. Both alternatives for the project will help students acquire leading edge knowledge.

CECS 7901 – Project Extension for Master in Computer Engineering

Zero credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

This is an extension of the Computer Engineering project. The project offers two alternatives: a research study or a software application development. The research study requires a thorough review of literature relevant to a current problem in a field relevant to the specialization area chosen by the student. The project should present a solution to the problem in the form of a research paper of publishable quality. For the software application development, a real-like problem amenable to a solution the leverages the Internet environment should be selected. The applications, programs and laboratories used during the academic sessions will be available to the student.

This course seeks to develop the research and/or application development skills to students at a graduate level scope. Both alternatives for the project will help students acquire leading edge knowledge.

CECS 7950 - Project for Master in Computer Science

Three credit-hours. Prerequisites: Graduate Program Mentor approval required. One four hours session per week.

The project alternative offers the student the opportunity to develop a software application and the planning of its launching as a product using an entrepreneurial focus. The project topic needs to be approved by the course instructor. The software application development involves a solution to a real-life problem that leverages the computer science knowledge gained through the program. Preference will be given to the development of leading edge applications in areas such as IT Management and Information Assurance, Knowledge Discovery and Data Mining, and Computer Graphics and Game Technology, among other related topics.

CECS 7951 – Project Extension for Master in Computer Science

No credit-hours. Prerequisite: Graduate Program Mentor approval required.

This is an extension to complete the development of a final project for the Master in Computer Engineering. The project offers two alternatives: (1) a research study or (2) the development of a software application and the planning of its launching as a product using an entrepreneurial focus. Preference will be given to the development of leading edge applications in areas such as IT Management and Information Assurance, Knowledge Discovery and Data Mining, and Computer Graphic and Game Technology, among other related topics.

This course in an extension for students to continue the development of the research project and/or application development. The project will help students demonstrate their domain of the Computer Science discipline.

CECS 7971 - Thesis MSCpE

Six credit-hours. Prerequisites: Graduate Program Mentor approval required in addition CECS 6010, 6030, 6430, 6750 and undergraduate prerequisites. One four hours session per week.

The purpose of the thesis is to expose the student to a reasonable independent research experience that enhances his/her academic development. The student should prepare, carry out and report a structured and methodical study of importance. The student graduate committee must approve the thesis topic in writing. The topic should be of sufficient relevance to illustrate the student's ability to conduct independent research. Students must approve an oral thesis examination before assigned graduate committee. The student will make an oral presentation followed by a session of question and answers. Once the graduate committee has accepted the student's topic the student must maintain continuous enrollment in thesis hours. Publication of this work in journals, conference proceedings, and /or poster presentations is strongly encouraged.

CECS 7972 - Thesis Extension

Zero credit-hour. Prerequisite: CECS 7971 and Graduate Program Mentor approval required. One four hours session per week.

This course provides the student the opportunity to continue the development of his/her experimental and/or theoretical research.

CECS 7980 - Thesis MSCS

Six credit-hours. Prerequisites: Graduate Program Mentor approval required in addition CECS 6010, 6030, 6430, 6750 and undergraduate prerequisites. One four hours session per week.

The purpose of the thesis is to expose the student to a reasonable independent research experience that enhances his/her academic development. Preference will be given to research topics in areas such as IT Management and Information Assurance, Knowledge Discovery and Data Mining, and Computer Graphics and Game Technology, among other related topics. The topic should be of sufficient relevance to illustrate the student's ability to conduct independent research. The student should follow the guidelines established by the Graduate School for the required format for writing the Thesis work.

CECS 7990 - Thesis Extension

No credit-hours. Prerequisite: CECS 7980 and Graduate Program Mentor approval required. One four hours session per week.

This extension gives the students the opportunity to continue with the Thesis (CECS 7980) in which they were previously enrolled.

CECS 6120 - Computer Architecture

Three credit-hours. Prerequisites: Undergraduate Computer Courses. One four hours session per week.

Fundamental concepts of the architectural structure and organization of computers are reviewed: fundamental execution cycle, central processing unit, input/output unit, and memory management unit are covered. Course reviews key abstractions supported at the architectural level such as virtual

memory, micro-architecture, I/O controllers and processors. A historical analysis of the evolution of the major architectures from complex instruction set computers (CISC) to reduced instruction set computers (RISC) is carried out. Additional topics include performance evaluation, multiprocessing and parallel architectures, and tightly and loosely coupled distributed architectures. The architectural layer is considered in the context of compilation processes, operating systems, as well as high level programming concepts.

CECS 6130 - Data Communication Networks

Three credit-hours. Prerequisites: Undergraduate Computer Courses. One four hours session per week.

The course covers the fundamentals of data communication networks, including architecture, principles of operations, and performance analyses. It provides a rationale from the engineering standpoint that justifies the way networks are currently structured, and facilitate understanding the issues and tradeoffs faced by designers of future networks. Strong emphasis is provided to understanding algorithms used in networking and their performance impact. An engineering mathematics background including probability is assumed. Some of the topics included are: multilayered network architecture, data link layer protocols, high-speed packet switching, queuing theory, LANs, and WANs issues.

CECS 6150 - Object Oriented Design

Three credit-hours. Prerequisites: Undergraduate Object Oriented Programming. One four hours session per week.

The object oriented paradigm is covered including all its fundamental concepts. Students write programs at increasing levels of complexity that illustrates the principles of encapsulation, inheritance, polymorphism, overloading, overriding and constructors. The course assumes familiarity with structured programming techniques, compilation and debugging tools.

CECS 6510 - Software Engineering I

Three credit-hours. Prerequisites: Undergraduate Computer Courses. One four hours session per week.

The course covers basic concepts of software requirements generation and analysis, software design, implementation, maintenance, structured design methodologies, object-oriented design methodologies, and data flow design. Project development and team software, budgets and computer ethics issues are also discussed. Students practice the analysis and design phases for a system and the required testing techniques. Various system development models are presented.

EE 5714 - Digital Communication Systems

Three credit-hours. Prerequisites: EE 4704. Co-requisite: EE 4710. One four hours session per week.

This course provides a review of Random Processes. Topics include the sampling theorem, pulse modulation including PAM, PPM, PWM and PCM; Base-band and pass-band transmission of digital signals including FSK, PSK, and QAM; M-ary modulation techniques; Introduction to spread spectrum systems; Behavior of digital communication systems in the presence of noise; Optimal threshold detection; Optimum Receivers.

EE 5720 - Digital Signal Processing

Three credit-hours. Prerequisites: Undergraduate Signal and Systems and Probability and Statistics. One four hours session per week.

Topics include LSI systems, DTFT, DFT, FFT, sampling, linear and cyclic convolution, the Z-transform and filter structures. Introduction to FIR and IIR digital filter design. Several DSP applications are discussed and demonstrated. A design project is required.

EE 5730 - Radio Frequency Circuit Design

Three credit-hours. Prerequisites: EE 3030, EE 3520, EE 4702. One four hours session per week.

This course is an introduction to high-frequency analog circuit design. It provides a solid background for continued studies in RF design as applied to different areas such as wireless communications and RF circuit design. Topics include RF concepts, lumped component models, transmission line fundamentals, the Smith Chart and its applications, resonant circuits and filters, and small signal amplifiers with s-parameters.

EE 6010 - Mathematical Methods for Signal Processing

Three credit-hours. Prerequisites: Undergraduate Calculus and Diff. Equations. One four hours session per week.
This course provides part of the extensive mathematical background needed for contemporary signal processing, practice and research. It emphasizes several linear algebra topics. Some of the topics covered are: Vector Spaces and Linear Algebra including Linear Operators, Inverse Matrices, Matrix Factorizations, Eigenvalues and Eigenvectors, Singular Value Decomposition, Some Special Matrices and their Application, Kronecker Products. The connection of these topics with signal processing is emphasized.

EE 6012 - Advanced Engineering Mathematics

Three credit-hours. Prerequisites: Undergraduate Calculus and Undergraduate Diff. Equations. One four hours session per week.

This course is an in-depth review of various mathematical concepts which are fundamental tools in the study of electromagnetic and antenna theory. Topics include Vector Calculus, Fourier Analysis, Partial Differential Equations and Boundary Value problems with applications.

EE 6020 - Stochastic Processes

Three credit-hours. Prerequisites: Undergraduate Probability and Statistics or Undergraduate Random Processes. One four hours session per week.

The course starts with a brief review of Probability. Other topics include: Random Processes, Spectral Characteristics of Random

Processes, Linear Systems with Random Inputs, Modeling Noisy Networks. Special Classes of Random Processes: Autoregressive Processes, Markov Processes, Gaussian Processes and others. Introduction to Signal Detection, Binary Detection, Linear Mean Square Estimation. Matched Filter. Wiener Filter and Kalman Filters.

EE 6030 - Linear Systems

Three credit-hours. Prerequisite: None. One four hours session per week.

Review of linear algebra; vector spaces and operators. Mathematical descriptions of linear systems; controllability and observability, irreducible realization of rational transfer-function matrices; canonical forms, state feedback, and state estimators; stability.

EE 6632 - Non Linear Control

Three credit-hours. Prerequisites: Undergraduate Linear Systems. One four hours session per week.

To study the essentials of nonlinear control systems. Topics covered are those techniques which have already been found effective. Several new techniques which are potentially useful to control applications and one detailed case study will also be discussed. Concepts will be re-enforced using computer-aided engineering tools such as MATLAB® , SIMULINK or similar.

EE 6660 - Advanced Robotic Manipulators

Three credit-hours. Prerequisites: Undergraduate Control. One four hours session per week.

Introduction to Robotic Manipulators, Dynamic Models, State Variable Representation, Controller Design, Adaptive Control and case studies.

EE 6720 - Pattern Recognition

Three credit-hours. Prerequisites: None. One four hours session per week.

The course presents a description of the general pattern recognition problem and the general methods employed for basic pattern recognition applications. Bayes theory is presented as the building block for statistical pattern recognition methods along with the different approaches used for solving real world problems. The techniques presented include both supervised and unsupervised methods and feature selection and reduction techniques.

EE 6740 - Intelligent Control

Three credit-hours. Prerequisites: Undergraduate Linear System. One four hours session per week.

To study the fundamentals of neural networks and fuzzy set theory with emphasis on their applications in control systems. Concepts will be re-enforced using computer-aided engineering tools such as MATLAB®, SIMULINK or similar.

EE 6750 - Engineering Electromagnetic Field Theory

Three credit-hours. Prerequisites: EE 6012 or equivalent. One four hours session per week.

Review of static fields, fundamental concepts, wave equationand its solutions, wave propagation, reflection and transmission; potential theory; construction of solutions; electromagnetic theorems: concepts of source, duality, uniqueness, equivalence, induction and reciprocity theorems.

EE 6760 - Digital Communications

Three credit-hours. Prerequisites: EE 5714. One four hours session per week.

A review of the behavior of digital communication systems in the presence of noise, optimal threshold detection and optimum receivers. Topics include optimum receivers for general M-ary signaling in the presence of AWGN, geometrical representation of signals, determination of an orthogonal basis set, MAP detectors, decision regions and error probability, equivalent signal sets, minimum energy signal set, colored channel noise, generalized Bayes Receiver, and Maximum Likelihood Receiver. Other topics are: Introduction to information theory, Huffman Code, Channel Capacity. Mutual Information, capacity of a band-limited AWGN channel, and Error Correcting Codes.

EE 6770 - Satellite Communication Systems

Three credit-hours. Prerequisites: EE 5714. One four hours session per week.

Analysis and design of satellite communication systems and links including the study of propagation, satellite transponders, earth stations and satellite networks. Analog and digital modulation schemes, as well as antennas and microwave components are studied at a block system level. This course also introduces the economics, regulatory law, and business characteristics of the satellite communications field. A final project or report is required.

EE 7712 - Image Processing

Three credit-hours. Prerequisites: None. One four hours session per week.

The purpose of the course is to give the student an approach to image processing, image fundamentals, image enhancement in the spatial and frequency domains, restoration, color image processing, wavelets, image compression, morphology, segmentation, image description, and the fundamentals of object recognition. It focuses on material that is fundamental and has a broad scope of application.

EE 7716 - Computer Vision

Three credit-hours. Prerequisites: None. One four hours session per week.

The aim of this course is to introduce the principles, models and applications of computer vision. The course will cover: image structure and encoding; edge and feature detection; interpretation of surfaces; texture, color, stereo, and motion; wavelet methods in vision; parameterizations for solids and shapes; visual inference; and strategies for automatic face recognition. The course requires an extensive use of MATLAB and other mainstream software packages for computer

implementation. The course requires a research report and paper reviews.

EE 7730 – Speech Processing

Three credit-hours. Prerequisites: None. One four hours session per week.

This course presents an overview of the area of speech processing using computers. The course includes topics such as the speech production process and the necessary mathematical background to study the major applications of the area. The applications presented in the course include speech coding, speech synthesis, speech recognition, and speaker and language identification.

EE 7740 - Algorithms for Digital Signal Processing

Three credit-hours. Prerequisites: None. One four hours session per week.

This course provides an introduction to the field of advanced digital signal processing algorithms, in particular to Fast Algorithms for Discrete Fourier Transforms, Discrete Linear and Cyclic Convolutions. Transforms such as the Discrete Cosine Transform, the Hartley Transform, the Walsh-Haddamard Transform and others are also reviewed. The course does extensive use of MATLAB and other mainstream software packages for computer implementation and as an aid to understand the structure of the different algorithms. The course requires a research project, research report or paper reviews.

EE 7772 - Wireless Communications

Three credit-hours. Corequisite: EE 5714. One four hours session per week.

This course will cover advanced topics in wireless communications for voice, data, and multimedia. We begin with a brief overview of current wireless systems and standards. We then characterize the wireless channel, including path loss for different environments, random log-normal shadowing due to signal attenuation, and the flat and frequency-selective properties of multipath. The course requires an extensive use of MATLAB and other mainstream software packages for computer simulation and implementation. The course requires a research report and paper reviews. The final project will generally be a literature survey, analysis, and/or simulation related to one of the topics

EE 7780 - Special Topics in Signal Processing

Three credit-hours. Prerequisites: Approval Required. One four hours session per week.

This course seeks to allow the inclusion into the curriculum of newly developing trends and other special areas of interest or research. The format of the course will vary, including student and lecturer presentations, and discussion and reporting on recent research results.

EE 7790 - Project for Master in Electrical Engineering

Three credit-hours. Prerequisites: Approval Required. One four hours session per week.

The specialization area project is composed of two alternatives: a research study on a current topic related to the student's specialization area (DSP or Communication Systems), or a related problem that has a solution through the development or enhancement of a digital signal processing or communication system, or component. The specialization area subject needs to be approved by the graduate project student counselor. For the development project the analysis and design phases should be applied to the problem with related modeling techniques to describe the system before and after the proposed solution. Conceptual and physical model design should be done with tools that have been used in the classroom during the student's pursuit of his program of study.

Students who choose to complete the non-thesis option with a specialization area project obtain additional hands-on skills that are required to excel as electrical or computer engineering professionals. Students in the thesis option can also benefit from this course. Both alternatives for the project will help students develop new skills and/or acquire additional technical knowledge.

EE 7791 - Project Extension for Master in Electrical Engineering

Zero credit-hours. Prerequisites: Graduate Program Mentor approval. One four hours session per week.

Extension to complete the Design Project. The design project is composed of two alternatives: a research study on a current topic related to the student's area of interest (DSP or Communication Systems), or a related problem that has a solution through the development or enhancement of a digital signal processing or communication system, or component. The project subject needs to be approved by the graduate student counselor.

EE 7800 - Thesis

Six credit-hours. Prerequisites: All Core Courses and Approval Required. One four hours session per week.

The purpose of the thesis is to expose the student to a reasonable independent research experience that enhances his/her academic development. The student should prepare, carry out and report a structured and methodical study of importance. The student graduate committee must approve the thesis topic in writing. The topic should be of sufficient relevance to illustrate the student's ability to conduct independent research. Students must approve an oral thesis examination before assigned graduate committee. The student will make an oral presentation followed by a session of question and answers. Once the graduate committee has accepted the student's topic the student must maintain continuous enrollment in thesis hours. Publication of this work in journals, conference proceedings, and /or poster presentations is strongly encouraged.

EE 7801 - Thesis Extension

Zero credit-hour. Prerequisites: EE 7800. Approval Required. One four hours session per week.

This course provides the student the opportunity to continue the development of his/her experimental and/or theoretical research.

ELECTRICAL AND COMPUTER ENGINEERING AND COMPUTER SCIENCE DEPARTMENT PROGRAM FACULTY

Cervoni, Fernando; Lecturer II; J.D. Inter American University of Puerto Rico, San Juan, Puerto Rico, 2010; **B.A.** Management, Inter American University of Puerto Rico, San Juan, Puerto Rico, 2007. Admitted to practice law in the Commonwealth of Puerto Rico. *Research Interests: Technology Law, Social Networkings.*

Cruz Triana, Alfredo – Professor; **Ph.D.** Computer Information Systems, Nova Southeastern University, Florida, 2002; **Ph.D.**, Computer Engineering, University of Cincinnati, Ohio, 1992; **B.A.** Mathematics and Computer Science, University of North Carolina, NC, 1984; **B.E.T** Electrical and Computer Engineering, University of North Carolina, 1984; **A.A.S.** Electrical Engineering, Fayetteville, Technical Institute, NC, 1982. *Research Interests: Parallel Processing, Genetic Algorithms, Fault Tolerant Computing, e-commerce, Artificial Intelligence.*

Curbelo, Aury- Lecturer IV; Ph.D. Human Community Resources Development (HCRD), The Ohio State University, Columbus, Ohio, 2002; **M.S.** Education, University of Puerto Rico, Mayaguez, 1999; **B.S**. Agricultural Education, University of Puerto Rico, Mayaguez, 1996. *Research Interests: Social Engineering, Phishing, Social networks, data breach, e-health and electronic record, mobile security, and network security. Certifications: Certified Ethical Hacker, Certified Forensic Investigator, Security + and Certified Master Security Professional.*

Fonseca, Sandra - Lecturer II; Computer Engineering, Computer Science; **DBA**, Management Information Systems, Turabo University, Gurabo, PR, 2008; **MIS**, Information Systems, EDP College, Hato Rey, PR, 1997; **BBA**, Information Systems, University of Puerto Rico Rio Piedras, PR, 1989; **GCIAS**, Graduate Certificate Information Systems Auditing, EDP College, Hato Rey PR, 2004; **CISA**, Certified Information Systems Auditor, 2009; **CISM**, Certified Information Security Manager, 2004; **CRISC,** Certified in Risk and Information Systems Control, 2009. *Research Interests: Incident Handling and Business Continuity, Business Process Re engineering, Knowledge Management in Project Management, E-Government Control and Security, Cyber and Power Grid Security.*

González, Angel – Associate Professor; Ph.D., Electrical Engineering, University of Dayton, Dayton, OH, 2003; **M.S.E.E.**, University of Puerto Rico, Mayagüez Campus, 1994; **B.S.E.E.**, Universidad del Zulia, Maracaibo, Venezuela, 1984. *Research Interests: Nonlinear Adaptive Control, Programmable Logic Devices, Power Systems and Machinery.*

López Bonilla, Román – Professor; **Ph.D.**, Electrical Engineering, University of Bradford, England; **M.S.** Applied Physics, Centro de Investigación Científica y de Educación Superior de Ensenada BC, México, 1981; **B.S.E.E.**, Universidad de Guadalajara, Jalisco, México, 1977; *Research Interests: Computer Vision, Image Processing, Neural Networks.*

Ramírez, Juan M. – Lecturer III; **Ph.D.**, Entrepreneur Development and Management, Inter-american University of Puerto Rico, San Germán Campus, 2005, **M.E.M.** Construction and Project Management, Polytechnic University of Puerto Rico, San Juan, PR, 1999, **B.S.E.E.** Electronics and Telecommunications, Polytechnic University of Puerto Rico, San Juan, PR, 1992. Registered Professional Engineer (P.E.) Puerto Rico. *Research Interests: Merger and Adquisitions, Construction and Project Management.*

Riera, Guillermo M. - Associate Professor; **Ph.D.**, Electrical Engineering, George Washington University, Washington D.C., 2000; **M.S.E.E.**, George Washington University, Washington D.C., 1996; **B.S.E.E.**, University of Puerto Rico Mayagüez Campus, Mayagüez, PR, 1994. Registered Professional Engineer (P.E.) Puerto Rico; Certified PV Installer (AAE) from Puerto Rico; Energy Auditor (AAE) from Puerto Rico; Certified Energy Manager Association of Energy Engineers; Green Building Engineer Association of Energy Engineers; Certified Power Quality Prof. Association of Energy Engineers. *Research Interests: Energy Conversion, Power and Transmission, Energy Management and Conservation, Renewable Energy Systems, Distributed Generation, Green Electrical Systems, Power Quality and Traditional Power Systems.*

Rodríguez Jiménez, Othoniel – Professor; Ph.D., Computer Engineering and Computer Science, University of Missouri-Columbia, Columbia Missouri, 2003; **M.S.E.E. and C.S.**, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1978; **B.S.E.E.**, University of Puerto Rico, Mayagüez Campus, 1975. Registered Professional Engineer (P.E.) Puerto Rico. *Research Interests: Data Mining, Reconfigurable Hardware, e-Learning, Entrepreneurship.*

Sarmiento, Jorge – Lecturer III; **D.A.** Mathematics, University of Miami, Coral Gables, Florida, 1982; **M.A.** Mathematics, University of Puerto Rico, Rio Piedras, 1979; **B.S.** Mathematics, IIA-World University, Hato Rey, PR, 1975; **B.E.E.** Power, University of Gijon, Spain, 1971; **A.A.S.** Computer Science, College of Morris, New Jersey, 1995. *Research Interests: Applied Mathematics, Combinatorial Analysis, Graph Theory.*

Sobrino, Eduardo – Lecturer II, **Ph.D.**, University of Michigan, School of Architecture, concentration on Information Sciences and Decision Support Systems., 1988; **Master on Architecture**, Applied Acoustics, University of Puerto Rico School of Architecture, 1981; **B.A.Arch**. University of Puerto Rico. *Research and Development interests: business-oriented information systems, software development project management, database management systems, call center software systems, networking including wireless systems, business intelligence software, data warehousing, data mining, medical informatics, e-Government.*

Solá, Juan – Lecturer III; Ph.D., Computing and Information Science and Engineering, University of Puerto Rico, 2009. **M.S.E.E.**, University of Puerto Rico, 1998; **B.S.E.E.**, University of Puerto Rico, 1996. Research Interests: developing Linux

applications, BSD socket API and protocol development, High Performance Computing environments, wireless networks, SAMBA, Netbeui,TCP/IP connectivity in UNIX to Windows environments.

Teixeira Abarno, Marvi – **Professor**; **Ph.D.**, Physical Oceanography, University of Puerto Rico, Mayagüez Campus, 1999; **M.S.E.E.**, University of Puerto Rico, Mayagüez Campus, 1994; **B.S.E.E.**, Polytechnic University of Puerto Rico, 1989. Registered Professional Engineer (P.E.) Puerto Rico. *Research Interests: Fast Algorithms for Digital Signal Processing, Time Series Analysis and Prediction Applied to the Geosciences, Analysis of Satellite Synthetic Aperture Radar Images Applied to the Study of the Oceans.*

Vicente López, Luis M. – **Associate Profesor; Ph.D.**, Electrical and Computer Engineering, University of Missouri, Columbia, MO, 2009. **M.S.E.E.**, Florida Internacional University, 1996; **B.S.E.E.**, Universidad Politécnica de Madrid, Madrid, Spain, 1990. *Research Interests: beamforming, array processing, statistical signal processing, and adaptive filters.*

Zaharov, Viktor – **Associate Professor; Ph.D.**, Electrical Engineering, Odessa Polytechnic State University, Ukraine, 1993; **M.S.** Electrical Engineering, Odessa Polytechnic State University, Ukraine, 1983; **A.S.** Control System and Automatics. College of Industry Automatics. Odessa, Ukraine , 1975. *Research Interests: 2G and 3G Communications, Mobile and Satellite Communication Systems, Radio Communications, Smart Antenna and its Application for Wireless Communications and Radar, Communications Standards IS-95, UMTS, IMT-2000, GSM, Signal and Image Processing Algorithms and Processors, Wavelets Transform and its Applications in Communication Systems, Kalman Filtering, Spectral and Time Series Analysis, Antennas and Wave Propagation.*

MASTER IN GEOSPATIAL SCIENCE AND TECHNOLOGY

Geospatial Science and Technology refers to the science and technology used for visualization, measurement, and analysis of features or phenomena that occur on the earth. This terminology has become common in the United States, and is synonymous with Spatial Information Science and Technology. Geospatial science and technology includes three different technologies that are all related to mapping features on the surface of the earth. These three technology systems are GIS (Geographical Information Systems), Remote Sensing and GPS (Global Positioning Systems).

The master program will expose the student to the principles and techniques related to geospatial data model generation, data capture and representation and will learn how these could help in the solution of different problems faced by society. By its integrative nature, the program will support research and application modeling in diverse disciplines such as Land Surveying, Architecture, Planning, Geography, Environmental Management, Biology, Engineering and other professionals who deal on a day to day basis with geospatial data capture and analysis.

CAREER OPPORTUNITIES

The program aims to develop professionals capable of contributing to the development of geospatial systems based on the principles of Geomatics. This broad overview of potential market provides a real and varied employment spectrum for graduates of the program. Given the extent of possible applications that can be generated, Geospatial Science and Technology graduates may be employed in areas ranging from spatial data management for environmental problems to management of data for studies in the insurance market. It is expected that many students are professionals in various fields who seek to add to their profession geospatial data management capabilities.

PROGRAM REQUIREMENTS

Admission Requirements

General requirements for admission to the program are established by the Graduate School of the Polytechnic University. In addition it is expected that the student has a 2.75 GPA in the bachelor degree that gives access to the program. If the candidate has a GPA lower than 2.75 he/she can request admission thru the Reconsideration Committee of the Graduate School.

Admission of any applicant to the program will be based on academic preparation. Qualified persons with a bachelor degree from a recognized and competent university who have approved credits in Geographic Information Systems and Statistics may be admitted directly to the program. Evidence of having these approved courses will be demonstrated through the submission of the transcript of the baccalaureate program in question. The Graduate School will evaluate the applicants program's qualifications to determine if he/she is admitted to the program directly. Applicants who do not have these courses will be asked to correct the deficiencies identified.

Graduation Requirements

The degree must be approved with 36 credits at a 3.00 GPA or higher. Course distribution is as follows:

Core - 12 Credits
Geospatial Technologies – 9 Credits
Geospatial Applications – 9 Credits
Research – 6 Credits

DEGREE OFFERED

Students in the Graduate Program in Geospatial Science and Technology earn a Master in Geospatial Science and Technology.

CURRICULAR STRUCTURE AND SEQUENCE

The structure and sequence of the curriculum include blocks of courses classified as Core, Advanced, Geospatial Applications and Research Project.

Core Courses

This block of courses provides the knowledge in four fundamental areas of geospatial science and technologies. These are Geographic Information Science, Remote Sensing, Cartography and Spatial Database Management. The core courses total 12 credit-hours, distributed among 4 courses of three credit - hours each.

Advanced Courses

Advanced courses are designed to provide specialized preparation in geospatial science and technologies. Advanced courses total 9 credit-hours, distributed among 3 courses of three credit - hours each.

Application Courses

Students select courses related to their research interest. The idea is to reinforce geospatial research techniques on particular study areas. The student should select a total of 9 credit-hours, distributed among 3 courses of three credit - hours each.

Research Project

The student must prepare a proposal for his/her Master Research Project once approved 12 credits and taken the Research Design and Methods course (GEOM 6680). The proposal must be approved by the student advisor. The student must conduct the Master Research Project under the supervision of the advisor, who is the chairperson.

Through the Master Research Project, students must demonstrate expertise of geospatial science and techniques, and the ability to apply them in a cohesive manner. The Master Research Project can be an application to a real case or situation. The application must demonstrate originality and contribution to the field of Geospatial Science.

At completion, the Master Research Project will be presented at the Graduate School Design Project Expo. As a final requirement of the Graduate School the student must submit a technical article of the Master Research Project.

The technical article should follow the publication rules established by the Graduate School of the Polytechnic University of Puerto Rico.

GEOSPATIAL SCIENCE AND TECHNOLOGY CURRICULUM STRUCTURE AND SEQUENCE

Core Courses

Course	Title	Credit-Hours
GEOM 6630	Geospatial Modeling & Analysis	3
GEOM 6632	Spatial Database Management Systems	3
GEOM 6634	Cartography, Map Design & Geovisualization	3
GEOM 6710	Image Acquisition, Analysis and Processing	3

Advanced Courses

Course	Title	Credit-Hours
GEOM 6636	Spatial Data Quality	3
GEOM 6638	Geospatial Programming Fundamentals	3
GEOM 6712	Advanced Image Analysis and Processing	3

Geospatial Applications Courses
(Select 9 Credits from the following)

Course	Title	Credit-Hours
GEOM 6520	GNSS for Geospatial Professionals	3
GEOM 6640	Geospatial Urban and Regional Applications	3
GEOM 6642	Land Information Systems Design & Implementation	3
GEOM 6644	Web Mapping Applications	3
GEOM 6646	Environmental Assessment & Geospatial Technology	3
GEOM 6648	Business Geography	3

Research Courses

Course	Title	Credit-Hours
GEOM 6680	Research Design and Methods	3
GEOM 6690	Master Research Project	3
GEOM 6691	Master Research Project Extension (If necessary)	0

LABORATORIES

The Geomatic Sciences Department offers students the opportunity to receive hands on experience to practice the concepts and techniques learned in the classroom allowing them the best opportunity to acquire current knowledge and the expertise that industry demands. In order to fulfill this commitment, these laboratories have been designed to cover all major areas of Geomatic Sciences. The Geomatic Science Department has the following laboratory facilities on campus: Geographic Information Systems Laboratory, Remote Sensing and Photogrammetry Laboratory, Surveying and Topography Laboratory and a General Computer Laboratory. These laboratories have been designed to perform a wide range of applications in each of the areas of interest.

Geographic Information Systems Laboratory (GIS) - This lab is used primarily for GIS and Cartography practice. It has several Dell Precision T5500 and Precision model T5400 workstations. It has different types of software for GIS development and geospatial analysis such as ArcGIS 10, FME, IDRISI and Manifold. Open source software is also used for educational purposes. It also has general applications software such as Microsoft Office and Open Office.

Remote Sensing and Photogrammetry Laboratory- This laboratory is used for Remote Sensing and Photogrammetry related practice. It has several Dell Precision model T5500, T5400 Precision and Optiplex 745 workstations. It has PCI Geomatics software for work in remote sensing and photogrammetry. Open source software is also used for

educational purposes. It also has general application software such as Microsoft Office.

Surveying and Topography Laboratory - This laboratory is used for practices and courses on Surveying and Topography. It has several Dell Precision T5400 workstations. It has the Autocad software, Carlson Survey, Mr. Cad, Autocad Map and general purpose software like Microsoft Office.
The Department also has surveying equipment such as Total Stations and Levels (Topcon, Leica, South Survey). There are also Topcon GPS receivers (GR3, GMS2, and Hyper) and Trimble GPS receivers.

General Computer Lab- This lab is available for general use projects and assignments. The laboratory has several Dell Precision T5500 and two Dell T5400 workstations. It has a page layout of 8.5 X 11 inches. In addition to the aforementioned equipment, the lab has software licenses of all the instructional software found in departmental laboratories. There is also general use software such as Microsoft Office and Open Office.

COURSE DESCRIPTIONS

GEOM 6520 - GNSS for Geospatial Professionals

Three credit-hours. Prerequisite: GEOM 6630. One four hours session per week.

This course focus on principles and techniques of data capturing including ground and global surveying systems.

GEOM 6630 - Geospatial Modeling & Analysis

Three credit hours. Pre requisite: GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One, four hours lecture per week.

Modeling of spatial data and data analysis most useful to professionals who use spatial data. Course provides the student with advanced methods with an emphasis on practical techniques for problem solving.

GEOM 6632 – Spatial Database Management Systems

Three credit hours. Pre requisite: GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One, four hours lecture per week.

Principles and techniques of geospatial database design, editing, and management needed to obtain required functionality from a GIS.

GEOM 6634 - Cartography, Map Design & Geovisualization

Three credit hours. Pre requisite: GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One, four hours lecture per week.

This course gives a technical introduction to graphic representation and visualization of geographic information. The lectures cover static and dynamic design aspects, thematic mapping, interface design, animation, and 3D. The lab sessions provide hands-on experience in designing thematic maps and constructing basic geovisual applications.

GEOM 6636 - Spatial Data Quality

Three credit-hours. Prerequisite: GEOM 6630. One four hours session per week.

Methods of error control and types of data to analyze. Discussion of standards as one of the principle thrusts of a Spatial Data Quality. The course provides a practical overview of the issues associated with developing and maintaining standards and metadata for geo-spatial data and services.

GEOM 6638 - Geospatial Programming Fundamentals

Three credit-hours. Prerequisite: GEOM 6630. One four hours session per week.

This course provides fundamental skills for geospatial programming. Topics include calling geographic processing tools, batch processing, performing file i/o in an external computing language. To support these tasks, students learn basic programming concepts. Familiarity with GIS software is required, but no prior programming experience is expected.

GEOM 6640 - Geospatial Urban and Regional Applications

Three credit-hours. Prerequisite: GEOM 6630 and GEOM 6710. One four hours session per week.

This is a course that focuses on the application of geospatial technologies in the practice of urban and regional planning, with a focus on land use and landscape planning. Topics covered will include data models and structures, spatial analysis, acquisition and integration of spatial data from various sources and GIS application development.

GEOM 6642 - Land Information Systems Design and Implementation

Three credit-hours. Prerequisite: GEOM 6630. One four hours session per week.

This course teaches strategies for successful GIS management and implementation. It will examine GIS from small-scale project-based GIS initiatives, through to large-scale enterprise GIS implementations. The consistent methodology of systematic user needs assessment, requirements specification, database design, application development, implementation, and operation and maintenance is carried through all levels of GIS implementation. Students will develop skills in GIS project planning, design, management and documentation. All students will improve their ability to independently acquire, evaluate, and implement new GIS-based skills and understanding and to put these into a context of effective GIS use.

GEOM 6644 - Web Mapping Applications

Three credit-hours. Prerequisite: GEOM 6634. One four hours session per week.

The course is focused upon the use of the Internet to deliver GIS applications. The material covered will include the hardware/software structure of the Internet, the means for

communication between Internet-connected devices, applications that provide GIS programs and data, and performance and security concerns.

GEOM 6646 - Environmental Assessment and Geospatial Technology

Three credit-hours. Prerequisite: GEOM 6630 and GEOM 6712. One four hours session per week.

This course deals with the subject of using Geospatial Technology for environmental impact assessment (EIA) and strategic environmental assessment (SEA). It provides the student with better understanding of the environmental problems currently facing our territories and the effective use of Geospatial Technologies for environmental modeling and decision making.

GEOM 6648 – Business Geography

Three credit-hours. Prerequisites: GEOM 6630. One four hours session per week.

Course introduces the student to the geospatial technology component of business geography. Students are exposed to GIS software with applications in real estate, land economics, marketing and other business applications.

GEOM 6680 - Research Design and Methods

Three credit-hours. Prerequisite: GEOM 6630 and GEOM 6710 with 12 credits in approved courses and Program Mentor Approval.. One four hours session per week.

Basic techniques and methods of investigation and presentation of data related to spatial research.

GEOM 6690 - Master Research Project

Three credit-hours. Prerequisite: GEOM 6680 and Program Mentor Approval. One four hours session per week.

Development of a research project as a demonstration of student competence in geospatial science and technologies.

GEOM 6691 – Master Research Project Extension

Three credit-hours. Prerequisite: GEOM 6691 and Program Mentor Approval. One four hours session per week.

Course that provides the student the opportunity to continue the development of his/her research.

GEOM 6710 - Image Acquisition, Analysis and Processing

Three credit hours. Pre requisite: GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One, four hours lecture per week.

Digital image processing and analysis applied to satellite and aircraft land remote sensing data. The course has an equal emphasis on the (1) physics of remote sensing (2) digital image processing of remote sensing data (3) application of remote sensing.

GEOM 6712 - Advanced Image Analysis and Processing

Three credit-hours. Prerequisite: GEOM 6710. One four hours session per week.

Detailed examination of land remote sensing instruments, observatories and resultant measurements in the optical portion of the EM spectrum. Includes computer-based exercises that examine the importance of data geo-registration and radiometric calibration in land measurements. Principles, technologies and applications of hyperspectral, laser and microwave remote sensing are also covered.

PROGRAM FACULTY

Matos, Raúl – Associate Professor, PhD (Candidate), Cartography, GIS and Remote Sensing doctoral program, Universidad de Alcalá, Madrid, 2012; Msc. in Geographic Information Systems, Huddersfield University, Great Britain, 2002; Master in Planning, Concentration: Urban Planning, University of Puerto Rico, 1997; Bachelor in Arts, Geography, University of Puerto Rico, 1991.

Rodríguez, Marisol – Assistant Professor, PhD (Candidate), Integration, Economic Development and Land Planning doctoral program 2012, Universidad de León, Spain; Master in Planning, Concentration: Urban Planning, University of Puerto Rico, 1997; Bachelor in Arts, Geography, University of Puerto Rico, 1991.

Romero, Victor - Assistant Professor; PhD (Candidate) Topographic Engineering and Photogrammetry, Universidad Politécnica de Madrid, 2004; Bachelor of Science in Land Surveying, Polytechnic University of Puerto Rico, 1994

MASTER IN MANUFACTURING COMPETITIVENESS

The Master Program in Manufacturing Competitiveness seeks to prepare professional engineers, scientists and business administrators for managerial positions and responsibilities in manufacturing organizations. The program offers the opportunity to specialize in the major manufacturing sectors of Puerto Rico, such as the pharmaceutical, quality management, and high tech sectors.

The program of study allows graduates to gain a deep knowledge in current and new manufacturing technologies, regulatory issues affecting manufacturing, decision making tools, as well as a thorough knowledge in key aspects regarding the operation and management of a high tech industry. Such knowledge will prepare them to assume important positions within manufacturing companies either in Puerto Rico, the U.S. or abroad. Professionals graduating from the Master Program in Manufacturing Competitiveness include engineers from the traditional disciplines such as industrial, electrical, mechanical and chemical engineering among other disciplines. It also includes professionals from careers in the natural science fields such as chemistry, pharmacy and biology among others.

Finally, it includes professionals from the business administration and related fields such as accountants, business administrators, financial analysts, etc.

CAREER OPPORTUNITIES

The graduate from this program will be amply qualified to occupy diverse managerial positions in manufacturing organizations, including but, not limited to the pharmaceutical, and high tech manufacturing companies.

PROGRAM REQUIREMENTS

Admission Requirements

Students with undergraduate preparation in engineering, natural sciences or business administration are encouraged to apply for admission. Admission to the Master's program is based on total academic and professional achievement. Applicants must have completed his/her Bachelor's degree at an accredited university with a minimum general Grade Point Average (GPA) of 2.75/4.00.

All entering students should have: a) completed a one-term course in Probability and Statistics; b) demonstrated proficiency to work with computer application programs such as electronic spreadsheets, presentation programs, and word processing.

Students with deficiencies in these prerequisites are required to take courses in these areas and earn a grade of C or better. These requirements must be fulfilled as early as possible in the student's program. Courses taken to remedy deficiencies cannot be used to fulfill course requirements for the Master's degree.

Graduation Requirements

The minimum graduation requirements for each of the degrees offered are as follows:

Master of Science in Manufacturing Competitiveness Degree (Thesis Option)

The program of study leading to a Master of Science in Manufacturing Competitiveness degree with a Thesis requires passing a minimum of 36 credit-hours including the following:

1. Fifteen (15) credit-hours in core courses.
2. Satisfactory completion of a Seminar on Business Writing and Presentation Skills (0 credit-hours).
3. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
4. An additional minimum of 3 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
5. The student must conduct research and prepare a thesis. The thesis consists of 6 credit-hours.

Master in Manufacturing Competitiveness Degree (Design Project Option)

The program of study leading to a Master in Manufacturing Competitiveness degree with a Design Project requires passing a minimum of 36 credit-hours including the following:

1. Fifteen (15) credit-hours in core courses.
2. Satisfactory completion of a Seminar on Business Writing and Presentation Skills (0 credit-hours).
3. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
4. An additional minimum of 6 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
5. The student must conduct a design project and prepare a final report. The design project consists of 3 credit-hours. The student must present a technical poster at the Design Project Expo.

DEGREES OFFERED

Students enrolled in the Graduate Program in Manufacturing Competitiveness may pursue their Master's degree according to two alternatives. The first one leads to the Master of Science in Manufacturing Competitiveness (MSMC) degree. Through this alternative students are required to complete a thesis. The second alternative leads to the Master in Manufacturing Competitiveness (MMC) degree.. In this alternative students must prepare a design project.

CURRICULAR STRUCTURE AND SEQUENCE

The structure and sequence of the curriculum include blocks of courses classified as Core, Area of Specialization, Elective and Thesis/Design Project.

Core Courses

This block of core courses provides the fundamental knowledge in current and new manufacturing technologies, decision making tools, as well as a thorough knowledge in all the aspects regarding the operation and management of high-tech manufacturing industries. The core courses total 15 credit-hours, distributed among 5 courses, 3 credit-hours each. As part of the core courses, all students must take the Business Writing and Presentation Skills Seminar. This is a 0 credit-hours seminar whose major purpose is to develop student's skills in preparing technical reports and making presentations using modern technology.

Areas of Specialization

Students may select from two areas of specialization: Pharmaceutical Products or Quality Management. Through these courses, students may gain fundamental knowledge in current and innovative manufacturing technologies, all pertinent regulatory aspects, as well as the profile and managerial insights of the industry in their field of area of specialization.

Elective Courses

The total number of credit-hours in elective courses varies depending on the degree and option selected. For the Master of Science degree, students must take a minimum of 3 credit-hours in elective courses. For the Master Degree with the

Design Project option the minimum is 6 credit-hours in elective courses.

Thesis/Design Project

Students must select one of two options: preparing a thesis based on an applied research topic; or preparing a design project in a topic intimately related to their area of studies.

MANUFACTURING COMPETITIVENESS CURRICULUM STRUCTURE

Core Courses - Pharmaceutical Products
(15 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement (1)	3
MMP 6002	Operations Planning and Control (1)	3
MMP 6006	Lean Manufacturing	3
MMP 6050	Materials Flow and Logistics	3
MMP 6052	Managerial Finances and Cost Accounting (2)	3
SEMI 5500	Business Writing and Presentation Skills Seminar	0

Pharmaceutical Products Area of Specialization Courses
(Must select 12 credit-hours from the following courses, including MMP 6132 which is required):

Course	Title	Credit-Hours
MMP 6110	Industry Profile and Business Management for Health Care Products	3
MMP 6132	Manufacture of Pharmaceutical Solid Dosage Forms	3
MMP 6180	Material Handling Automation	3
MMP 6224	Manufacture of Pharmaceutical Parenteral Dosage Forms	3
MMP 6230	Manufacture of Pharmaceutical Semisolid Dosage Forms	3
MMP 6234	GMP's and Regulatory Issues	3
MMP 6236	Packaging Technology	3
MMP 6564	Process Validation and Technology Transfer	3

Core Courses - Quality Management
(15 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement (1)	3
MMP 6002	Operations Planning and Control (1)	3
MMP 6006	Lean Manufacturing	3
MMP 6008	Foundations in Quality Learning and Assurance	3
MMP 6052	Managerial Finances and Cost Accounting (2)	3
SEMI 5500	Business Writing and Presentation Skills Seminar	0

Quality Management Area of Specialization Courses
(Must select 12 credit-hours from the following courses, including MMP 6130 which is required):

Course	Title	Credit-Hours
MMP 6130	Six Sigma	3
MMP 6190	Measuring and Managing Customer Satisfaction and Loyalty	3
MMP 6250	Audit Program Management	3
MMP 6256	Assessment Tools to Improve Business Performance	3
MMP 6558	Machine and Process Characterization	3
MMP 6570	Design and Implementation of Statistical Sampling Plans	3

Elective Courses(3)

Course	Title	Credit-Hours
MMP 6145	Lean Six Sigma	3
MMP 6162	Medical Devices Technology I	3
MMP 6518	Project Management	3
MMP 6520	Industrial Systems Simulation	3
MMP 6535	Research in Manufacturing	3
MMP 6550	Ergonomics and Human Factors in the Workplace	3
MMP 6552	Industrial Safety and OSHA Regulations	3
MMP 6560	Organizational Behavior	3
MMP 6599	Special Topics in Manufacturing	3

Thesis and Design Project

Course	Title	Credit-Hours
MMP 6700	Design Project	3
MMP 6701	Design Project Extension	3
MMP 6800	Master's Thesis	3
MMP 6801	Master's Thesis Extension	3

(1) Students with a Bachelor degree in Industrial Engineering must substitute this course with an elective course with MMP code.
(2) Students with a Bachelor degree in Business Administration must substitute this course with an elective course with MMP code.
(3) In addition of the current list of elective courses, the student could select as an elective course any course with MMP code that is not specified as a core or interest graduate course in compliance with the prerequisite component requirement (not including Industrial Automation courses).

MASTER IN MANUFACTURING ENGINEERING

The Master Program in Manufacturing Engineering distinguishes itself by its depth and focus in state of the art technology. It seeks to prepare engineers for managerial positions and responsibilities in manufacturing organizations. The program offers the opportunity to specialize in the pharmaceutical manufacturing sector. It also offers the opportunity to specialize in the fields of Industrial Automation, or Quality Management to serve a wide range of manufacturing companies.

The program of study allows graduates to gain a deep knowledge in current and new manufacturing technologies, regulatory issues affecting manufacturing, decision making tools, as well as a broad knowledge in key aspects regarding the operation and management of a high technology industry. Such knowledge will prepare them to assume important positions within manufacturing companies either in Puerto Rico, the U.S. or abroad.

Professionals graduating from the Master Program in Manufacturing Engineering include engineers from the traditional disciplines such as industrial, electrical, mechanical, and chemical engineering among other disciplines.

CAREER OPPORTUNITIES

The graduate from this program will be amply qualified to occupy diverse managerial, supervisory, and technical positions in many manufacturing organizations including, but not limited to, pharmaceutical and high technology manufacturing plants.

PROGRAM REQUIREMENTS

Admission Requirements

Students with undergraduate preparation in industrial, electrical, mechanical, chemical, environmental and other engineering programs are encouraged to apply for admission. Admission to the Master's program is based on total academic and professional achievement. Applicants must have completed their Bachelor's degree in engineering at an accredited university with a minimum general Grade Point Average (GPA) of 2.75/4.00.

All entering students should have: a) completed a one-term course in Probability and Statistics; b) demonstrated proficiency to work with computer application programs such as electronic spreadsheets, presentation programs, and word processing.

Students with deficiencies in these prerequisites are required to take courses in these areas, and earn a grade of C or better. These requirements must be fulfilled as early as possible in the student's program. Courses taken to remedy deficiencies cannot be used to fulfill course requirements for the Master's degree.

Graduation Requirements

The minimum graduation requirements for each of the degrees offered are as follows:

Master of Science in Manufacturing Engineering Degree (Thesis Option)

The program of study leading to a Master of Science in Manufacturing Engineering Degree with a Thesis requires passing a minimum of 36 credit-hours including the following:

1. Twelve (12) credit-hours in core courses.
2. Satisfactory completion of a Seminar on Business Writing and Presentation Skills (0 credit-hours).
3. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
4. An additional minimum of 6 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
5. The student must conduct research and prepare a thesis. The thesis consists of 6 credit-hours.

Master of Engineering in Manufacturing Engineering Degree (Design Project Option)

The program of study leading to a Master of Engineering in Manufacturing Engineering Degree with a Design Project requires passing a minimum of 36 credit-hours including the following:

1. Twelve (12) credit-hours in core courses.
2. Satisfactory completion of a Seminar on Business Writing and Presentation Skills (0 credit- hours).
3. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
4. An additional minimum of 9 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
5. The student must conduct a design project and prepare a final report. The design project consists of 3 credit-hours. The student must present the research at the Design Project Expo.

DEGREES OFFERED

Students in the Graduate Program in Manufacturing Engineering may pursue their Master's degree according to two alternatives. The first one leads to the Master of Science in Manufacturing Engineering degree. Through this alternative students are required to complete a thesis. The second alternative leads to the Master of Engineering in Manufacturing Engineering degree. In this alternative students must prepare a design project.

CURRICULAR STRUCTURE AND SEQUENCE

The structure and sequence of the curriculum include blocks of courses classified as Core, Area of Specialization, Elective and Thesis/Design Project.

Core Courses

This block of courses provides the fundamental knowledge in current and new manufacturing technologies, decision making tools, as well as a thorough knowledge in all the aspects regarding the operation and management of high-technology manufacturing industries. The core courses total 12 credit-hours, distributed among 4 courses, three credits each. As part of the core courses, all students must take the Business Writing and Presentation Skills Seminar. This is a 0 credit-hours seminar whose major purpose is to develop student's skills in preparing technical reports and making presentations using modern technology.

Area of Specialization

Students may select from three areas of specialization: Pharmaceutical Processes, Industrial Automation, or Quality Management. Through these areas, students may gain fundamental knowledge in current and innovative manufacturing technologies of the industry.

Elective Courses

Through this block of courses students may select courses of with the objective of rounding their graduate education in those areas of their interest. The total number of credit-hours in elective courses varies depending on the degree option selected. For the Master of Science degree, students must take a minimum of 6 credit-hours in elective courses. For the Master of Engineering degree the minimum is 9 credit-hours in elective courses. The total number of credit-hours is distributed among courses of 3 credit-hours each.

Thesis /Design Project

Students must select one of two options: preparing a thesis based on an applied research topic; or preparing a design project in a topic intimately related to their specialized courses.

The thesis or design project required in the Graduate Programs in Manufacturing is intended to test the ability of the Master's candidate to engage in original research or complex design projects, and to organize and evaluate themselves creatively in the areas of Manufacturing Engineering .

Thesis

In the Thesis alternative, the student must prepare a research proposal, after the completion of all the courses in the core and specialized courses components, including the seminar. The proposal has to be approved by the student advisor and the student graduate committee. After that, the student must conduct the research under the direct supervision of his/her advisor, who is the chairperson of the student graduate committee. The final report must include original contributions to a specific area of knowledge.

The thesis will be designed to test the candidate not only in his/her thesis research, but also in the Manufacturing Engineering areas and related fields that are relevant for the thesis development. The graduate committee, chaired by the student advisor, conducts the examination (defense) after the completion of the written thesis report.

Design Project

In the Design Project alternative, the student must prepare a project proposal, after the completion of all the courses in the core and area of specialization courses components, including the seminar. The proposal has to be approved by the student advisor and the graduate program mentor. After that, the student must conduct the design project under the direct supervision of the advisor, who is the chairperson. The project has to be a special design within the student's area of specialization.

MANUFACTURING ENGINEERING CURRICULUM STRUCTURE AND SEQUENCE

Core Courses - Pharmaceutical Processes
(12 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement [1]	3
MMP 6002	Operations Planning and Control [1]	3
MMP 6005	Process Engineering [2]	3
MMP 6006	Lean Manufacturing	3
SEMI 5500	Business Writing and Presentation Skills Seminar	0

Pharmaceutical Processes Area of Specialization Courses
(Must select 12 credit-hours from the following courses, including MMP 6132 which is required):

Course	Title	Credit-Hours
MMP 6132	Manufacture of Pharmaceutical Solid Dosage Forms	3
MMP 6180	Material Handling Automation	3
MMP 6224	Manufacture of Pharmaceutical Parenterals Dosage Forms	3
MMP 6230	Manufacture of Pharmaceutical Semisolid Dosage Forms	3
MMP 6234	GMP's and Regulatory Issues	3
MMP 6236	Packaging Technology	3
MMP 6564	Process Validation and Technology Transfer	3

Core Courses - Industrial Automation
(12 Credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement [1]	3
MMP 6002	Operations Planning and Control [1]	3
MMP 6005	Process Engineering [2]	3
MMP 6006	Lean Manufacturing	3
SEMI 5500	Business Writing and Presentation Skills Seminar	0

Industrial Automation Area of Specialization Courses
(Must select 12 credit-hours from the following courses, including MMP 6141, MMP 6143, and MMP 6246 which are required)

Course	Title	Credit-Hours
MMP 6141	Industrial Instrumentation	3
MMP 6143	Process Control	3
MMP 6180	Material Handling Automation	3
MMP 6236	Packaging Technology	3
MMP 6244	Process Measurement and Control Standards	3
MMP 6246	Industrial Systems Automation	3

Core Courses - Quality Management
(12 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement [1]	3
MMP 6002	Operations Planning and Control [1]	3
MMP 6006	Lean Manufacturing	3
MMP 6008	Foundations in Quality Learning and Assurance	3
SEMI 5500	Business Writing and Presentation Skills Seminar	0

Quality Management Area of Specialization Courses
(Must select 12 credit-hours from the following courses, including MMP 6130 which is required):

Course	Title	Credit-Hours
MMP 6130	Six Sigma	3
MMP 6190	Measuring and Managing Customer Satisfaction and Loyalty	3
MMP 6250	Audit Program Management	3
MMP 6256	Assessment Tools to Improve Business Performance	3
MMP 6558	Machine and Process Characterization	3
MMP 6570	Design and Implementation of Statistical Sampling Plans	3

Elective Courses(3)

Course	Title	Credit-Hours
MMP 6145	Lean Six Sigma	3
MMP 6162	Medical Devices Technology I	3
MMP 6518	Project Management	3
MMP 6520	Industrial Systems Simulation	3
MMP 6535	Research in Manufacturing	3
MMP 6550	Ergonomics and Human Factors in the Workplace	3
MMP 6552	Industrial Safety and OSHA Regulations	3
MMP 6560	Organizational Behavior	3
MMP 6599	Special Topics in Manufacturing	3

Thesis and Design Project

Course	Title	Credit-Hours
MMP 6700	Design Project	3
MMP 6701	Design Project Extension	0
MMP 6800	Master's Thesis	6
MMP 6801	Master's Thesis Extension	0

(1) Students with a Bachelor degree in Industrial Engineering must substitute this course with an elective course with MMP code.
(2) Students with a Bachelor degree in Chemical Engineering must substitute this course with an elective course with MMP code.
(3) In addition of the current list of elective courses, the student could select as an elective course any course with MMP code that is not specified as a core or interest course component requirement.

LABORATORIES

The Industrial Engineering Department offers students the opportunity to receive hands on experience to practice the concepts and techniques learned in the classroom allowing them the best opportunity to acquire current knowledge and the expertise that industry demands. In order to fulfill this commitment, these laboratories have been designed to cover all major areas of Industrial Engineering. The Industrial Engineering Department has the following laboratory facilities on campus: Human Factors Laboratory, Methods Engineering and Work Measurement Laboratory, Operations Management Laboratory, Software Instruction Laboratory, and Lean Six Sigma Laboratory. These laboratories have been designed to perform a wide range of experiments in each of the areas of interest.

Human Factors and Methods Engineering Laboratory was created to provide the students with the opportunity to carry out practical experiments concerning anthropometry, noise and illumination, work-station design, manual material handling, biomechanics and other areas of human performance evaluation and machine-human interactions for the workstation design. The laboratory includes adjustable workstations, ergonomic equipment, soundproof cabins, sound level meters, light meters, goniometers, push/pull gauges and Windows 7 network with eight (8) Intel Xeon personal computers.

Methods Engineering and Work Measurement Laboratory exposes the students to the basic tools of analyzing and designing a job in a cost-effective manner, as well as measuring the resulting output to establish standards. This laboratory was designed to provide the students the opportunity to carry out practical experiments related to motion and time studies techniques (Stopwatch, Work Sampling and Predetermined Time), method improvement, performance rating, allowance factor and learning curve. Different practices require the use of the following equipment: stopwatches, random reminders, MTM equipment, tables, assembling parts and computers to download manufacturing assemblies and use of statistical software in order to develop time-study analyses and design software for workstation improvements (Design Tools).

Operations Management Laboratory consists of Windows 7 network with twenty (28) Intel Xeon personal computers for the student use. It is based on an open-access environment where students are given the opportunity to work on assignments and work on after class jobs at their own pace. This network offers the student the opportunity to access specialized software to tackle industrial engineering problems using state-of-the-art technologies. The laboratory has the equipment and software required to develop the system analysis, solutions development and decision-making skills of the students. There is support-hardware available including a laser printer. Some of the applications in the network include AutoCAD, Statgraphics Plus, Minitab, Witness, Arena for Simulation, Mathcad, Microsoft Office 2010 Professional, Microsoft Project 2010, 3DSSPP, Lindo, Google Sketchup 8, Microsoft Visio 2010, Microsoft Visual Studio, Microsoft SQL Server, and PSpice student version.

Software Instruction Laboratory consists of a Windows 7 network with 24 Intel Pentium-D personal computers for student use. It is based on specific class needs and assignments, where student are requested to manage critical applications and on-class work. This network offers the student the opportunity to access specialized software to tackle industrial engineering problems using state-of-the-art technologies. This laboratory has the equipment and software required to develop the system analysis, solutions development and decision-making skills of the students. There is support-hardware available including a laser printer and a HP plotter. Some of the applications in the network are AutoCAD, Statgraphics Plus, Minitab, Witness, Arena for Simulation, Mathcad, Microsoft Office Professional, Microsoft Project, Microsoft Visio, Microsoft

Visual Studio, Microsoft SQL Server, and PSpice student version. The Laboratory also a LCD 55, TV, two projector, and an interactive screen where the professor can write electronically to the computer and over a Power Point presentation.

Lean Six Sigma Laboratory consists of an assembly line for educational racing car models. In this laboratory, the attendees can take advantage of the Lean Six Sigma courses for graduate and undergraduate students, which provide the professional expertise to apply most of the techniques used in a DMAIC and Lean projects. The students will be able to apply techniques and concepts such as Failure mode and effect analysis, Supplier Input Process Output Customer, Project Charter, Voice of Customer, Lean Manufacturing, Statistics, Design of Experiments, Hypothesis Tests, Inventory Management, Production Control, Productivity, Cost Accounting, Total Quality Control, Statistical Process Control, Industrial Safety, Job Design, and others within a simulated manufacturing environment.

COURSE DESCRIPTIONS

MMP 6000 - Advanced Statistics and Quality Improvement

Three credit-hours. Prerequisite: MGM 5700 or undergraduate course in Probability and Statistics (Not required to graduates from an Industrial Engineering Program). One four hours session per week.

Practical applications of advanced statistical concepts. Quality improvement techniques and management philosophies. The use of statistical computer packages and their application to manufacturing problems will be emphasized.

MMP 6002 - Operations Planning and Control

Three credit-hours. Prerequisite: MGM 5700 or undergraduate course in Probability and Statistics (Not required to graduates from an Industrial Engineering Program). One four hours session per week.

This course focuses on solving managerial problems associated with planning and controlling operations. Major topics include inventory, capacity and demand management, aggregate planning, and activity control.

MMP 6005 - Process Engineering

Three credit-hours. Prerequisite: None (Not required to graduates from a Chemical Engineering Program). One four hours session per week.

This course introduces non-chemical engineers to the field of process engineering. Starting with mass and energy balances and then introducing the main unit operations used in chemical processes.

MMP 6006 - Lean Manufacturing

Three credit-hours. Prerequisite: MMP 6002 (Not required to graduates from an Industrial Engineering program offering a similar undergraduate course).

This course presents the Lean Manufacturing Theory. Discussion of the concepts and procedures related to Lean Thinking: how to simultaneously achieve high efficiency, flexibility, responsiveness, and cost reduction.

MMP 6008 - Foundations in Quality Learning and Assurance

Three credit-hours. Prerequisite: None. One four hours session per week.

Understanding quality-oriented philosophies and theories such as quality leadership, strategy development and deployment, quality management tools, customer-focus organizations, supplier performance, training and introduction to a quality system development and the audit process using quality assurance systems such as the ISO 9000: 2000. Understand the importance of establishing goals and identify ongoing goals for certified partnerships.

MMP 6050 - Materials Flow and Logistics

Three credit-hours. Prerequisite: None. One four hours session per week.

This course will introduce the components and analytical tools of logistics to support the operations of supply chain. Through the explanation of the logistic components like demand, procurement, customer service, warehousing, information systems, transportation, material flow and handling the ability of analytical tools will improve the supply chain application.

MMP 6052 - Managerial Finances and Cost Accounting

Three credit-hours. Prerequisite: None (Not required to graduates from a Business Administration Program). One four hours session per week.

Financial analysis, including sources and uses of fund statement, cost control of business funds, working capital management, long term financing, capital business and financial structure. Study of the methods and procedures of accounting in the determination of the unit cost of a product.

MMP 6110 - Industry Profile and Business Management for Health Care Products

Three credit-hours. Prerequisite: None. One four hours session per week.

Study of the Pharmaceutical and Medical Devices industries including industry configuration, types of drugs and devices, manufacturing technologies, product's life cycle, global competition and trends. It also covers the macro perspective of the administration of a manufacturing business, emphasizing the pharmaceutical and medical devices industries.

MMP 6130 - Six Sigma

Three credit-hours. Prerequisite: MMP 6000. One four hours session per week.

Understanding the strategic and statistical principles underlying the Six Sigma quality model; learn and apply tools and concepts such as voice of the customer, process yield, defects per opportunity and sigma calculation. Be able to apply the six sigma methodology to define a Sigma project: DMAIC from a green belt perspective.

MMP 6132 - Manufacture of Pharmaceutical Solid Dosage Forms

Three credit-hours. Prerequisite: None. One four hours session per week. One four hours session per week.

Basics of Manufacturing Process Technology for Oral Dosage Forms. New Manufacturing Technologies**.**

MMP 6141 - Industrial Instrumentation

Three credit-hours. Prerequisite: None. One four hours session per week.

Course in the field of process instrumentation. Includes the construction, functionality and mathematical representation of the various commercially available instrumentation components such as pressure, level, flow and temperature sensors. Also covers the final actuators and control valves, integral part of a closed control loop. Also the analysis and operation of industrial controllers is a part of this course.

MMP 6143 - Process Control

Three credit-hours. Prerequisite: MMP 6005. One four hours session per week.

This course addresses the following aspects of Process Control: analysis of factors affecting process dynamics, instrumentation required for control system design, modes of control and feedback controllers, stability, design case studies, simulation of processes, cascade, ratio, override, and feedforward control. The course focuses on a practical approach through the application of basic concepts to the solution of process control problems.

MMP 6145 - Lean Six Sigma

Three credit-hours. Prerequisites: MMP 6006 and MMP 6130. One four hours session per week.

Fundamental concepts of Lean Production and Six Sigma methodologies. Includes identifying the customer's critical-to-quality issues and evaluating value streams in key processes and translating identified opportunities into cost, quality, capital and lead time improvement projects through a case-study learning environment. Statistical and visual software analysis criteria will be used throughout the whole course.

MMP 6162 - Medical Devices Technology I

Three credit-hours. Prerequisite: None. One four hours session per week.

Manufacturing Process Technology for Non Critical Devices. New Manufacturing Technologies. Product and process flow, use and market; product classification according to FDA; compliance program, systems and practices in place used in industry to assure compliance with FDA Regulations.

MMP 6180 - Material Handling Automation

Three credit-hours. Prerequisite: MMP 6002. One four hours session per week.

Evaluation, design, control, and implementation of material handling systems. Interrelationships between material handling and plant layout, industrial robots, production planning and control, and integrated manufacturing systems.

MMP 6190 - Measuring and Managing Customer Satisfaction and Loyalty

Three credit-hours. Prerequisite: MMP 6008. One four hours session per week.

Designing and implementing a customer satisfaction measurement program for capturing the voice of the customer. Link the voice of the customer with value and retention. Methods and models for creating a long-term customer value and improved business performance.

MMP 6224 - Manufacture of Pharmaceutical Parenterals Dosage Forms

Three credit-hours. Prerequisite: None. One four hours session per week.

Manufacturing Process Technology for Topical Dosage Forms and Parenterals. New Manufacturing Technologies.

MMP 6230 - Manufacture of Pharmaceutical Semisolid Dosage Forms

Three credit-hours. Prerequisite: None. One four hours session per week.

This course presents the most relevant and important principles and controls for the manufacturing processes and equipment for the manufacturing of semi-solid dosage forms.

MMP 6234 - GMP's and Regulatory Issues

Three credit-hours. Prerequisite: None. One four hours session per week.

History, importance, law, regulation and regulatory mapping in quality as applied to health related industries. GMP's, 21CFR210 and other related regulations and documents.

MMP 6236 - Packaging Technology

Three credit-hours. Prerequisite: None. One four hours session per week.

This course covers the most relevant and important concepts of packaging technologies. Discussion of current methods, materials, processes and equipment. It includes packages for tablets, capsules, ointments and liquids.

MMP 6244 - Process Measurement and Control Standards

Three credit-hours. Prerequisite: MMP 6141. One four hours session per week.

This course covers the most relevant and important elements Instrumentation and control standards. Discussion of commonly used standards in industry including Instrumentation symbols and identification, batch control, control center design, environmental conditions, electronic records and signatures, and safety instrumented systems among others.

MMP 6246 - Industrial Systems Automation

Three credit-hours. Prerequisite: MMP 6143. One four hours session per week.

This course presents the most important elements of many alternative technologies and systems available for the automation of production lines. It describes important topics in production automation such as industrial control systems, PLCs, Sensors and actuators, PC control, industrial robotics, bar code, and vision systems.

MMP 6250 - Audit Program Management

Three credit-hours. Prerequisite: MMP 6008. One four hours session per week.

Describes and explains in detail the audit process that provide the expertise for examining processes and systems and making data based decisions to improve work processes and systems.

MMP 6256 - Assessment Tools to Improve Business Performance

Three credit-hours. Prerequisite: MMP 6008. One four hours session per week.

Describes and explains in detail the Baldrige Quality Award and European Quality Award. Define relevant guidelines to develop organizations assessment criteria. Describes tools to designing organization scorecards and the approach for balance metrics. Explain the linked process between scorecards and the company improves performance.

MMP 6518 - Project Management

Three credit-hours. Prerequisite: MGM 5700 or undergraduate course in Probability and Statistics. One four hours session per week.

The aim of this course is to educate an individual to develop expertise to manage projects. The course will accomplish this aim by introducing the fundamental concepts of projects management to graduate students. The fundamental concepts revolve around the individual or project manager, the organizational processes and structures, and the project management tools. The students will learn how to balance conflicting demands to ensure successful project management.

MMP 6520 - Industrial Systems Simulation

Three credit-hours. Prerequisites: MMP 6000. One four hours session per week.

This course presents the most relevant concepts of systems simulation. It describes simulation as an analysis technique used to evaluate and improve dynamic systems of all types. The course contains a blend of theory and practice. It also covers the use of simulation in both manufacturing and service systems. It has a strong focus on the practical aspects of simulation. Emphasis is placed on the use of simulation in actual problem-solving situations.

MMP 6535 - Research in Manufacturing

Three credit-hours. Prerequisite: 24 Credits Approved. One four hours session per week.

This course provides students the tools required to conduct original research in the area of manufacturing, including the selection of a problem, development of a literature review, and determination of the research methodology.

MMP 6550 - Ergonomics and Human Factors in the Workplace

Three credit-hours. Prerequisite: None. One four hours session per week.

A graduate level in-depth exposure to the design and management of industrial workplaces with emphasis on people at work. Discussion of worker behavior and performance, industrial safety, standards and regulations, industrial ergonomics, manual material handling, and cumulative trauma disorders.

MMP 6552 - Industrial Safety and OSHA Regulations

Three credit-hours. Prerequisite: None. One four hours session per week.

The most relevant concepts of safety engineering, as applied to manufacturing environments. OSHA and other regulatory aspects are covered.

MMP 6558 - Machine and Process Characterization

Three credit-hours. Prerequisite: MMP 6000. One four hours session per week.

Statistical design of experiments for machine and process characterization and improvement. Discussion of experimentation strategy including factorial experiments, response surface experiments, and empirical model building.

MMP 6560 - Organizational Behavior

Three credit-hours. Prerequisite: None. One four hours session per week.

This course offers the most relevant concepts applicable to the study, understanding, and application of human behavior in organizations. Discussion of historical and behavioral science research methodology. Examines the interrelations of personality, perception, attitudes and job satisfaction. Focus is on the importance of motivation, group dynamics, conflicts and leadership, communication and modern organization designs.

MMP 6564- Process Validation and Technology Transfer

Three credit-hours. Prerequisites: None. One four hours session per week.

Study of the most relevant concepts and organization for effective validation of processes and equipment for pharmaceutical and medical devices industries. Technology transfer fundamentals.

MMP 6570 - Design and Implementation of Statistical Sampling Plans

Three credit-hours. Prerequisites: MMP 6000. One four hours session per week.

In depth analysis of the statistical sampling plans with emphasis in the design, performance and implementation of the plans. Also, includes the discussion of the quality metrics used

for the evaluation, and selection of the sampling strategy. The course will be oriented to the correct and effective implementation of sampling plans in the Manufacturing Industry.

MMP 6599 - Special Topics in Manufacturing

Three credit-hours. Prerequisite: Graduate Program Mentor approval. One four hours session per week.

Special topics in any of the areas of specialization in manufacturing.

MMP 6700 - Design Project

Three credit-hours. Prerequisites: All core and specialization courses and Graduate Program Mentor approval. One four hours session per week.

This course consists on the development of an applied design project in an area of the specialization selected by the student. This course will guide the student to develop and test a model of some process, conduct experiments to test a hypothesis (manufacturing, ergonomics, etc.), develop a software package to solve some type of manufacturing, human factors, or operational problem, solve an actual industrial engineering problem using one or several quantitative, analytical, and/or qualitative methods.

MMP 6701 - Design Project Extension

Zero credit-hours. Prerequisites: MMP 6700 Graduate Program Mentor approval. One four hours session per week.

This course provides the student the opportunity to continue the development of his/her applied design project.

MMP 6800 - Master's Thesis

Six credit-hours. Prerequisites: All core and specialization courses and Graduate Program Mentor approval. One four hours session per week.

This course consists on the development of experimental and/or theoretical research in an area of the specialization selected by the student to be presented in a thesis with merits for granting the degree. This course will guide the student to develop and test a model of some process, conduct experiments to test a hypothesis (manufacturing, ergonomics, etc.), develop a software package to solve some type of manufacturing, human factors, or operational problem, solve an actual industrial engineering problem using one or several quantitative, analytical, and/or qualitative methods.

MMP 6801 - Master's Thesis Extension

Zero credit-hours. Prerequisites: MMP 6800 and Graduate Program Mentor approval. One four hours session per week.

This course provides the student the opportunity to continue the development of his/her experimental and/or theoretical research.

SEMI 5500 - Business Writing and Presentation Skills Seminar

Zero credit hours. Prerequisite: None. One four hours session per week.

This course is designed to provide graduate students with the most relevant concepts governing effective business writing, oral, and nonverbal communication. It presents the steps required for developing an effective presentation and the different resources available for multimedia presentations. Students will strengthen their presentation skills through a series of presentations required as part of the course.

PROGRAM FACULTY

Ayala Cruz, Jorge – Professor - **Ph.D.**, Management Engineering, Operation Research, Rensselaer Polytechnic Institute, Troy, New York, 1993; **M.B.A.** Production Management, Quantitative Methods, University of Puerto Rico, Río Piedras Campus, 1990; **M.S.** Operation Research Statistics, Rensselaer Polytechnic Institute, Troy, New York, 1991; **B.S.M.**, Mathematics, University of Puerto Rico, Río Piedras Campus 1983.

Castro, Judith – Lecturer IV - **Ed.D**., Curriculum and Teaching, University of Puerto Rico, Rio Piedras Campus, 1999; **Ed.M.**, Pedagogy (Education), University of Puerto Rico, Rio Piedras Campus, 1974; **B.S.**, Pedagogy (Education), University of Puerto Rico, Rio Piedras Campus, 1970.

De Cárdenas, Lourdes – Lecturer III, **Ph.D.**, Chemistry, Purdue University, 1986; **B.S.**, Chemistry, University of Puerto Rio, Río Piedras, 1981.

Dávila Aponte, Edwin – Assistant Professor – **Ph.D.**, Entrepreneurship Development, Interamerican University of Puerto Rico, Río Piedras Campus, 2006; **MBA** Accounting, Interamerican University of Puerto Rico, Río Piedras Campus, 1999; **BBA**., Accounting, Caribbean University, Bayamón, Puerto Rico, 1986.

García Sandoval, María M. – Assistant Professor, Learning Outcomes Assessment Coordinator, **Ed.D.,** Universidad Metropolitana, 2012; **M.I.E**, University of Puerto Rico, Mayagüez Campus, 1997; **B.S.I.E.**, Instituto Tecnológico de Santo Domingo, Dominican Republic, 1994.

Godoy Vinaja, Cuauthémoc – Professor, Associate Dean of the College of Engineering and Land Surveying, and IE Department Head, **Ed. D.**, University of Pennsylvania, 2010, **M.S.I.E.**, Purdue University, 1984, **B.S.I.E.**, Institute of Technology at Madero, Mexico, 1981.

González Lizardo, Angel – Associate Professor, Director Plasma Engineering Laboratory, **Ph.D.**, Electrical Engineering, University of Dayton, OH, 2003; **M.S.**, Electrical Engineering, University of Puerto Rico, Mayagüez,1994; **B.S.**, Electrical Engineering, Universidad del Zulia, Venezuela, 1984.

González, Clara – Lecturer III, **Ph.D.**, Materials Science and Engineering, University of Illinois at Urbana-Champaign, 1997; **M.S.**, Industrial Engineering, Texas A&M University, College

Station, 1991; **B.S.**, Chemical Engineering, University of Puerto Rico, Mayagüez, 1988.

González Miranda, Carlos – Professor, Dean of School of Engineering and Geomatic Science, **Ph.D.**, Industrial Engineering, North Carolina State University, 1995; **M.I.M.S.E.**, Manufacturing Systems Engineering, North Carolina State University, 1990; **B.S.**, Industrial Engineering, University of Puerto Rico, Mayagüez, 1987.

Morales Morales, José A. – Associate Professor, **Ph.D.**, Materials Management, Walden University, Minnesota 1995; **M.B.A.**, Industrial Management, Interamerican University, 1984; **B.S.**, Industrial Engineering, University of Puerto Rico, Mayagüez, 1980.

Nieves Castro, Rafael A. – Associate Professor, **Pharm.D.**, Pharmacy, Nova Southeastern University, 2005; **M.S.**, Pharmaceutical Sciences, University of Puerto Rico, Medical Sciences, 1997; **B.S.**, Pharmacy, University of Puerto Rico, 1993.

Pabón González, Miriam – Associate Professor, Dean Graduate School, **Ph.D.**, Industrial Engineering, University of Massachusetts, Amherst 2001; **P.E.**, 2002; **M.E.M.**, Engineering Management, Polytechnic University of Puerto Rico, 1995; **B.S.**, Industrial Engineering, University of Puerto Rico, Mayagüez, 1990.

Pesante Santana, José A. – Lecturer III, **Ph.D.**, Industrial Engineering, Virginia Polytechnic Institute and State University, 1997; **M.S.**, Industrial Engineering, Georgia Institute of Technology, 1990; **B.S.**, Industrial Engineering, University of Puerto Rico, Mayagüez, 1989.

Pons Fontana, Carlos – Associate Professor, **Ph.D.**, Psychology, Universidad Carlos Albizu, 2004; **M.E.M.**, Engineering Management, Polytechnic University of Puerto Rico, 1994; **P.E.**, 1989; **B.S.**, Industrial Engineering, Polytechnic University of Puerto Rico, 1986; **M.S.**, Psychology, Universidad Carlos Albizu, 1975; **B.A.**, Psychology, University of Puerto Rico, 1972.

Rivera Cruz, Aida – Lecturer III, **Ph.D.**, Industrial Organizational Psychology, Caribbean Center for Advanced Studies, 1991; **M.S.**, Industrial Organizational Psychology, Caribbean Center for Advanced Studies, 1987; **B.A.**, Business Administration, University of Puerto Rico, 1976.

Rodríguez Pérez, José – Lecturer III, **Ph.D.**, Biology, University of Granada, 1989; **B.S.**, Biology, University of Granada, 1984.

Torres Plaza, Edgar O. – Associate Professor, **Ph.D.**, Pharmaceutical Sciences, University of Sciences, Philadelphia, 2009; **M.E.**, Manufacturing Engineering, Polytechnic University of Puerto Rico, 2002; **B.S.**, Chemical Engineering, University of Puerto Rico, Mayagüez, 1998.

MASTER IN MECHANICAL ENGINEERING

Mechanical Engineering embraces design, construction, operation and maintenance of mechanical systems as well as the generation, conversion, transmission, and operation of mechanical and thermal energy systems. The program is suited for students with a keen interest in science and its applications. The curriculum in the Master of Mechanical Engineering covers the advanced aspects of the field, stresses on basic principles and educates students in the use of these principles to solve engineering problems. Advanced courses in the areas of mathematics, optimization, fluid mechanics, thermodynamics, solid mechanics, and manufacturing, CFD and finite element analysis are included to provide new tool of analysis to the student. The student best fits his/her interest in areas of specialization that includes the areas of alternative and renewable energy, wind turbine, turbo machinery, vibrations, tool and tooling design, tribology, manufacturing simulations, composite materials, and new areas such as aerospace. Mechanical Engineering Master students may decide to earn a specialization in aerospace engineering with emphasis in the areas of gas dynamics, high speed aerodynamics, aircraft design, and airplane propulsion and aerospace control.

PROGRAM PHILOSOPHY AND OBJECTIVES

The main objective of the program is to prepare students for a professional career that broadly spans industrial, governmental and academic settings. The program is committed to impart to students the leadership and professional requirements needed in the mechanical engineering environment (in all sectors), enabling them to participate in the development and enhancement of composite systems and components. This know-how is obtained through the development of fundamental knowledge, technical, analytical, and project management, and leadership skills and initiatives, all acquired throughout the program.

The program aims to prepare graduates with a desire and capacity for life-long learning and self-development. Students will have the opportunity to take courses at different times; allowing the availability to a larger student population. Mechanical Engineering is a dynamic field where the fast pace of innovation leads to a need for continuous actualization of knowledge. The emphasis on standard practices, tools and methodologies will provide graduates with empirical knowledge. The program also prepares graduates for academic careers that can fill the demand for professors in related areas of instruction. The programs also seek to develop skills in decision-making, leadership, and collaboration. Graduates will possess in-depth engineering and technological knowledge that will allow them to further develop these skills while performing successfully at strategic levels.

The main objective of the programs is to fill the mayor market needs that have been identified with qualified, competent candidates, providing PUPR graduate mechanical engineering students with:

- Skills to use, evaluate, and apply mathematics, physics, mechanical engineering fundamentals, time-proven techniques and principles, and advanced topics towards the development of novel solutions.
- Communication, leadership, and group collaboration skills, which will enable students to work effectively on diverse projects within multidisciplinary and multicultural teams.

- The necessary knowledge for the application of physical principals such as heat, force, the conservation of mass and energy, and others, to design composite products such as vehicles (automobiles, aircraft, others), weapon systems, heating and cooling systems, industrial equipment and machinery, and household appliances.
- The necessary skills to work in a research and development environment and/or in industrial projects.
- The understanding needed to acquire a professional and ethical attitude, adhering to ethical standards on engineering and intellectual property which will help the student develop the necessary initiative, character and judgment that is required in the profession.
- An understanding of the fundamental trade-offs and constraints related to the economic aspects of mechanical engineering.
- Experiences that lead to strong analytical thinking and problem solving capacity.
- The awareness needed to seek life-long professional development, independent study, and creativity, in order to stay on the cutting-edge of technology.
- Use of modern engineering tools to assist in the analysis of complex systems.

CAREER OPPORTUNITIES

The demand for mechanical engineers is growing at a steady rate. Mechanical engineers apply physical principals such as heat, force, the conservation of mass and energy to design composite products such as vehicles (automobiles, aircraft, others), weapon systems, heating and cooling systems, industrial equipment and machinery, and household appliances. Mechanical engineers need to be well trained in the physical, mechanical, analytical, computational, and experimental practices used in this industry.

The aerospace and manufacturing sectors are considered the most in-demand areas of the industry for mechanical engineers, but emerging technologies such as biotechnology, materials science, and nanotechnology have also created job opportunities. Additional opportunities of employment outside of the discipline also arise for mechanical engineers because the skills and knowledge acquired through earning a degree can be applied to other engineering specialties.

Mechanical engineers research, design, develops, manufacture, and test tools, engines, machines, and other mechanical devices. They work on power-producing machines such as electric generators, internal combustion engines, and steam and gas turbines; and power-using machines such as refrigeration and air conditioning equipment, machine tools, material handling systems, elevators and escalators, industrial production equipment, and robotics used in manufacturing. They also design tools that other engineers use. They usually work in the manufacturing or agricultural production, maintenance, or technical sales. Many acquire the skills and knowledge to become managers or administrators.

A growing demand in the aerospace industry has opened a vast gamma of opportunities for graduate mechanical engineers that posses the technical and administrative skills to embrace state-of-the-art research and innovative technology projects in the most important enterprises located in the U.S., Puerto Rico, and the world. This industry is establishing itself in Puerto Rico and promises to grow at a significant rate in the next five to ten years. Many aerospace engineers have training in mechanical engineering. They design, develop, and test aircraft, spacecraft, and missiles. They supervise and manufacture these products. They develop the technologies for use in aviation, defense systems, and space exploration. Our specialization in aerospace will give students the skills and know-how needed to commence a career in aerospace engineering in Puerto Rico or the mainland.

Aerospace and mechanical engineers are expected to have a fourteen percent growth from 2006 to 2016. In 2006, twenty-two percent of the mechanical engineering specialties were concentrated in the architectural, engineering, and related services industries; fourteen percent were in the transportation equipment manufacturing industry. In that year forty-nine percent of the aerospace engineers were in the aerospace product and parts manufacturing industry. An increase in the number and scope of military aerospace projects and new technologies to be used in commercial aircraft should spur this demand for the present and next decade.

PROGRAM REQUIREMENTS

Admission Requirements

Students with Bachelor's degree in Mechanical Engineering from an accredited institution can apply directly with the only requirement of a minimum general Grade Point Average (GPA) of 2.80/4.00. Students with a GPA lower than 2.8 can apply and the graduate committee reconsideration analyzes the case to determine if the student can be admitted.

Students with Bachelor's degree from other engineering programs can apply for admission. Additional undergraduate pre-requisites may apply after the evaluation of the application by the program mentor. The number of undergraduate credits must not exceed 12 credit hours, if it exceeds this amount the student must enroll as a special student in the bachelors program to be able to take the necessary pre-requisites. After the completion of these credit hours the student may apply to the master's program.

Graduation Requirements

The minimum graduation requirements are as follows:

Master of Engineering in Mechanical Engineering Degree (Design Project)

Degree requirements for this program include thirty (30) credits of coursework and three (3) credits of a project course. This is a total of 33 credit hours of graduate level courses, which consists of:

1. Three credit hours (1 courses) of core courses.
2. A minimum 27 credit hours (9 courses) in the area of general courses.
3. Three credit hours of a Design Project. The student must conduct a design project and prepare a final tech article. The project subject matter is to be approved by the

Graduate Program Coordinator and the student's advisor.

The program is intended to be flexible; students can petition the Program Mentor to substitute other courses dealing with practical applications in Mechanical Engineering Special Topics or in other Departments. In addition, a maximum of 6 credit-hours advanced undergraduate courses can be used to replace graduate courses. The student is thus free to construct a program consisting of courses consistent with the program requirements.

DEGREE OFFERED

Students in the Graduate Program in Mechanical Engineering earn a Master of Engineering in Mechanical Engineering.

CURRICULAR STRUCTURE AND SEQUENCE

The structure and sequence of the curriculum include blocks of courses classified as Core, General and Design Project.

Core Courses

This block provides the advanced knowledge in mathematics that every master student in the Mechanical Engineering must have. The course includes analytical and numerical analysis technique to solve math problems. The core course has a total of 3 credit-hours.

General Courses

This block contains a wide list of courses in different topic related to Mechanical Engineering. Through this block of courses students may select courses of their interest with the purpose of rounding their graduate education in the areas of Energy/Thermal/Fluids and Design/Materials/Manufacturing. It focuses on modern computational, analytical, and experimental techniques applied to thermal, fluid mechanics, structural, materials systems. Courses as composite materials, wind energy, renewable energy, tools and tooling design, advanced manufacturing simulation and turbo machine theory, among others are important applications relevant in Mechanical Engineering.

There is a shortage of skilled mechanical engineers specialized in aerospace technologies capable of making significant contributions to this industry in Puerto Rico and the U.S. Graduates will acquire knowledge in areas such as aerospace structures, aerospace systems and controls, high speed aerodynamics, and stability. The Aerospace (AE) area of specialization trains graduates to become leaders in the aerospace industries, including knowledge in design and analysis of structures, dynamic systems, compressible fluids, and controls related to aerospace research and industrial applications. The general courses block has a total of 27 credits-hours.

Design Project

Students must prepare a design project in a topic that has been approved by faculty and the program mentor. The project can be suggested by students or presented by the faculty members.

CURRICULAR STRUCTURE AND SEQUENCE

Core Courses

Course	Title	Credit-Hours
ME 6014	Advanced Engineering Mathematics	3

General Courses

(Must select 12 credit-hours from the following courses):

Course	Title	Credit-Hours
ME 6100	Advanced Engineering Thermodynamics	3
ME 6110	Conduction and Radiation Heat Transfer	
ME 6120	Advanced Convection Heat Transfer and Fluid Mechanics	3
ME 6130	Gas Dynamics*	3
ME 6140	High Speed Aerodynamics*	3
ME 6150	Theory of Turbomachines	3
ME 6160	Computational Fluid Dynamics	3
ME 6170	Alternative and Renewable Energy Technologies	3
ME 6200	Advanced Solid Mechanics	3
ME 6220	Fracture Mechanics	3
ME 6240	Tools, Tooling, and Machine Tool Design	3
ME 6250	Advanced Manufacturing Simulation	3
ME 6260	Introduction to Composite Materials	3
ME 6270	Fundamentals of Tribology and Surface Layer Technology	3
ME 6300	Advanced Aerospace Structures*	3
ME 6330	Finite Element Analysis	3
ME 6340	Vibration Systems	3
ME 6350	Mechanical and Aerospace Control Systems*	3
ME 6360	Optimization in Engineering Design	3
ME 6390	Special Topics in Mechanical Engineering	3

*Students who take these courses will obtain a Specialization in the Aerospace Area.

Design Project

Course	Title	Credit-Hours
ME 6400	Design Project for Master in Mechanical Engineering	3
ME 6401	Design Project Extension	0

Design Project Descriptions

The design project is required to test the ability of the Master's candidate to engage in original research or complex design projects, and to organize and evaluate themselves creatively in the areas of Energy / Thermal / Fluids, or Design / Materials / Manufacturing, or Aerospace. The student must prepare a project proposal, after the completion of all the courses in the core and area of specialization courses components. After that, the student must conduct the design project under the direct supervision of the advisor, who is the chairperson.

LABORATORIES

These are several laboratories in the Mechanical Engineering Department that can be used either for teaching or research purposes to support the master's program:

Materials Engineering Laboratory - Students receive hands on experience in the use of equipments dedicated to the determination of material properties such as the stress-strain diagrams, hardness testing, and microstructure observation and material identification, and material treatment. Laboratory equipments include tension testing machines, brinnel hardness machine, Vickers hardness machine, Rockwell hardness testing machine, microscopes, ovens, etching chemicals, polishing equipment, etc.

Thermology Laboratory - The students have the opportunity of applying knowledge of convection, radiation and conduction, laws of thermodynamics, and property relations to different thermal equipment.

The laboratory is provided along with a variety of equipment for teaching lab-based for thermal, fluid science courses and turbomachinery. The facility also includes features computer controlled heating and cooling systems that mimic the types of equipment found in industry. Equipments include a wind tunnel, compressible fluid flow, convective heat transfer, thermal radiation, air conditioning, steam boiler, cross flow heat exchanger, Tube and tube, shell and tube, and plate heat exchangers, series and parallel pumping systems, axial and centrifugal fans, hydraulics turbines, and centrifugal compressors.

Fluid Mechanics Laboratory - Hands on experiences on the fundamentals of fluid mechanics is provided in this lab. Students perform and conduct simple experiments for incompressible fluids. Besides, students develop the ability to measure, analyze and interpret data.

This lab is equipped with four work benches, set of different accessories and devices to measure flow, hydrostatic forces, stability of floating bodies, friction in pipes and forces of impact of jets. Other experiments included are ventury meters, weirs and orifices where students determine loss coefficient and learn some characteristics and application of them.

Mechatronics, Controls, and Measurements Laboratory- Hands on experience in Fluid Power and Hydraulic Motion Control Systems; Pneumatic Power and Pneumatic Motion Control Systems; equipment for Controls and Instrumentation for Automation and mechanical actuation systems is available.

This laboratory includes electronic data acquisition cards, PID Controllers, Programmable Logic Controllers (Allan-Bradley and DirectLogic), microprocessors, sensors, transducers, actuators, and power supplies. At the same time, it is provided with computer machine and the different necessary software to accomplish this task.

High Computing Performance Laboratory - This room is specifically reserved for mechanical engineering students of the graduate program where numerical experiments can be performed. The uses include design and analysis of thermal, fluid, and structural numerical experiments. Ten Sun Microsystem workstations and software licenses that include ProEngineering, Ansys, Fluent and VX are available.

Manufacturing and Product Realization Laboratory - This lab provides hands on experiences on a variety of techniques and process for the manufacturing of engineering components including, operation of machine tools and welding machines. Prototypes are designed and manufactured by teams by the guidance of the instructor. This lab is equipped with CNC lathes and millings, conventional lathes, milling machines, grinder surfaces, bandsaws, drills, cuttingsaw, welding machines, oxyacetylene, and tube bender.

In addition, reverse engineering equipment is available such as a Stratasys rapid prototyping machine and a 3-D scanner, and computer machine and software for the state-of-art manufacturing technology.

There are other centers available that were created from grants that our university has developed over the years that can be used in this effort. These centers are:

Plasma Engineering Laboratory - In this Plasma Laboratory it is possible to create plasmas with a very wide range of plasma densities and plasma temperatures, and consequently many different plasma applications can be performed in this Laboratory. The Plasma Engineering Laboratory provides an interdisciplinary research experience for graduate students interested in the development and modification of materials for aerospace applications via plasma treatments. The plasma treatments are performed using the ECRH device existing in the laboratory, which allows for performing Plasma Assisted Gas Deposition as well as Nitriding processes. The Plasma Engineering Laboratory is equipped with a set of tools for plasma diagnostics which allows the accurate measurement of the plasma parameters while the treatments are being performed, and is working in collaboration with University of Missouri-Columbia, who provides for the material analysis techniques that are not available at PUPR. The laboratory is also affiliate of NASA Puerto Rico Space Grant Consortium, which expose the graduate students to a number of initiatives and resources for their research work. This laboratory is funded by U.S. Department of Energy and NASA Puerto Rico Space Grant Consortium. The Plasma Engineering Laboratory has produced 18 publications in the recent past, 8 of them at international conferences.

High Performance Computing Laboratory - Supported by the Department of Defense (DoD), the High Performance Computing Laboratory is designed to provide for the needs of high computing power for multi-disciplinary research as required. The laboratory is equipped with three Beowulf PC Clusters (two 64 processor and one 256 processor) and an Altix 350 supercomputer. The laboratory also provides for the development of joint research projects and software development between university-industry partnerships to enable PUPR to assist in the scientific, technological, and

economic transformation of Puerto Rico and in meeting national unmet needs in scientific high performance computing.

COURSE DESCRIPTIONS

ME 6000 - Advanced Numerical Analysis

Three credit-hours. Prerequisites: None.

The course presents numerical methods and modern algorithms for solving some technical problems: solving systems of linear and nonlinear equations; numerical solutions of ordinary differential equations; initial value problems, one-step and multi-step methods, and Taylor series method. Also includes automatization of input data, practical applications of boundary value problems, partial differential equations, and modern computing.

ME 6012 - Advanced Engineering Mathematics

Three credit-hours. Prerequisites: None.

The course covers advanced mathematical topics as they relate to practical problems. The material is arranged into independent parts: ODE; Linear Algebra, Vector Calculus; Fourier Analysis and Partial Differential Equations; and, Complex Analysis. The course will present the analytical solutions and numerical methods.

ME 6014 - Advanced Engineering Mathematics

Three credit-hours. Prerequisites: None.

The course covers advanced mathematical topics as they relate to practical problems. The material is arranged into independent parts: ODE; Linear Algebra, Vector Calculus; Fourier Analysis and Partial Differential Equations; and, Complex Analysis. The course will present the analytical and numerical methods solutions.

ME 6100 - Advanced Engineering Thermodynamics

Three credit-hours. Prerequisites: None.

Course covers advanced thermodynamics topics as they relate to practical problems. The material is arranged as follows: single-phase systems, energy analysis, multiphase systems, chemically reactive systems, power generation, solar power, refrigeration, entropy-energy minimization, and irreversible thermodynamics.

ME 6110 - Conduction and Radiation Heat Transfer

Three credit-hours. Prerequisites: None.

This course is designed to be a graduate course in conduction and radiation heat transfer. It includes a review of the nature of thermal radiation; implications from electromagnetic theory; radiative characteristics of surfaces; enclosures; configuration factors; radiosity; specular and diffuse reflection; transfer in absorbing, emitting and scattering media; combined radiation conduction and convection; experimental methods. The first half of the course includes general heat conduction equation derivations, one and two dimensional steady and unsteady state heat conduction using closed and numerical approaches. The second half includes basic relations of radiation, radiation exchange between surfaces in a non-participant medium using the net exchange and Monte Carlo methods.

ME 6120 - Advanced Convection Heat Transfer and Fluid Mechanics

Three credit-hours. Prerequisites: None.

This course is an analytical study of convective heat transfer in laminar and turbulent flows; forced convection, natural convection, and mixed convection; combined heat and mass transfer; heat transfer with change of phase; instability of laminar flow; current topics in convection.

ME 6130 - Gas Dynamics

Three credit-hours. Prerequisites: None.

This course teaches the effects of compressibility occurring at high-speeds in internal and external flows with relevance to Aerospace applications. The primary focus of the course is on the teaching of inviscid compressible aerodynamics in nozzle, around wings, and around blunt bodies.

ME 6140 - High Speed Aerodynamics

Three credit-hours. Prerequisites: None.

This course introduces the branch of fluid mechanics which describes the flow of compressible flow; fluids which show appreciable variation in density as a result of the flow, mainly to variation in pressure and temperature. The conservation of mass, first and second law of thermodynamics and Newton's laws of motion of sonic and supersonic, bounded and unbounded are studied and analyzed.

ME 6150 - Theory of Turbomachines

Three credit-hours. Prerequisites: None.

This course covers rotor dynamics machines; dimensional analysis; energy transfer in rotating passages; flow through passages and over blades and vanes; centrifugal pumps, fans, and compressors; axial flow pumps; fans, and compressors; steam and gas turbines; hydraulic turbines; and wind turbines.

ME 6160 - Computational Fluid Dynamics

Three credit-hours. Prerequisites: None.

This a graduate course on modern computational fluid dynamics. Topics include theory, numerical techniques and the use of CFD software on the solution of complex fluid flow. Also includes finite difference and finite volume methods; Grid Generation; Explicit, implicit, and iterative techniques; solutions of elliptic, parabolic, and hyperbolic equations. Emphasis will be on applications and commercial software; validation and verification of solutions.

ME 6170 - Alternative and Renewable Energy Technologies

Three credit-hours. Prerequisites: None.

The course covers energy conversion, utilization and storage for renewable technologies such as wind, solar, biomass, fuel cells and hybrid systems. Thermodynamic concepts (including the first and second law) will form the basis for modeling the renewable energy systems. The course also touches upon the environmental consequences of energy conversion and how

renewable energy can reduce air pollution and global climate change.

ME 6200 - Advanced Solid Mechanics

Three credit-hours. Prerequisites: None.

Mechanics of materials is based on the simplified assumption related to the geometry of deformation. The load-stress relations are derived first and used to obtain load-deflection relations for the members under study. The course discusses stress and strain concepts, mechanical elastic and inelastic behavior of materials, energy methods, torsion, non symmetrical bending and shear center, curved beams, beams on elastic foundations, thick wall cylinder, elastic and inelastic stability of columns, and flat plates and contact stress.

ME 6220 – Fracture Mechanics

Three credit-hours. Prerequisites: None.

The elasticity theory and the mathematical background of fracture theories review. History of the fracture concepts. Presentation of failed engineering structures and failed mechanical elements, analysis of the type of failure. The Atomic view of the failure process. Study of Linear Elastic Fracture Mechanics concepts of Energy and Stress Intensity Factor. Study of Elastic-plastic Fracture Mechanics concepts of Crack Tip Opening Displacement and J Integral. Review of the mechanisms of failure of metals, ceramics and composites. Design of mechanical structures using computer tools.

ME 6240 - Tools, Tooling, and Machine Tool Design

Three credit-hours. Prerequisites: None.

The fundamentals of proper selection of manufacturing processes, machinery, tool and tooling design are considered. Process selection depends on, in addition to technical requirements, factors such as the production quantity and production rate. Guideline and considerations for sequence in process planning and tool, tooling design are given.

ME 6250 - Advanced Manufacturing Simulation

Three credit-hours. Prerequisites: None.

This course will provide the basic understanding of the mechanics of manufacturing processes, their modeling and their simulation. Both simple analytical and computer simulation methods will be covered. Greater emphasis will be given in understanding the fundamentals of the process modeling and less on computational methods. Details and governing theory behind the construction of software will not be provided. However, the intelligent use of software in the solution of industrial problems will be the goal.

ME 6260 - Introduction to Composite Materials

Three credit-hours. Prerequisites: None.

The objective of this course is to present advanced analysis techniques used to support the advanced design of composite structures. The course covers those topics overlooked during preliminary design courses. On the other hand, refined computations of deflections, stress, strength, and buckling loads can only be done using finite element analysis. FEA of composite structures includes many aspects that set it apart from standard FEA, thus requiring some attention as part of this course.

ME 6270 - Fundamentals of Tribology and Surface Layer Technology

Three credit-hours. Prerequisites: None.

Friction and wear are surface phenomena. This course considers friction and wear and their important effects in manufacturing and service of machine components. The three topics of friction; wear, lubrication, and interacting of surfaces in relative motion are grouped together in the term TRIBOLOGY. This consideration involves; types of wear, lubrication, surface integrity, surface technology-surface treatments, protection from wear and friction, fundamentals of tribology, and surface layer technology and their applications in engineering design. Surface integrity is an important consideration in manufacturing and design because it influences properties such as fatigue strength, corrosion, wear, and service life.

ME 6300 – Advanced Aerospace Structures

Three credit-hours. Prerequisites: None.

Students are expected to be able to analyze thin-walled structures under torsion, bending, and buckling type loads; and apply the above knowledge to carry out preliminary structural design of an aerospace component such as the wing of an aircraft. Given an engineering problem, graduates will be able to analyze an appropriate system in which they identify and all forces, flows, constraints, boundary conditions or other parameters pertinent to the solution of the problem. Given a set of governing equations, graduates will be able to choose and execute an appropriate method of solution for the given equations.

ME 6330 - Finite Element Analysis

Three credit-hours. Prerequisites: None.

This course is intended to cover numerical methods of Finite Element to solve problems in the areas of mechanics of material, heat transfer, and dynamics with the development of mathematical descriptions and programming.

ME 6340 - Vibration Systems

Three credit-hours. Prerequisites: None.

Course covers free and forced vibration of single degree and multiple degrees of freedom; discrete and continuous systems; Eigen value and boundary value problems; exact solutions for classical continuous systems; and numerical methods for the analysis of nonlinear systems.

ME 6350 - Mechanical and Aerospace Control Systems

Three credit-hours. Prerequisites: None.

This course provides tools for the analysis of dynamical systems, as well as the mechanisms and techniques to enable their operation, and to improve their behavior.

ME 6360 - Optimization in Engineering Design

Three credit-hours. Prerequisites: None.

This course is intended as a first course on engineering design optimization for graduate students in all areas of engineering. The basic idea of the course is to introduce the design of engineering systems as a systematic and well-organized activity. Emphasis is on establishing a firm understanding of modern optimization. Many assignments are open-ended and subject to individual interpretation and creativity.

ME 6390 - Special Topics in Mechanical Engineering

Three credit-hours. Prerequisite: Graduate Program Mentor Approval. One four hours session per week.

Special topics in any areas of Mechanical Engineering.

ME 6400 - Design Project for Master in Mechanical Engineering

Three credit-hours. Prerequisites: Graduate Program Mentor approval. One four hours session per week.

The specialization area project is composed of a research study on a current topic related to the energy/fluids/thermal, design/materials/manufacturing, or aerospace areas. The specialization area subject needs to be approved by the graduate project student counselor. For the development project the analysis and design phases should be applied to the problem and validated using simulations, modeling techniques, experimental tests, and/or prototype construction. Conceptual and physical model design should be done with tools that have been used in the classroom during the student's pursuit of his program of study.

ME 6401 - Design Project Extension

Zero credit-hours. Prerequisites: ME 6400. One four hours session per week.

This course provides the student the opportunity to continue the development of his/her applied design project.

PROGRAM FACULTY

Alvarado Díaz, Carlos A. - Professor, **Ph.D.** Bio-Medical Engineering, University of Connecticut 2005, **M.S.** Mechanical Engineering, Ohio State University, 1997, **B.S.** Mechanical Engineering University of Puerto Rico, Mayagüez, 1995.

González Lizardo, Angel – Associate Professor, **Ph.D.** Electric Engineering University of Dayton, Ohio, 2003, **M.S.** Electrical Engineering 1994, **B.S.** Universidad del Zulia, Venezuela, 1984.

Noriega Motta, Julio A. - Associate Professor, **Ph.D.**, West Virginia University, 2006; **M.S.** Mechanical Engineering, University of Puerto Rico, Mayagüez, 1993; **B.S.** Mechanical Engineering, University of San Carlos, Ciudad de Guatemala, Guatemala, 1983.

Pelaez Carpio, Hugo M. - Assistant Professor, **Ph.D.**, University of Puerto Rico, Mayagüez, 2001; **M.S.** Chemical Engineering, University of Puerto Rico, Mayagüez, 1995; **B.S.** Chemical Engineering, University of San Marcos, Lima-Perú, 1987.

Restrepo Torres, Bernardo – Associate Department Head and Associate Professor, **Ph.D.** Mechanical Engineering, University of West Virginia, 2011; **M.S.** Mechanical Engineering, University of Puerto Rico, 2001; **B.S.** Mechanical Engineering, Corporación Universitaria Tecnológica de Bolívar, 1996.

Rodríguez Dávila, Héctor – Department Head and Professor, **M.B.A.**, University of New Orleans, 2010; **Ph.D.**, Mechanical Engineering, Virginia Tech, 1996, **B.S.** Civil Engineering, University of Puerto Rico, 1996.

Skrzypinski Romanow, Antoni E. - Professor, D.Sc. Mechanical Engineering, 1980, **Ph.D.** Mechanical Engineering, 1970, **B.S.** Mechanical Engineering, *Universidad de Minería y Metalurgia de Cracow*, Polonia, 1961.

Suárez Alvites, Alejandro - Associate Professor, **Ph.D.**, Nuclear Engineering, University of Missouri, Columbia, Missouri, 2001; **M.S.** Chemical Engineering, University of Puerto Rico, Mayagüez Campus, 1993. **B.S.** Chemical Engineering, Major University of San Marcos, Lima, Perú, 1987.

MASTER OF LANDSCAPE ARCHITECTURE

The Landscape Architecture program at Polytechnic University of Puerto Rico offers two graduate curricula leading to the Master of Landscape Architecture (MLA), both of which require thesis work.

PROGRAM PHILOSOPHY AND OBJECTIVES

At Polytechnic University of Puerto Rico's *Landscape Architecture Master Degree Program*, humanistic, intellectual, creative, and technological endeavors encourage individuals from diverse backgrounds to explore and excel in a discipline that impacts the public realm, issues of quality of life, the environment, and the future physical development of the island.

The program strives to imbue students with social, ecological, and global responsibilities, empowering them with professional skills essential for inquiry, critical thinking, competent and creative 'engagement', and leadership through outstanding scholarship.

Strong students excel at communicating their intentions and realizations, also at conveying technological skills verbally and graphically, being passionate about the stewardship of the landscape entrusted to them, and to the people who live, work and play in it.

1. To highlight the critical role of landscape architecture within a local and regional context.
2. To develop an ethic towards the land.
3. To challenge "myopic" positions regarding landscape in Puerto Rico.
4. To promote landscape architectural research.
5. To contest technology as myth.
6. To build on pedagogical tools and experiences anchored in Puerto Rico.
7. To foster the identification and development of spatial conceptions characteristic of the Caribbean.

8. To encourage debate and critical analysis of the built legacy of landscape architecture locally.
9. To stimulate excellence in landscape architectural design in Puerto Rico.
10. To collaborate in kindling a spirit of stewardship towards the landscape.

GRADUATE PROFILE & OUTCOMES

The graduate program intends to develop in the newly formed Landscape Architects, competence in areas of environmental, social and an aesthetic nature. We strive to encourage students to gain: an understanding of how individuals and groups respond to and affect their built and un-built environment; an awareness of the principles and theories that deal with environmental context, and the landscape architect's responsibility with respect to global environmental issues; and, an understanding of ways in which different forms respond to programmatic, technical, accessibility and contextual objectives in a design proposal.
Students completing the LA degree will be able to acquire knowledge and skills in the:

- Assessment of past and contemporary landscape architecture examples, in light of theoretical tenets in order to be able to inform future changes.
- Dexterity and understanding of the research process required to guide or support a design practice.
- Understanding of the heterogeneity of urban, suburban and other conditions associated to development, and how these circumstances influence human and environmental growth, development and survival.
- Ability to integrate all skills and knowledge gained in positions of leadership at local, regional and international levels.

CAREER OPPORTUNITIES

The program aims at graduate students, entrance to the industry's workforce, pursuit of further studies at the doctoral level or work in a research and educational environment.

The landscape architecture, architecture, planning and construction industries in Puerto Rico and the United States comprise the primary sources of employment for professionals holding a Master of Landscape Architecture. Federal, state and local governmental agencies, and conservation entities in the Island and abroad offer additional opportunities for these practitioners. Furthermore, graduates of the Master of Landscape Architecture degree can enter the workplace as educators at the undergraduate and graduate levels, and are poised to pursue a Doctoral degree.

PROGRAM REQUIREMENTS

In addition to the General Graduation requirements section stated in this catalog, candidates to the Master's degree must:

- Complete the plan of study with at least the minimum number of credit hours specified by the MLA II or MLA III curricula.
- Present and defend an independently produced, single-authored, Design Thesis.

Admissions Requirements

The first professional degree (MLA III) option is a program designed for individuals who have completed a four-year Bachelor degree in any discipline, having obtained a minimum GPA of 2.85/4.00, from an accredited institution. The post-professional (MLA II) degree is a two-year post professional program intended for students who have completed a Bachelor of Science in Landscape Architecture (BSLA), a Bachelor of Landscape Architecture (BLA), a Bachelor in Architecture (BArch), or a Master's in Architecture (MArch). Applicants to the MLA II degree must have completed a degree at an accredited institution with a minimum Grade Point Average (GPA) of 2.85/4.00.

Applicants must meet the following general admission requirements to either curricula, MLA II or MLA III: a) submit an essay (1,200 words maximum in length) describing a local landscape architectural issue, accompanied by an image representative of said issue; and, b) conduct an interview with the program director and/or admissions committee.

Graduation Requirements

In addition to the General Graduation requirements section stated in this catalog, candidates to the Master's degree must:

- Complete the plan of study with at least the minimum number of credit hours specified by the MLA II or MLA III curricula.
- Present and defend an independently produced, single-authored, Design/Thesis.

Pre-Requisite Structure

Candidates to the first professional degree (MLA III) should have completed the subsequent pre-requisite courses at an undergraduate level with a minimum grade of C, from an accredited institution: Biology, and Botany, prior to entering the program. Applicants to the post-professional degree (MLA II), who have completed a Bachelor of Science in Landscape Architecture (BSLA), a Bachelor of Landscape Architecture (BLA), must complete AutoCad as a pre-requisite prior to entering the MLA program. For those candidates holding a Bachelor in Architecture (BArch), or a Master's in Architecture (March), Biology, and Botany serve as pre-requisites to the program.

DEGREE OFFERED

The Landscape Architecture Program includes two curricula: a three-year first professional degree (MLA III), and a two-year post-professional degree (MLA II) leading towards one degree: a Master of Landscape Architecture (M.L.A.).

Thesis is required for all Master of Landscape Architecture candidates. For both program offerings, Thesis consists of 5 credit-hours of Theory and Research, and 6 credit-hours of Design/Thesis work.

The thesis research shall be directed by a member of the faculty, which also acts as the student's graduate committee chairperson. The purpose of the thesis is to expose the student to a reasonable independent research experience that enhances his/her academic development. The student should prepare and carry out a structured and methodical study of pertinence to the profession. Publication of this work in journals, conference proceedings, and/or presentations will be strongly encouraged.

CURRICULAR STRUCTURE AND SEQUENCE

The Master of Landscape Architecture focuses on landscape architecture design and theory within a challenging studio-based curriculum. In addition to the development of a strong foundation of traditional knowledge and skills, the program is committed to scholarship in its various forms, as a means of learning and serving diverse communities and individuals.

The breakdown of credit-hours for the MLA III and MLA II offerings is as follows:

- For students enrolled in the first professional degree track, 58 credit-hours comprise core courses, 11 credit-hours Research and Thesis work, and 9 credit-hours elective courses, for a total of 78 credit-hours.
- For students enrolled in the post professional degree track, MLA II, 40 credit-hours comprise core courses, 11 credit-hours Research and Thesis work, and 9 credit-hours elective courses, for a total of 60 credit-hours.

The required design studio curriculum is organized as a series of units exploring three major themes:

Design process - Considers landscape design skills, including concept abstraction and design development, site analysis, communication and techniques to create 'built landscapes' of a scale and character appropriate to their uses. Integral to the graduate curriculum, the design studio addresses conceptual and applied design. The studio format entails lectures, demonstrations, site visits, one-on-one critiques and instruction, as well as group discussions.
The limited number of participants in the design studio allows for greater interaction between faculty and students. Multiple design philosophies are presented, in order to offer students all available options for their consideration.

Site and landscape - Planning integrates bio-regional contexts, historic land use and appropriation, also contemporary programs at a variety of scales, in order to seek a creative synthesis of environment, human use and also landscape manipulation.

Urban, rural and regional landscape design - Involves the systematic evaluation – employing principles of natural science, rural and regional ecology and landscape design – of a variety of sites in order to creatively develop new approaches to landscape design interventions within the structure of the 'city', its suburbs, the countryside and entire regions.

CURRICULAR STRUCTURE

The curriculum reaches maturity with a final thesis. Courses, credit-hours and the curricular sequence are presented in the following table:

MLA III Curricular Sequence

Year 1

Fall Trimester

Course	Title	Credit-Hours
LA 6110	Design: Foundations and Drawing	5
LA 6210	History of Landscape Architecture	3
LA 6310	Plant Material and Establishment	3

Winter Trimester

Course	Title	Credit-Hours
LA 6120	Design: The Garden Studio	5
LA 6320	Soils	3
LA 6710	Representation: Tools and Techniques	3

Spring Trimester

Course	Title	Credit-Hours
LA 6130	Design: The Urban Studio	5

Note: Student must register a program elective for this trimester.

Year 2

Fall Trimester

Course	Title	Credit-Hours
LA 6410	Environmental Resources	3
LA 6220	Historiography	3

Winter Trimester

Course	Title	Credit-Hours
LA 6140	Design: The Rural Studio	5
LA 6420	Site Engineering	3

Spring Trimester

Course	Title	Credit-Hours
LA 6150	Design: The Regional Studio	5
LA 6330	Advanced Plant Material and Establishment	3
LA 6430	Site Construction	3

Year 3

Fall Trimester

Course	Title	Credit-Hours
	Open Graduate Elective*	3
LA 6440	Ecology and Technology	3

Winter Trimester

Course	Title	Credit-Hours
LA 6230	Theory & Research of Landscape Architecture	5
LA 6510	Professional Practice and Ethics	3

Spring Trimester

Course	Title	Credit-Hours
LA 6800	Design Thesis	6
LA 6801	Design Thesis Extension	0

Note: Student must register a program elective for this trimester.

Electives Courses

Six (6) credit-hours from the Landscape Architecture program offering.
*3 credit-hours from any other Institutional Graduate program offering.

Each student must verify pre-requisite requirements prior to registering for said Open Graduate Elective.

Course	Title	Credit-Hours
LA 6610	Modes of Representation	3
LA 6611	Computer Representation for Landscape Architecture	3
LA 6650	Gardens: Types, Typologies & Design Approaches	3
LA 6240	Contemporary Issues in Landscape Architecture	3
LA 6640	Special Topics: Sculptural Landscape	3
LA 6640C	Special Topics: COOP	3

MLA II Curricular Sequence

Year 1

Fall Trimester

Course	Title	Credit-Hours
LA 6410	Environmental Resources	3
LA 6310	Plant Material and Establishment	3
LA 6220	Historiography	3

Winter Trimester

Course	Title	Credit-Hours
LA 6140	Design: The Rural Studio	5
LA 6320	Soils	3
LA 6420	Site Engineering	3

Spring Trimester

Course	Title	Credit-Hours
LA 6150	Design: The Regional Studio	5
LA 6330	Advanced Plant Material and Establishment	3
LA 6430	Site Construction	3

Year 2

Fall Trimester

Note: Student must register a program elective for this trimester.

Course	Title	Credit-Hours
LA 6240	Contemporary Landscape Architecture Issues	3
LA 6440	Ecology and Technology	3

Winter Trimester

Note: Student must register a program elective for this trimester.

Course	Title	Credit-Hours
LA 6230	Theory & Research of Landscape Architecture	5
LA 6510	Professional Practice and Ethics	3

Spring Trimester

Course	Title	Credit-Hours
LA 6800	Design Thesis	6
LA 6801	Design Thesis Extension	0

Elective Courses

(6 credit-hours from the Landscape Architecture program).

Course	Title	Credit-Hours
LA 6610	Modes of Representation	3
LA 6611	Computer Representation for Landscape Architecture	3
LA 6650	Gardens: Types, Typologies & Design Approaches	3
LA 6640	Special Topics: Sculptural Landscape	3
LA 6640C	Special Topics: COOP	3

COURSE DESCRIPTIONS

LA 6110 - Design: Foundations and Drawing

Five credit-hours. Pre-requisite: None. Two three-and-a-half hour lecture/studio periods per week. Design Laboratory Fee.

As the introductory course of the Landscape Architecture program, this design course serves as foundation work, confronting students with the discipline. A range of basic design principles and techniques for graphic representation as applied to landscape architectural design are explored focusing on the development of spatial thinking, and its communication.

LA 6120 - Design: The Garden Studio

Five credit-hours. Pre-requisites: LA 6110, LA 6310. Two three-and-a-half hour lecture/studio periods per week. Design Laboratory Fee.

The first of four landscape architecture design studios addresses issues of landscape design at a small scale, while applying concepts presented during the design foundations course. Design projects explore the domestic context by scrutinizing garden design from theoretical and formal vantage points, placing emphasis on the development of critical thinking, spatial literacy, and design process.

LA 6130 - Design: The Urban Studio

Five credit-hours. Pre-requisite: LA 6120. Two three-and-a-half hour lecture/studio periods per week. Design Laboratory Fee.

The second studio in the design-course series, covers the urban context through projects of moderate to high complexity. Urban and suburban development is the focus of this studio

where design will be examined as it relates to the philosophies and theories that have shaped neighborhoods, villages, towns, cities, suburbs, and regions of the world throughout history.

LA 6140 - Design: The Rural Studio

Five credit-hours. Pre-requisite: LA 6130. Two three-and-a-half hour lecture/studio periods per week. Design Laboratory Fee.

This advanced design course covers complex large scale analysis, planning and design within rural and peri-urban contexts. The expansion of urban areas to the rural fringe and the impact of humans on places of co-habitation with animal and vegetative life are addressed. An interdisciplinary approach to teaching and learning highlights relevant social, environmental, aesthetic, and economic issues.

LA 6150 - The Regional Studio

Five credit-hours. Pre-requisite: LA 6140. Two three-and-a-half hours lecture/studio periods per week. Design Laboratory Fee.

As the last in the sequence of design studios, this course confronts students with complex large scale regional issues. Contemporary topics and trends such as sustainable design, gray and green infrastructure, watershed and coastal zone management, among others, guide discussion.

LA 6210 - History of Landscape Architecture

Three credit-hours. Pre-requisite: None. One four-hour lecture period per week.

The first in a sequence of three history, theory and research courses, this class provides a historical survey of landscape architectural development from ancient times to the present. History is explored with the understanding that the relationship of humans to the land translates into forms which derive from expressions of function, social values, technological influences, economics and politics – landscape as the footprint of culture.

LA 6220 - Historiography

Three credit-hours. Pre-requisite: LA 6210 (no-applicable to students in the MLA II track). One four-hour lecture period per week.

In this course the "history of history" will be examined to provide students with an acute, critical sense of how to interpret processes and events (past and present). Using the history of landscape architecture "as text" students will be able to apprehend history as a science and grow familiar with the discipline's attributes and limitations.

LA 6230 - Theory and Research of Landscape Architecture

Five credit-hours. Pre-requisites: LA 6130, LA 6210, LA 6220. Two three-and-a-half hours lecture period per week.

Theories and research pertinent to the practice and study of landscape architecture, aesthetic and cultural principles, and values related to the ecological aspects are debated upon. The relationship between humans and the design environment are reviewed. A single authored written document is developed as theoretical backdrop for the design phase of the final thesis project.

LA 6240 – Contemporary Landscape Architecture Issues

Three credit-hours. Pre-requisites: None. One four-hour lecture period per week. (NOTE-This course comprises part of the core courses for students in the MLA II track, or a Program Elective for students registered in the MLA III track.)

A graduate seminar designed to explore vital current topics in the theory and practice of landscape architecture. Students will examine and critically discuss important theoretical texts and landscape architectural projects that represent the variety of issues and multitude of complexities confronted in contemporary practice.

LA 6310 - Plant Material and Establishment

Three credit-hours. Pre-requisites: None. Co-requisite: LA 6110. One four-hour lecture period per week.

This course is intended to familiarize the landscape architect with environmental constraints affecting successful plant establishment and growth. Successful planting design will ultimately depend upon knowledgeable analysis, appropriate placement, installation and maintenance specifications by the design professional.

LA 6320 - Soils

Three credit-hours. Pre-requisites: None. One four-hour lecture periods per week.

This course covers in depth soil's ecological processes and management in terrestrial environments. The class discusses soil's biological and physical properties, and its interaction with land uses and human interventions in different ecosystems. The emphasis of the course is on plant response to soil conditions, and their interface with building material.

LA 6330 - Advanced Plant Material and Establishment

Three credit-hours. Pre-requisite: LA 6310. One four-hour lecture period per week.

The last in the sequence of science related topics, emphasis is given to plant groups as part of larger systems. Plant population ecology and community analysis will serve as backdrop for field experience with the vegetation of Puerto Rico. Coastal, wetland, karstic systems – among others – comprise part of the organization of a larger ecological region which will be studied in depth throughout the trimester.

LA 6410 - Environmental Resources

Three credit-hours. Pre-requisite: None. One four-hour lecture period per week.

This course will cover in depth the methods employed by the landscape architecture profession to examine and address issues related to environmental resources. A prerequisite to environmental planning is an understanding of and respect for natural ecosystems. Class work on this topic will be considered

at a regional scale, examining interrelations between various systems: vegetative, human and riparian.

LA 6420 - Site Engineering

Three credit-hour. Pre-requisite: None. One four-hour lecture period per week.

In this technology course, landscape design will be addressed through bi-dimensional landscape representation of the three-dimensional reality. Site analysis, its intervention or conservation, and structure location in a site, will complement the understanding of the site's attributes: geographical, topographical, climatic, and ecological. Grading, road alignment, irrigation systems, and storm water management are among the topics explored.

LA 6430 - Site Construction

Three credit-hours. Pre-requisite: None. One four-hour lecture period per week.

Coursework exposes students to the processes and materials required in the assemblage of physical features. It introduces candidates to the properties, uses and qualities of materials inherent to landscape architecture applications and associated construction techniques. Materials and methods are additionally explored as a source of design ideas, form and expression in landscape architecture.

LA 6440 - Ecology and Technology

Three credit-hours. Pre-requisite: LA 6410. One four-hour lecture period per week.

Current concerns regarding environmental conservation are examined and questioned against their impact on available and developing technologies including green roof technology. Appropriateness to resources and culture are discussed in relationship to cost and time effectiveness. Laboratory type projects constitute an integral part of the course.

LA 6510 - Professional Practice and Ethics

Three credit-hours. Pre-requisites: None. One four-hour lecture period per week.

The role of the practitioner is questioned from the ethical, financial and managerial standpoint. Personnel organization, supervision, office procedures, payments for service, marketing and career options are examined. Critical analysis of moral dilemmas inherent to professional practice, considering wide-ranging implications of ethics in a globalized society where disciplines overlap but also obscure responsibilities form part of class readings, discussions and debates.

LA 6610 – Modes of Representation

Three credit-hours. Pre-requisites: None. One four-hour lecture period per week.

This course delves into concepts, techniques and methods related to the representation of forms and space on a two-dimensional, flat surface, and three-dimensional work.

LA 6611 – Computer Representation for Landscape Architects

Three credit-hours. Pre-requisites: None. One four-hour lecture period per week.

The course aims to inform the design process of landscape architects through the application of digital media. Decision making using the information garnered through digital drawings is clearly articulated to the designer as well as others involved in the implementation process. The course explores the representation of complex geometrical forms, their spatial organization, materiality, interaction with the context, and tectonics.

LA 6640 – Special Topics: Sculptural Landscape

Three credit-hours. Pre-requisite: None. One four-hour lecture period per week.

The course *Sculptural Landscape* presents students with fundamentals and principles which guide the art of sculpture, while also underlining its function in the landscape. Materials, cohesion and consistency of the object itself and in regards to the sculpture's final siting, are among some of the topics examined in the classroom. The relationship between solids and the surrounding void (the context) is explored, particularly as it relates to the varying levels of importance among them which can be attained.

LA 6640 C – Special Topics: COOP

Three credit-hours. Pre-requisite: None. One four-hour lecture period per week.

Coursework in COOP establish a relationship where theory and professional practice overlap. Given the interdisciplinary nature of the industry, this class is structured to reflect the amalgam of optics and needs set forth upon the execution of the discipline. Be it design firms, governmental or conservation entities, education institutions or professional associations, the diversity of places and forms of practice offer venues for students to pursue a professional experiences.

LA 6650 – Gardens: Types, typologies and design approaches

Three credit-hours. Pre-requisites: LA 6210, LA 6220. One four-hour lecture period per week.

The course focuses on the study of gardens around the world, identifying different types, characteristic elements, typologies and design issues that have changed or remained constant through time. Coursework will unravel design intentions through the analysis of the relation of human activities, epochs, places, function and form.

LA 6710 – Representation: Tools & Techniques

Three credit-hours. Pre-requisites: None. One four-hour lecture period per week.

An introductory class to the skills required for landscape architectural representation, communication of design intent is sought through the use of various two-dimensional and three-dimensional drawing and modeling media. This course

concentrates on the use of representation as complement to the design process.

LA 6800 – Design Thesis

Six credit-hours. Pre-requisites: LA 6150, LA 6230, LA 6330; LA 6430, LA 6510. One four-hour studio period per week.

The last in a series of five design studios this course is intended to provide students the forum to pursue an in depth design exploration based on the previously developed single-authored research project. Completion of this work will demonstrate students' ability to define a contemporary problem and overarching strategies with which to address it. The course provides an opportunity for the student to integrate the theoretical frameworks and technological skills acquired during the degree in a comprehensive manner.

LA 6801 – Design Thesis Extension

Zero credit-hour. Pre-requisite: LA 6800. One four-hour studio period per week.

This course provides students the opportunity to continue and complete design thesis work.

PROGRAM FACULTY

Areces Mallea, Alberto – **Ph.D.**, Biology, CUNY, New York, 2003; **Master of Philosophy**, Biology, CUNY, New York, New York, 1996; Licensure in Biological Sciences and Botany, University of Havana, Cuba, 1969.

Benero Rivera, Ricardo – Master of Landscape Architecture, Polytechnic University of Puerto Rico, 2010; **Bachelor of Arts**, Escuela de Artes Plásticas, 2001.

Colón Arizmendi, Edmundo – **BS** in Civil Engineering, University of Puerto Rico, Mayagüez 1974.

Colón Izquierdo, Edmundo - **Master of Landscape Architecture**, Harvard University, Graduate School of Design, Massachusetts, 2006; BArch, Polytechnic University of Puerto Rico, Hato Rey, Puerto Rico, 2004.

Lorenzo Torres, José - Master of Urban Design, Harvard University, Graduate School of Design, Massachusetts, 2005; **BArch**, Polytechnic University of Puerto Rico, 2001.

Rigau Pérez, Jorge – Master of History, University of Puerto Rico, Río Piedras, Puerto Rico, 1993; **BArch**, Cornell University, Ithaca, New York, 1975.

Rodríguez Toledo, Marisabel - **Master of Landscape Architecture**, Cornell University, 1996; **BA**, Education, University of Puerto Rico, Río Piedras, Puerto Rico, 1982.

Sánchez Nieves, Roberto L. – Master of Landscape Architecture, Polytechnic University of Puerto Rico, 2010; **Bachelor of Arts Education**, University of Puerto Rico, 2001.

Suárez Toro, Jaime - **Master of Arts**, Columbia University, New York, New York, 1970; **BArch** Catholic University of America, Washington, DC, 1969.

Terrasa Soler, José Juan- Master of Landscape Architecture, Harvard University, Graduate School of Design, Massachusetts, 2007; **Master of Environmental Studies**; Yale University, Connecticut, 1997; **MS**, Biology, University of Michigan, Michigan, 1992; **BS**, Biology, Mount Saint Mary's College, Maryland, 1990.

Velázquez Figueroa, Juan Carlos – Master of Fine Arts, Complutense University, Madrid, Spain, 1988; **Bachelor of Fine Arts**, School of Fine Arts, San Juan, Puerto Rico, 1985.

Victorio Sánchez, Jammile A. – Master of Architecture, University of Puerto Rico, Río Piedras, Puerto Rico, 2005; **Bachelor of Environmental Design**, University of Puerto Rico, Río Piedras, Puerto Rico 1999.

MASTER OF BUSINESS ADMINISTRATION

The Master of Business Administration (MBA) degree is one of the most sought after degrees in the world because of its value to people in business and administration. The MBA degree has been designed to provide the student with a personalized education that fits his/her background, experience, and goals, and that challenges to reach fullest potential. It provides students from diverse academic backgrounds a solid foundation in business concepts and a broad management perspective for today's global business environment. Emphasis is placed on teaching students to fully utilize today's rapidly advancing technology to more quickly and effectively attain the organization's goals and objectives.

PROGRAM PHILOSOPHY AND OBJECTIVES

Organizations today demand multitalented knowledgeable professionals who can contribute and succeed in a team/project management environment. The MBA Program has been carefully crafted to train professionals through the study of management theory and practical problems solving. It focuses on developing versatility through critical thinking, intellectual flexibility, analytical and applied research skills, creativity, and high standards for professional integrity and ethics. Globalization issues of management are instilled into many of the Program courses. Teamwork is an essential component of organizational dynamics, and it is stressed through team projects that encourage face-to-face meetings as well as synchronous and asynchronous on-line meetings. To implement our Philosophy and vision, the MBA Program has established the following goals:

- To help students transform themselves into knowledgeable managers that understand business dynamics at all levels.
- Present the interrelatedness of the functional areas of business, and be able to integrate them in the performance of business decisions and in solving complex business issues.

- Dispense relevant curriculum that combines academic theory with practical problem-solving skills.
- Provide the fundamental concepts and principles that underlie the operation of business enterprises as well as offer a comprehensive set of more specialized courses to allow students to tailor their education to their specific needs and career goals.
- Develop students with the ability and insight to apply cross-functional approaches.

CAREER OPPORTUNITIES

Because of their ability to analyze problems, address unstructured business challenges, and generate alternatives for a given situation, MBA graduates are among the most sought by companies throughout the world. There are many opportunities in the private sector as well as in the public or not-for-profit sectors, which offer extensive employment opportunities. Success will depend ultimately on self-awareness, research and preparation. The Master of Business Administration degree has been so popularized over the last decades that many employers now consider it a prerequisite for entry into several career fields, and a must for growth consideration. It is a requisite in many companies for certain positions, just as the bachelor's degree was a few decades ago.

DEGREES OFFERED

The MBA degree offers the following three specializations:

- International Enterprises
- General Management
- Computer Information Systems

PROGRAM REQUIREMENTS

Admission Requirements

The MBA program is subject to the general admission requirements of the Graduate School. The admission requirements specific to the MBA program are as follows:

1. Possess a Bachelor's degree in any discipline from an accredited college or university.
2. Have obtained a minimum of a 2.50/4.00 GPA in undergraduate course work.
3. Present results of the EXADEP (*Examen de Admisión a Estudios de Posgrado*) or GMAT (Graduate Management Admission Test) or GRE (Graduate Record Examination). Scores must be no older than 5 years prior to requesting admission.

Minimum Graduation Requirements

The MBA degree requires a minimum of 48 credit-hours of graduate course work with a minimum grade point average of 3.0 out of a 4.0 scale. No thesis or comprehensive examination is required.

General Prerequisites

The MBA curriculum is designed for students from diverse academic backgrounds. In a broad philosophical sense, the MBA program is not geared exclusively for undergraduate business students; rather, students with a wide range of undergraduate experiences such as engineering, science, liberal arts as well as business administration are encouraged to apply. The student will work with a wide breadth of business disciplines with the objective of maximizing the organization's effectiveness and financial performance as required by its major stakeholders.

An introductory level course in Marketing from an accredited university is required. Applicants who did not take this undergraduate course can take it at PUPR. A grade of C (2.0) or above in the undergraduate prerequisite courses is necessary to complete the requirement. In addition to the above undergraduate prerequisite courses, MBA students pursuing the Computer Information Systems specialization must have both, a database management and a programming language course.

CURRICULAR STRUCTURE AND SEQUENCE

Core Courses in Management

There are 18 credit-hours in core management courses, which are common to all offered Management degrees. They provide a common body of knowledge in quantitative and qualitative areas, which are necessary prior to undertaking deeper exposure to other business issues. These courses are:

Course	Title	Credit-Hours
MGM 5500	Managerial Accounting	3
MGM 5700	Probabilities and Statistical Methods	3
MGM 6070	Managing Human Resources	3
MGM 6560	Management of Information Systems	3
MGM 6620	Managerial Finance	3
MGM 6690	Decision Making Techniques	3

Core Courses in Business Administration

Today's business managers need to understand how overall economic conditions, marketing strategies, and business operations interact to influence the organization's desired goals and objectives. To assure an adequate preparation on these subjects, all MBA students are required to take the following Business Administration Core Courses:

Course	Title	Credit-Hours
MBA 5600	Managerial Economics	3
MBA 5700	Managerial Marketing	3
MBA 6830	Operations Management	3

In addition, MBA students pursuing the *General Management* or *International Enterprises* specialization complete the academic curriculum with a course in Strategic Management. Using the Harvard Case Study method, students analyze real world business problems, and recommend solutions utilizing the entire body of knowledge acquired throughout the program. Specifically, this core course is:

Course	Title	Credit-Hours
MBA 6900	Strategic Management	3

Instead of the above, MBA students pursuing the *Computer Information Systems* specialization complete the academic curriculum with a Strategic Management course specific to their field of emphasis. *Computer Information Systems* students should choose one of the following courses:

Course	Title	Credit-Hours
CIS 6905	Strategic Management Project in Database or	3
CIS 6906	Strategic Management Project in E-Commerce	3

Areas of Specialization

International Enterprises

The specialization in Management of *International Enterprises* teaches students to view organizational management in a global context, and to realize that marketing strategies must be designed while considering the different cultural perspectives. Business operations and legal ramifications must also be carefully analyzed when operating in a multinational environment. Finally, currency exchange rates and other financial considerations must be carefully managed to properly achieve the parent organization's objectives.
International Enterprises students should complete the following courses:

Course	Title	Credit-Hours
MIE 7010	International Business Operations	3
MIE 7020	International Business Strategies	3
MIE 7110	International Finances	3
MIE 7120	Business Law in Global Perspectives	3

General Management

The specialization in *General Management* allows the students to design their own program to match specific interests. The *General Management* student completes 12 credit-hours in general interdisciplinary courses. Students could choose courses in fields related to Engineering Management, International Enterprises or Environmental Management, among others. Instead of specializing in any one field, selecting courses from several areas will serve to broaden the student's perspective.

MBA students pursuing the *General Management* specialization must also complete six credit-hours in elective courses.

In summary, the MBA *General Management* 48 credit-hours curriculum is composed of 18 credit-hours in Management core courses, 12 credit-hours in Business Administration core courses, 12 credit-hours in general interdisciplinary courses, and 6 credit-hours in electives.

Computer Information Systems

The *Computer Information Systems* (*CIS*) specialization under the MBA degree program provides the knowledge, skills and ability to develop creative solutions to substantive real-world problems. The *CIS* program has the perfect fitness of the crossover between Computer Science and Information Systems with a healthy emphasis in Electronic Commerce (E-Commerce) and Data Base Management. The *CIS* program is rated highly among recruiters in the area of Information Technology (IT). It has the ingredients needed for candidates to succeed in the real world (technical and business abilities). This program is especially well suited for professionals in business, government, industry, or education.

CIS as an academic field that encompasses two broad areas: (1) acquisition, deployment, and management of information technology resources and services (the information systems function) and (2) development and evolution of infrastructure and systems for use in organization processes (system development).

CIS students should complete the following courses:

Course	Title	Credit-Hours
CIS 6605	Data Base Management Systems	3
CIS 6615	Software Engineering for Business	3
CIS 6705	Data Communications and Computer Networks	3
CIS 6713	Internet Marketing	
CIS 6715	Electronic Commerce and Web Information Systems	3
CIS 6725	Applied Artificial Intelligence for Business	3

MBA students pursuing the *CIS* specialization must also complete three credit-hours in an elective course oriented either to database or electronic commerce.

In summary, the MBA *CIS* 48 credit-hours curriculum is composed of 18 credits in Management core courses, 9 credit-hours in Business Administration core courses, 18 credit-hours in *CIS* courses, and 3 credit-hours in an elective course.

MASTER IN ENGINEERING MANAGEMENT

The Master in Engineering Management (MEM) program prepares engineers for managing complex technological organizations in service and manufacturing industries. The program of study is multi and intra disciplinary, merging the latest development in management and technology theory and practices. The program design aims at developing the knowledge, abilities and judgment to become a successful manager and entrepreneur using best practices, techniques and paradigms of project management, supply chain operations and system thinking. Therefore, it provides a well balanced education among management and business thinking, engineering judgment, and technological operations. The Master's Degree in Engineering Management was authorized by the Council of Higher Education of Puerto Rico in 1992.

PROGRAM PHILOSOPHY AND OBJECTIVES

The combination of management concepts and technical skills presented in the MEM Program allows engineers to acquire the managerial skills necessary to advance in today's technological driven organizations, in either the service or manufacturing sector. Emphasizing the continuity of management and

engineering related efforts from planning through development, operations and controlling, and stressing the application of management and system theory and techniques to increase the efficiency and effectiveness of the organization, is one key issue facing many organizations. Based on these realities the Program stresses the importance on using practices of project and program management, management information systems, organizational behavior, and system operations. It is amply confirmed that the MEM Program is well designed to develop future industry leaders by combining a core management curriculum with a master's level education.

The goals of the Program are:

- To help students understand the management dimension, and advantages in technological driven organizations.
- Gain experience using management methods of a quantitative nature to design and efficiently operate today's technically involved business systems.
- Demonstrate an understanding of management and organizational theory and the principles of organized labor as they apply to the efficient and effective operation of the organization.
- Develop skills and competencies related to a broad range of management functions, allowing the student to work in fields of management, in organizations of varying size, requiring strategic planning, technical knowledge, development skills, and general operational knowledge of management.

CAREER OPPORTUNITIES

The complete experience is stimulating and offers outstanding career opportunities. The graduates from this program will be adequately qualified to perform effectively as managers of technological or scientific enterprises. The Program has been particularly structured to fit the needs of engineers in Puerto Rico and Latin America. Also, through its areas of emphasis, it provides an opportunity to hold leadership positions in managing business firms in Manufacturing, Public and Service Enterprises, Construction, and Environmental Management.

PROGRAM REQUIREMENTS

Admission Requirements

The MEM program is subject to the general admission requirements of the Graduate School. The admission requirements specific to the MEM program are as follows:

1. Possess an undergraduate degree in Engineering from an accredited college or university.
2. Have obtained a minimum undergraduate GPA of 2.50/4.00.

Graduation Requirements

The MEM degree requires a minimum of 39 credit-hours of graduate course work with a minimum grade point average of 3.00. No thesis is required.

DEGREE OFFERED

The program offers graduate instruction leading to the Master of Engineering Management Degree. The emphasis areas are:

- Manufacturing Management
- Construction Management
- Environmental Management
- Public Work Management

CURRICULAR STRUCTURE AND SEQUENCE

The structure of the program and the sequence of the curriculum include a series of courses on basic, general, and areas of emphasis.

All students entering the Graduate School of Management will take 18 credit-hours as part of the General Core Courses in Management. These courses are:

Course	Title	Credit-Hours
MGM 5500	Managerial Accounting	3
MGM 5700	Probabilities and Statistical Methods	3
MGM 6070	Managing Human Resources	3
MGM 6560	Management of Information Systems	3
MGM 6620	Managerial Finance	3
MGM 6690	Decision Making Techniques	3

This core will provide all graduate students with a common and basic core of knowledge needed to carry out further graduate work in their respective areas of specialization.

The present Master in Engineering Management is specially designed for engineers.

Core Courses in Engineering Management

Afterwards, the students in this area will take in 12 credit-hours additional courses in Engineering Management. These courses are:

Course	Title	Credit-Hours
MEM 5600	Engineering Economic Analysis	3
MEM 6110	Engineering Management I	3
MEM 6120	Engineering Management II	3
MEM 6200	Engineering Management Project	3

Emphasis Area Courses

The students can choose among four emphasis areas: 1) Construction Management; 2) Environmental Management; 3) Manufacturing Management or; 4) Public Works Management. As an alternative the students could combine courses of any of the four emphasis areas to finish the curriculum with a general emphasis.

The students must complete 9 credit-hours in their emphasis area chosen. The courses in these areas are the following:

Construction Management

Provides managerial knowledge essential in the utilization of different and available information systems in managing construction projects from their initial design, cost estimates, labor organization, contracts and construction management. Real situations are emphasized. The contractor is visualized as a manager who has to administer each phase of the project.

Course	Title	Credit-Hours
MEM 6410	Construction Management	3
MEM 6170	Cost Estimate and Contracting	3
MEM 6820	Business and Construction Law	3

Manufacturing Management

Provides managerial knowledge required to administer the design, implementation, operation, maintenance and quality control in the complex technical processes of manufacturing. A substantial number of courses in this specialization are geared toward quality control and modern productivity techniques. The student must choose up to 9 credit-hours from the following courses:

Course	Title	Credit-Hours
MEM 6420	Maintenance Management	3
MEM 6610	Productivity Management	3
MBA 6830	Operations Management	3
MGM 5800	Supply Chain Management and Logistics	3

Environmental Management

Provides managerial knowledge that will enable engineers to administer and take charge of, and control projects and processes to minimize environmental pollution. Federal and state laws that regulate the handling, disposal, treatment of contaminants and environmental protection will be stressed. Awareness will be created in the student about environmental problems in Puerto Rico and engineering methods and processes required to minimize and decrease environmental pollution. The student must choose up to 18 credit-hours from the following courses:

Course	Title	Credit-Hours
MEM 6910	Air Quality	3
MEM 6915	Water Quality	3
MEM 6940	Introduction to Pollution Control of Earth Systems	3
EPM 6800	Solid Waste Management	3
EPM 6810	Environmental Regulations	3
EPM 6850	Management for Sustainable Future	3

Public Works Management

Provide knowledge that will enable engineers to become managers and executive personnel in governmental agencies/departments offices, or public corporations. The emphasis lies specifically on courses designed to train the student in the use of computerized information systems, public policy governmental regulation, cost estimates, contracting and modern productivity techniques. The application of this knowledge will result in a more efficient public administration by the graduate who enters public service.

Course	Title	Credit-Hours
MEM 6170	Cost Estimate and Contracting	3
MEM 6610	Productivity Management	3
MEM 6710	Professional Ethics and Public Policy	3

MASTER IN ENVIRONMENTAL MANAGEMENT

Environmental Management is concerned with the development of new and better ways to design and operate facilities and systems that will provide for protection and improvement of environmental quality and the conservation of natural resources. This is a new and developing field, and the emphasis is on environmental resource management and sustainable development. Professionals in this field help industries and government agencies to find ways of accomplishing their objectives without causing pollution and without damaging the environment while protecting public health and safety.

The content of the Master in Environmental Management (MEnvM) program covers the disciplines of water pollution treatment and pollution prevention, air pollution control, solid and hazardous waste management, industrial safety and environmental impact assessment. These topics are discussed in a carefully integrated approach with the vision of a world in which it will be possible for everyone to meet their basic needs and to achieve an equitable share of their aspirations while maintaining an environment that is healthy, physically attractive, and biologically productive.

PROGRAM PHILOSOPHY AND OBJECTIVES

To be successful, persons with primary interests in careers in environmental policy and analysis, stewardship, education, consulting, or management dealing with natural resource or environmental issues have to be able to integrate technological knowledge with social studies. The main goal of this program is to prepare students to address ecological and social systems within a complex underlying social and ecological context. This program also provides opportunities for professionals who have graduated in other fields to extend their knowledge in environmental management. This program is designed for professionals who require the skills and knowledge to integrate environmental planning, and monitoring into the broader decision-making process within their organizations.

The main objectives of the MEnvM program are:

- To strengthen the proficiency to adapt a multi-disciplinary approach to environmental problem solving and decision making.
- To improve the expertise and skills required to perform strategic planning on environmental and sustainable development issues.
- To reinforce the ability to evaluate alternative means of environmental regulation at the local, and regional level.

- To study the nature and implications of environmental policy options.

GRADUATE PROFILES AND OUTCOMES

Graduates from the MEnvM program will be able to:

- Understand complex local and federal environmental laws and compliance regulations.
- Apply statistical analysis, risk assessment, surveying and monitoring techniques to promote solutions to environmental problems.
- Evaluate and prepare environmental impact assessment documents.
- Apply sustainable development as a management tool and use broad based sustainable development laws in the analysis of countries, cities, etc.
- Be up to date in the fields of water pollution treatment and pollution prevention, air pollution control, solid and hazardous waste management, industrial safety and environmental impact assessment.
- Manage environmental emergencies.

CAREER OPPORTUNITIES

Environmental managers work in industrial and service corporations, in consulting firms, in local, state and federal government, in Universities and with other professional corporations such as lawyers, financial institutions and public-interest groups. Almost all industries and government agencies have Departments or Sections of environmental protection.

The MEnvM degree is designed to prepare professionals for managerial positions and responsibilities in manufacturing, public utilities, and service industries whose operations could produce or generate pollutant or environmental contaminations. These professionals would help the enterprises to meet their environmental responsibilities and improve them.

The program is designed to help the student to develop the knowledge, abilities, and judgment to become a successful manager of the environmental areas and/or occupational safety department or office. The program will teach the student managerial knowledge, skills and abilities to know the environment and its susceptibility to human/industrial impacts, the laws and regulations related to the environment, the techniques to control air, water and solid pollution, the management of hazardous waste and environmental and occupational emergencies and the related licensing and compliance aspects. The latest technological and regulatory know-how and case studies will be emphasized.

PROGRAM REQUIREMENTS

Admission Requirements

The MEnvM program is subject to the general admission requirements of the Graduate School. The admission requirements specific to the MEnvM program are as follows:

1. Possess an undergraduate degree in Natural Sciences, engineering, architecture, landscaping architecture, business administration, management or related fields from an accredited college or university.
2. Have obtained a minimum undergraduate great point average (GPA) of 2.50/4.00.

Applicants not meeting these requirements may request reconsideration by a committee.

Graduation Requirements

The MEnvM degree requires a minimum of 36 credit-hours of graduate course work with a minimum GPA of 3.00/4.00. No thesis is required.

DEGREE OFFERED

The program offers graduate education leading to the Master of Environmental Management (MEnvM).

PROGRAM STRUCTURE AND CURRICULAR SEQUENCE

The students registered in this degree will take 18 credit-hours in core courses related to management, 12 additional credit-hours in Environmental Management and 6 credit-hours in electives.

Management Courses

Course	Title	Credit-Hours
MGM 5500	Managerial Accounting	3
MGM 5700	Probabilities and Statistical Methods	3
MGM 6070	Managing Human Resources	3
MGM 6560	Management of Information Systems	3
MGM 6620	Managerial Finances	3
MGM 6690	Decision Making Techniques	3

Environmental Management Courses

Course	Title	Credit-Hours
EPM 6810	Environmental Regulations	3
EPM 6820	Environmental Impact Assessment	3
EPM 6850	Management for Sustainable Future	3
EPM 6900	Environmental Management Applications	3

Elective Courses

MEnvM students could select the 6 credit-hours in electives from any course labeled as EPM, MEM, MBA, MIE or CIS. Among these, the following are recommended.

Course	Title	Credit-Hours
EPM 6800	Solid Waste Management	3
MEM 6910	Air Quality	3
MEM 6915	Water Quality	3
MEM 6940	Introduction to Pollution Control of Earth Systems	3

COURSE DESCRIPTIONS

Business Administration, Engineering Management and Environmental Management

CIS-6605 - Data Base Management Systems

Three credit-hours. Prerequisite: COMP-3010 or undergraduate equivalent. One four hours session per week.

This course presents methodologies and principles of database design. The focus is on database architectures, logical modeling, the relational model, and database design process and techniques. Topics covered include the entity relationship model, the relational model, relational operators, integrity constraints, the SQL language, and data normalization. Also included are topics in distributed databases, objects-oriented databases, and security issues.

CIS-6615 - Software Engineering for Business

Three credit-hours. Prerequisite: ISYS-3520 or undergraduate equivalent. One four hours session per week.

Most relevant concepts of software requirements generation and analysis, software design, structured design methodologies, data flow design, and programming of an engineering system and testing.

CIS-6705 - Data Communications And Computer Networks

Three credit-hours. Prerequisite: None. One four hours session per week.

Recent advances and new applications in the expanding field of computer networks and distributed systems are examined. The technical fundamentals, architecture, and design of computer networks and distributed systems are described. Strategies, tools, and techniques for network planning, implementation, management, maintenance, and security are delineated. Topics include ISDN, and ATM, the OSI model, transmission media, network operating systems, topologies, configuration protocols, and performance characteristics. Trends in standardization, internetworking, downsizing, and the development of local-networks (LANs), wide-area networks (WANs), metropolitan-area networks (MANs), and enterprise-wide networks are explored.

CIS-6713 - Internet Marketing

Three credit-hours. Prerequisite: None. One four hours session per week.

This course is intended to introduce students to the marketing aspects of the Internet. The student will learn traditional and online marketing strategies, as well as the analysis of Internet business situations in which duties, ethics and laws are put to test.

CIS-6715 - Electronic Commerce and Web Information Systems

Three credit-hours. Prerequisite: None. One four hours session per week.

Enterprises thrive on receiving information. The Internet has emerged as the dominant server for national academic organizations and network host. This course will study the structure, organization, and use of the Internet. Internet technologies ant their potential applications are examined including electronic commerce, database connectivity, and security. An emphasis will be placed on evaluating, organizing, and developing efficient models of electronic transactions.

CIS 6725 - Applied Artificial Intelligence for Business

Three credit-hours. Prerequisite: CIS-6605. One four hours session per week.

Principles and techniques relating to automate support for decision-making and organizational problem solving are studied. Topics include decision theory, modeling and simulation, decision support system architecture and group decision support systems. Knowledge-based expert systems and intelligent agents are studied. Applications of rule chaining, heuristic search, constraint propagation, constrained search, inheritance, and other problem-solving paradigms are presented. Other topics are: the application of identification trees, neural nets, genetic algorithms, and other learning paradigms.

CIS 6843 - Computer Graphics

Three credit-hours. Prerequisite: None. One four hours session per week.

Representation and manipulation of two and three-dimensional transformations, projection, illumination and shading models.

CIS 6833 - Human-Computer Interaction

Three credit-hours. Prerequisite: None. One four hours session per week.

Issues on effective human-computer interaction are presented. Basic elements, procedures, tools, and environments contributing to the development of successful user interface are explored. User interface design principles, guidelines, and methodologies are reviewed. Other topics include multidisciplinary dynamics of human-computer interaction as a field of study, current developments in HCT research and usability engineering.

CIS 6893 - Data Warehousing

Three credit-hours. Prerequisite: None. One four hours session per week.

This course includes the various factors involved in developing data warehouses and data marts; planning, design, implementation, and evaluation; review of vendor data warehouse products; cases involving contemporary implementation in business, government, and industry;

techniques for maximizing effectiveness through OLAP and data mining.

CIS 6905 - Strategic Management Project in Data Base

Three credit-hours. Prerequisite: CIS-6605 and CIS-6615. One four hours session per week.

The main objective of this course is to pursue a research study on a current database system topic or to define a business related problem that has a solution through the development of a data base system. Areas of current interest include object oriented database systems, extended relational DBMS, federated or homogeneous database systems, high performance parallel database systems, query optimization and advance logic database modeling. For the development project the analysis and design phases should be applied to the problem with related DFDs to describe the system before and after the proposed solution. Conceptual model will be designed with the use of an E-R diagram. The physical design will be done in a DBMS such as Oracle or SQL server.

CIS 6906 - Strategic Management Project in E- Commerce

Three credit-hours. Prerequisite: CIS-6715. One four hours session per week.

The main objective of this course is to pursue a research study on a current e-commerce topic or to define a business related problem that has a solution through the development of an e-commerce application. Areas of current interest include leading edge practices such as electronic publishing, e-shopping, e-distribution, knowledge creation and dissemination, search engines, agent and filters, etc., and understanding issues or problems that surround e-commerce such as security and privacy, new practices, EDI on the Web, evolving options for local access, etc. For the development project the analysis and design phases should be applied to the problem. Conceptual model will be designed with the use of any CASE tool. The physical design will be done using programming tools available to the student that have been used in the classroom (Front Page, Pearl, Java, HTML, etc).

CIS 6923 - Special Topics In Data Base

Three credit-hours. Prerequisite: None. One four hours session per week.

This course presents the state of the art in information technology. Several topics will be offered.

CIS 6924 - Special Topics In E-Commerce

Three credit-hours. Prerequisite: None. One four hours session per week.

This course presents the state of the art in information technology. Several topics will be offered.

EPM 6800 - Solid Waste Management

Three credit-hours. Prerequisite: None. One four hours session per week.

This course provides an in-depth analysis of the core engineering concerns and management issues associated with the management of solid wastes. The student will become knowledgeable in the process of material recovery, processing and transportation.

EPM 6810 - Environmental Regulations

Three credit-hours. Prerequisite: None. One four hours session per week.

Technical, economic, political, administrative and social forces influence the environmental quality regulations and the use of natural resources. Review of federal and state laws, regulations and programs enacted to minimize pollution of air, land water. Review of public participation mechanisms. Discussion of environmental problems such as greenhouse effect, acid rain, ozone depletion, marine pollution, etc. Understanding of the major theoretical approaches in the field of environmental regulations using an interdisciplinary approach. Background and content of environmental politics and policies, environmental resources issues, policy development, and specific regulatory issues as they pertain to water resources, air pollution, solid and hazardous waste management -disposal and, environmental quality.

EPM 6820 - Environmental Impact Assessment

Three credit-hours. Prerequisite: EPM 6810. One four hours session per week.

This course covers the technology available conduct environmental assessments and needed to establish new operations or projects. The student will acquire the knowledge and develop the expertise about Federal and Local environmental permits and the studies and demonstrations needed to obtain them.

EPM 6850 - Management of Sustainable Future

Three credit-hours. Prerequisite: None. One four hours session per week.

This course provides an in-depth analysis of the sustainable development concept discussing the ecological principles on which modern resource management is based.

EPM 6900 - Environmental Management Applications

Three credit-hours. Prerequisite: EPM 6820, EPM 6850. One four hours session per week.

The course is an overall application of all the knowledge acquired during the master program in environmental management. The student will generate a project concerned with the development of new and better ways to design and operate facilities and systems that will provide for protection and improvement of environmental quality and the conservation of natural resources. The obtained results will focus on environmental resource management and sustainable development based on Puerto Rico current needs.

MBA 5600 - Managerial Economics

Three credit-hours. Prerequisite: None. One four hours session per week.

Most relevant points regarding supply and demand, analysis of consumer behavior, analysis of production cost, main

structures of the market place, linear programming, the economic systems and development of economic concepts and macro economic.

MBA 5700 - Managerial Marketing

Three credit-hours. Prerequisite: MARK-1010 or undergraduate equivalent. One four hours session per week.

The study of the strategic process of creating time and place utilities. It deals with how to identify customer's needs, change those needs to wants, and sustain the desire of the particular product (service or good). How this process can be applied to profit and non-profit organizations.

MBA 5800 - Leadership

Three credit-hours. Prerequisite: None. One four hours session per week.

This course is organized around the concept that leadership involves influencing others in a non- coercive manner where capital reigns, competitive advantage occurs when an organization utilizes the knowledge and experience of all its members. “Command and control” leadership styles are limited to specific emergency circumstances. Instead leaders should direct their efforts toward shared goals, collaborative methods and leverage the leadership potential of all members of the entire organization. The course integrates current research on leadership and real world business events. The design offers an experiential, practical and theoretical approach to understanding the qualities, characteristics, styles and behaviors of successful leaders. The course also provides participants to focus on their own leadership abilities and to explore strategies for building teamwork, motivation, creativity, effective communication, conflict resolution, strategic leadership, and innovative leadership practices that enhance innovation and organizational performance.

MBA 6830 - Operations Management

Three credit-hours. Prerequisite: None. One four hours session per week.

This is a graduate course in manufacturing techniques. In this course the student will acquired deep knowledge of the tools, techniques and types of manufacturing processes and management of the production planning, schedule and operation. Topics such as Production and Inventory Control, just-in-time, total quality control, statistical process control, waste analysis, work measurement and world class Manufacturing will be discussed. Also cover manufacturing systems such as factory layout, machine center, robotics, sensing, manufacturing cells and automated factories will be included.

MBA 6900 - Strategic Management

Three credit-hours. Prerequisite: 36 credits approved. One four hours session per week.

The corporate world is becoming a very different place. Mergers and acquisitions have transformed the landscape. International boundaries are fading in importance as businesses take on a more global perspective, and the technology of the "Information Age" is narrowing the time it takes to communicate and make decisions. Business Policy or Strategic Management takes a panoramic view of this changing corporate terrain.

This course unifies the various departments, majors, and sub discipline found in a business school. The material of this course will be explained in the context of cases which have been class tested and revised based on he feedback from those classes. The firms range in size and maturity from large, established multinational to small, entrepreneurial ventures, and cover a broad range of issues and address questions raised.

The students are expected to have a general knowledge of the basic business functions; finance, marketing, operations management, accounting, quantitative methods and human resources.

MEM 5600 - Engineering Economic Analysis

Three credit-hours. Prerequisite: None. One four hours session per week.

This is a graduate course in engineering analysis emphasizing the planning and control of engineering economics including manufacturing costs. In this course project cost evaluation including interest rates and continuous compounding, present-worth and capitalized cost, is discussed. Methodology to determine rate-of-return for various alternatives, benefit/cost ratio evaluation, replacement analysis and others are described. The preparation of cash-flow diagrams and introduction to cost estimation are studied. Determination of break-even values, sensitivity analysis and decision trees and introduction to value engineering techniques is included.

MEM 6110- Engineering Management I

Three credit-hours. Prerequisite: None. One four hours session per week.

In depth discussion of the elements of modern management and business practices is conducted. This course is designed to provide student without specialized business training to understand the principles used by professionally trained managers to guide the typical industrial and business enterprise

MEM 6120 - Engineering Management II

Three credit-hours. Prerequisite: MEM-6110. One four hours session per week.

This course enables students to deepen in the understanding of fundamental concepts and principles of general management emphasizing their application in technological and scientific organizations in industry and government. For the purpose of the study of management, one needs to perceive all major functions in some coherent framework. Such a framework is provided by breaking down the totality of the management process into its four major components: planning, organizing, leading and controlling. In this course, the student will explore the concepts that provide the foundations for these four managerial functions.

MEM 6170 - Cost Estimation And Contracting

Three credit-hours. Prerequisite: None. One four hours session per week.

This course takes the engineer to cover in depth the fundamental principles that govern public enterprises such as government departments, public instrumentalities, state and municipal government, etc. Probability and decision theory in cost- effectiveness studies, profit and risk analysis are also covered.

MEM 6200 - Engineering Management Project

Three credit-hours. Prerequisite: MEM-6120. One four hours session per week.

This is a project course that provides the opportunity to apply concepts and methods previously studied to the solution of problems in engineering management. Students will work individually, on problems proposed by the student and approved by the professor.

MEM 6410 - Construction Management

Three credit-hours. Prerequisite: None. One four hours session per week.

The management of construction is at one time an art and a science. Both have to deal with planning, scheduling, controlling, and following different activities of great diversity such as cost estimating, scheduling, contracting, insuring, accounting, labor relations, etc. At times the manager must use highly quantitative methods while at other times the intuitive or empirical approach is all what is available. Therefore construction and maintenance managers must be masters of a wide range of qualitative and quantitative subjects. Consequently he must possess a very high level of competency in a large number of areas.

This course is designed to help students gain a perspective regarding the construction industry and some cross-sectional understanding of the things to be mastered if they wish to be successful as construction managers.

MEM 6420 - Maintenance Management

Three credit-hours. Prerequisite: None. One four hours session per week.

This course is designed to help students gain a perspective regarding the maintenance of buildings and industries and some cross-sectional understanding of managers. New administrative and management tools and methodology specific to maintenance activities are covered. Students will learn how to manage the resources: money, machines, materials and personnel that are basic to realize effective maintenance.

MEM 6610 - Productivity Management

Three credit-hours. Prerequisite: None. One four hours session per week.

This course moves the engineer through the different approaches to Total Quality Management. Total Quality Management is a system to effectively achieve institutional goals with the active participation of all the employees, clients and suppliers. Through the course traditional management for productivity techniques, TQM, Crosby, Juran and Deming philosophies are discussed. The concepts of quality cycles, changes in institutional culture, zero defects, corrective action, productivity measurements, error cause removal, Pareto Principle, etc, are discussed.

MEM 6710 - Professional Ethics and Public Policy

Three credit-hours. Prerequisite: None. One four hours session per week.

This course permits the engineer to imbue in the law and codes professional ethics that govern public enterprises such as government departments, public instrumentalities, state and municipal governments and professional ethics.

MEM 6820 - Business And Construction Law

Three credit-hours. Prerequisite: None. One four hours session per week.

Concepts of business and construction law in general and applied to Puerto Rico are covered. This course is designed to provide students with the professional skills of understanding the clauses and applications of commercial law emphasizing construction litigation.

MEM 6910 - Air Quality

Three credit-hours. Prerequisite: None. One four hours session per week.

This course will be covering several topics regarding the air quality and pollution control. Some of the topics that will be studied in this course are as follows: Indoor Air, The Atmosphere, Ozone Depleting Substances (Montreal Protocol), Aldrin Inhalation Toxicity Weight (TRI), Banned or Severely Restricted Pesticides (USEPA), Explanation of Criteria, Air Pollutant: Rank States, Particulate Size 10 microns Pollution Locator: Criteria Air Pollutants, Lead, Particulate Size 2.5 Microns, Respiratory Toxicity Health Effects, Greenhouse Gases, (Intergovernment Panel of Climate Change), EPA'S National Ambient Air Quality Standards, The Standard Review and Re-evaluation Process, Introduction to Air-Pollution Control, Air Pollution Effect, and Environmental Preservation.

MEM 6915 - Water Quality

Three credit-hours. Prerequisite: None. One four hours session per week.

This course exposes the student to different methods of water purification for commercial and industrial use, wastewater treatment and disposal, and topics associated to water quality.

MEM 6940 - Introduction to Pollution Protection of the Earth System

Three credit-hours. Prerequisite: None. One four hours session per week.

The course presents the concept of the earth as an integrated system, where human activity, based on the use of the natural resources for material development, generates impacts on the environment, interfering with ecology, and creating scenarios

that present challenges related to human health and a balanced environmental.

MGM 5500 - Managerial Accounting

Three credit-hours. Prerequisite: None. One four hours session per week.

This is a graduate course where the accounting principles and techniques for making decisions are taught. The role of decision criteria based on General Accepted Accounting Principles and others are explained in detail. Therefore, this course provides the essential information that the manager or business man needs to have control of the firm in order to obtain his objectives effectively and efficiently.

MGM 5700 - Probabilities and Statistical Methods

Three credit-hours. Prerequisite: None. One four hours session per week.

This is a graduate course in relevant business statistics emphasizing applications specific to engineering disciplines. In this course various probability and statistical methods to sample, measure of dispersion and skewness, probability distributions are studied. Also testing hypothesis and making decisions, analysis of variance, chi-square analysis and linear regression and correlation are examined. Advanced topics such as nonlinear regression, multivariable analysis, time series analysis and exploratory data analysis are introduced. Case studies of quality control and engineering decisions are assigned and discussed.

MGM 5800 - Supply Chain Management and Logistics

Three credit-hours. Prerequisite: None. One four hours session per week.

This course introduces students to the concept of value-driven supply chains, a system approach to managing the entire flow of information, materials, and services from raw materials suppliers through factories and warehouses to the end-customer. Emphasis will be placed on understanding the impact of demand and supply flows across the supply chain and its fundamental principles, using insights from both operations management and logistics. The course demonstrates the design and management of effective supply chains based on current research and organizations' practices, illustrated with case studies. An important message across the course is the need of using a system-thinking view, and the importance of using integrative tools to analyze and evaluate alternative courses of action.

MGM 6070 - Managing Human Resources

Three credit-hours. Prerequisite: None. One four hours session per week.

Psychology concepts and corresponding methodology to manage human resources in a scientific and technical enterprises. Techniques for hiring, benefits, incentives, promotion, retention, development, replacement of personnel, and creativity, among others are discussed emphasizing the human dimension. Techniques to solve complaints, insubordination, and violations of regulations are introduced.

MGM 6560 - Management of Information Systems

Three credit-hours. Prerequisite: None. One four hours session per week.

Information systems that provide support for management in areas such as finance, manufacturing, cost estimation, and marketing. Introduction to analysis of data flow diagrams, databases, and data communication are introduced.

MGM 6620 - Managerial Finances

Three credit-hours. Prerequisite: MGM-5500. One four hours session per week.

Financial concepts encountered in engineering. Situations are introduced based on the fact that they are an integral part of planning, organizing, directing and controlling activities.

The financial cycle budgeting, accounting, controlling and auditing is discussed.

MGM 6690 - Decision Making Techniques

Three credit-hours. Prerequisite: MGM-5700. One four hours session per week.

This is a graduate course where the scientific management methods for making decisions and solving administrative problems are taught. The role of decision criteria and subjective factors, Bayesian analysis, advanced decision making methods, linear programming and analysis of alternatives are discussed. Also the value of reliable and representative information, utilization of statistical information, strategic analysis and projections, forecasting, PERT, CPM and other management techniques to solve problems are introduced.

MIE 7010 - International Business Operations

Three credit-hours. Prerequisite: None. One four hours session per week.

This course examines the basics of international business operations. The course begins discussing the global environment and reasons for an organization to become global, including the two main ways about how international business takes place. Then, the characteristics of multinational companies will be explained, followed by global competitiveness and affairs. Among the material that will be covered are Michael Porter's diamond theory of international competitiveness, the latest work in the theory of multinational enterprises, global markets, and new research on organizational learning within corporations.

MIE 7020 - International Business Strategies

Three credit-hours. Prerequisite: None. One four hours session per week.

This course examines international business strategies using an integrative approach, specially set around the questions of "how functional strategies are integrated?" It begins discussing functional international strategies and explaining actual actions by global companies in different global settings. Then, an integrative approach for global strategy will be taken.

Among the materials that will be covered are foreign exchange rate management (currency swapping), "absolute" and

"comparative" advantages in developing multinational strategies, and strategies for doing business in the "triad" markets.

MIE 7110 - International Finances

Three credit-hours. Prerequisite: None. One four hours session per week.

Financial concepts encountered in engineering situations are presented based on the fact that they are an integral part of planning, organizing, directing and controlling, and auditing is discussed. The general goal is to provide the necessary knowledge to the student about different financial concepts that a manager of scientific and technological activities uses in order to prepare budgets, secure funding, analyze financial alternatives and control expenses.

MIE 7120 - Business Law In Global Perspective

Three credit-hours. Prerequisite: None. One four hours session per week.

Concepts of Business Law in general and on a global dimension as applied to cross-cultural and cross-border legal issues. This course is designed to provide students with the fundamental and professional skill of understanding the concepts and applications of business and commercial law in a global environment.

FACULTY

Ayala Cruz, Jorge – Professor - **Ph.D.**, Management Engineering, Operation Research, Rensselaer Polytechnic Institute, Troy, New York, 1993; **M.B.A.** Production Management, Quantitative Methods, University of Puerto Rico, Río Piedras Campus, 1990; **M.S.** Operation Research Statistics, Rensselaer Polytechnic Institute, Troy, New York, 1991; **B.S.M.**, Mathematics, University of Puerto Rico, Río Piedras Campus 1983.

Cervoni, Fernando – Lecturer II, **J.D.**, Inter American University, School of Law, 2010; **B.B.A.**, Management, Inter American University, 2007.

Cruz Triana, Alfredo – Professor; Computer Science; **Ph.D.** Nova Southeastern University, FL, 2002; **Ph.D.**, University of Cincinnati, Ohio, 1992; **B.S.** Math and Computer Science, University of North Carolina, North Carolina, 1984; **B.E.T.** Electrical and Computer Engineering, University of North Carolina, North Carolina, 1984; **A.A.S.**, Electrical Engineering,

Cruzado Vélez, Héctor – Professor and Civil Engineering Graduate Program Coordinator, **Ph.D.** in Wind Science and Engineering, Texas Tech University, 2007; **M.S.C.E.**, Massachusetts Institute of Technology, 1998; **B.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1996, **P. E.**

Cuevas Miranda, David N. – Lecturer II, **Ph.D.** Marine Sciences - University of Puerto Rico, Mayagüez Campus, 2010; **M.S.** Geology, Saint Louis University, St. Louis, MO, 2003; **B.S.** Geology, University of Puerto Rico, Mayagüez Campus, 1998.

Dávila Aponte, Edwin – Assistant Professor – **Ph.D.**, Entrepreneurship Development, Interamerican University of Puerto Rico, Río Piedras Campus, 2006; **M.B.A.** Accounting, Interamerican University of Puerto Rico, Río Piedras Campus, 1999; **BBA**., Accounting, Caribbean University, Bayamón, Puerto Rico, 1986.

Elias Rivera, Johnny – Professor – **L.L.M.**, Law and Economy, Catholic University of Puerto Rico, 1993; **J.D.,** University of Puerto Rico, 1974; **Ph.D.**, Civil, Systems Engineering, University of California, 1964; **M.S.C.E.**, Civil, Structural Engineering, University of California, 1962; **B.S.C.E.**, Civil Engineering, University of Puerto Rico, 1959.

Faría González, Rafael – Professor, **Ph.D.**, Industrial Engineering, The Pennsylvania State University, 1973; **M.S.**, Industrial Engineering; The Pennsylvania State University, 1967; **B.S.**, Industrial Engineering, University of Puerto Rico, 1964.

González Juarbe, Juan – Lecturer II, **De.E**., University of Puerto Rico, **M.B.A.**, Financial and Construction Management, University of Puerto Rico, Río Piedras, 1990; **M.E.**, Structures, Lamar University, Beaumont, Texas, 1971; **B.S.**, Civil Engineering, University of Texas at El Paso, Texas, 1969; Associates, Arts, Pre-Engr. Canal Zone College, Panama, 1967; Project Manager Certification, Bortech Institute, Hato Rey, PR, 2006.

González Miranda, Carlos J. – Professor, Dean School of Engineering and Geomatic Science, **Ph.D.,** Industrial Engineering, North Carolina State University, 1995; **M.M.S.E.**, North Carolina State University, 1990; **B.S.**, Industrial Engineering, University of Puerto Rico, Mayagüez Campus, 1987.

Irizarry, Janet – Associate Professor, **Ph.D.,** Organizational Psychology, California School of Professional Psychology, 1992; **M.A.**, Organizational Psychology, California School of Professional Psychology, 1991; **M.A.**, Education, Counseling and Guidance, University of Puerto Rico, 1983; **B.A.**, Education, University of Puerto Rico, 1981; **B.A.**, Philosophy and Arts, University of Puerto Rico, 1976.

Modesto Ortíz, Pedro – Lecturer II, **M.E.M.**, Polytechnic University of Puerto Rico, 1995; **B.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1984, **P.E.** Area of Interest: Environmental Engineering.

Molina Bass, Omar I. – Lecture I, **Ph.D.**, Construction Engineering, Universidad Politécnica de Madrid, Spain, 2008; **D.E.A.**, Construction Engineering, Universidad Politécnica de Madrid, Spain, 2006; **M.Eng.**, Construction Engineering & Management, University of Alberta, Canada, 2000; **B.S.C.E.**, Magna Cum Laude, University of Puerto Rico, Mayagüez Campus, 1998.

Mueses Pérez, Auristela – Professor, **Ph.D. in Civil Engineering**, University of Florida; **M.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 1992; **B.S.C.E.**, Technological Institute of Santo Domingo, Dominican Republic, 1987; P.E.

Pabón González, Miriam – Professor, **Ph.D.**, Industrial Engineering, University of Massachusetts, Amherst 2001; **M.E.M.**, Polytechnic University of Puerto Rico, 1995; **B.S.**, Industrial Engineering, University of Puerto Rico, 1990.

Pagán, Leticia – Associate Professor, **Ph.D.**, Information Systems and Globalization, Lesley University, Cambridge, Massachusetts 2004; **M.B.A.**, Inter-American University, San Juan, Puerto Rico, 1976; **B.S.**, Business Administration, University of Puerto Rico, 1979.

Pons Fontana, Carlos A. – Associate Professor, **Ph.D.,** General Psychology, Carlos Albizu University, 2004; **M.E.M.**, Polytechnic University of Puerto Rico, 1994; **B.S.I.E.**, Polytechnic University of Puerto Rico, 1986; **M.S.** Psychology, Carlos Albizu University, 1975; **B.A.** Psychology, University of Puerto Rico, 1972.

Rentas Rivera, Edgar J. – Lecturer III, **Ed.D.**, Education, Inter American University, San Juan Campus; **M.B.A.**, Accounting and Marketing, Inter American University, San Juan Campus; **B.B.A.**, Accounting, University of Puerto Rico, Cayey Campus.

Ramírez Santiago, Juan – Lecturer II, **Ph.D.**, Entrepreneurship Development and Management, Inter-American University of Puerto Rico, San Juan, Puerto Rico, 2005; **M.E.M.**, Management in Engineering Management, Polytechnic University of Puerto Rico, 1999; **B.S.E.E.**, Science in Electrical Engineering, Polytechnic University of Puerto Rico, Hato Rey, 1992.

Rodríguez Pérez, Luis H. - Associate Professor in Marketing; **J.D.** Inter American University, School of Law, 1999; **M.B.A.** with major in Marketing, 1993; **B.S.** in Computer Science, University of Puerto Rico, Bayamon Campus, 1989.

Solá Sloan, Juan M. - Lecturer III, **Ph.D.**, Philosophy in Computing and Information Science and Engineering, University of Puerto Rico, Mayaguez Campus, 2009; **M.Eng.** Computer Engineering, University of Puerto Rico, Mayaguez Campus, 1998; **M.S.**, Computer Science, University of Puerto Rico, Bayamón Campus, 1996.

Torres Plaza, Edgar – Associate Professor, **Ph.D.**, Philosophy in Pharmaceutical Sciences, University of the Sciences in Philadelphia, Philadelphia College of Pharmacy and Science, Philadelphia, **P.A.**, 2009; **M.Eng.**, Engineering in Manufacturing, Polytechnic University of Puerto Rico, San Juan Campus, 2002; **B.S.Ch.E.**, Science in Chemical Engineering, University of Puerto Rico, Mayaguez Campus, 1998.

Villalta Calderón, Christian A. – Assistant Professor, **Ph.D.,**Civil Engineering, University of Puerto Rico, Mayagüez Campus, 2009; **M.S.C.E.**, University of Puerto Rico, Mayagüez Campus, 2004; **B.S.C.E.** University of Costa Rica, 2001.

GRADUATE CERTIFICATE

Certification in Information Assurance & Security

Information Assurance and Security (IAS) has actually become important areas of interest in the Computer Science field due to the IT boom of the twenty-first century. The increase in the number of Internet applications and users, combined with the computerization of business processes, has made IAS professions of great demand. Studies have revealed that computer-based criminal activities are costing businesses and government organizations billions of dollars every year. Due to the shortage of information system security professionals there exists a need for comprehensive programs and certificates to educate more individuals in the field of Information Assurance and Security (IAS). As the US government in general, and the Department of Defense (DoD) in particular, become more dependent on computer networks, systems and software, we become more vulnerable to hostile intelligence gathering as well as computer network attacks. The need for graduate computer scientists specialized in IAS is pervasive in industry, scientific research, academic institutions, business, commerce, appliance manufacturing, and the government.

PROGRAM OBJECTIVES & GOALS

The main objective of this certificate is to prepare students in one of the most demanding fields in IT at this moment: Information Assurance and Security (IAS).

The goals of the PUPR GCIAS program are to:

1. Develop a national/internationally-recognized quality Graduate Certificate Program in Information Assurance and Security (GCIAS).
2. Develop joint research projects in IA between university and industry partnerships.
3. Prepare IT professionals in computer and information security areas, which are of great demand, worldwide.
4. Attract more faculty members with specializations in these areas of great concern.
5. Increase the quality of IAS education, which will lead to strengthening our curriculum and augmenting the quantity of research projects in the areas of information assurance and security.
6. Make PUPR an effective candidate pool for IT Security Managers, Computer Scientists, Engineers, and related positions in Puerto Rico and the Caribbean.

GRADUATE PROFILE

Students taking the GCIAS courses will learn how to use many of the tools and technologies used in these security related occupations including: Network analyzers or LAN analyzers, Protocol analyzers, authentication server software, identity management and password management software, remote authentication dial-in user service software, Internet directory services software, Network monitoring software, hardware and software auditing software, system testing software, network security or Virtual Private Network (VPN) management software, Intrusion Detection System IDS software; Intrusion Prevention System IPS software; network and system vulnerability assessment software; snort intrusion detection technology, transaction security and virus protection software; stack smashing protection SSP software; and virus scanning software.

The graduate of the GCIAS should possess the following know-how:

1. Enough knowledge of computer hardware and software, (including applications and programming) to recognize the physical and logical threats that can affect information assets.
2. As consultants or service providers, graduates should have knowledge of principles, standards, ethical and legal

aspects, processes, auditing and controls for providing secure operations and IT security services. This includes customer needs assessment, meeting quality standards for services, and evaluation of customer satisfaction.

3. Law and Government knowledge of laws, legal codes, court procedures, precedents, government regulations, executive orders, agency rules, and the democratic political process.
4. IT security management. The knowledge of business and management principles involved in strategic planning, resource allocation, human resources modeling, leadership techniques, production methods, and coordination of people and resources, in order to plan and evaluate secure business operations throughout the organization.
5. Change Management. The knowledge to determine how, when and why a system requires change to improve its effectiveness, and provide its' secure operations.
   a. The judgment and decision-making required to consider the relative costs and benefits of the potential actions that are implicated in the changes; to be able choose the most appropriate one.
   b. Ability to manage the resistance of employees, managers, and even administrators to changes in both logical and physical controls.
6. Risk Management. The ability to identify and control the risks facing an organization.
   a. Risk identification to document the security posture of an organizations IT and the risks it faces.
   b. Risk control to apply the controls to reduce the risks to data and information systems.
7. Knowledge of IT Auditing. The review of a system; the observation, evaluation, and action taken to ensure secure operations; effective controls for physical and logical security in IT systems. Determine if misuse or malfeasance has occurred.
8. Engineering and technology knowledge of the practical application of engineering science and technology to administer and evaluate security systems. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services for secure IT operations and for the evaluation of these systems and products.
9. Telecommunications knowledge of transmission, broadcasting, switching, control, and operation of telecommunications systems.
10. Education and training knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.
11. Public safety and security knowledge of relevant equipment, policies, procedures, and strategies to promote effective local, state, or national security operations for the protection of people, data, property, and institutions.
12. Understand the importance of contingency planning, and be able to develop and execute business continuity, disaster recovery, and strategic security plans, and their applications, without affecting business performance.

Graduates of the GCIAS should also have the following personal and professional skills:

1. Understand the implications of information assurance and security for both current and future problem solving and decision-making in the development of IT systems and secure IT operations.
2. Have technical knowledge of cryptography and cryptanalysis skills to secure the transmission of critical information and to decrypt coded information. Be able to test these systems periodically to ensure the efficient use of these techniques.
3. Identify controls, processes or procedures that can endanger information assets and affect system security, and the actions needed to improve these, relative to the goals of the system.
4. Critical thinking using logic and reasoning to identify the strengths and weaknesses of IT systems and develop alternative solutions, conclusions or approaches to problems related to the security of information assets.
5. Time management skills to manage ones own time and the time of others.
6. Systems Analysis skills to determine how a system should work and how changes in conditions, operations, and the environment will affect outcomes.
7. Troubleshooting skills to determine the causes of security breaches and operational errors in IT systems, and decide who is responsible and what to do about it.
8. Effective writing and communication skills to disseminate security policies and practices, including awareness on new company policies. Ability to read and understand information and ideas presented in writing, arranging things or actions in a certain order or pattern.
9. Ability toward inductive reasoning in order to combine pieces of information to sense when something is wrong or is likely to go wrong with a system. This does not necessarily involve solving the problem in its initial stage, but recognizing there is a problem and taking actions to correct it.

PROGRAM REQUIREMENTS

Admission

Prerequisites necessary to apply for enrollment in the GCIAS:

- Calculus I or equivalent
- A high level programming language
- Bachelor Degree in related areas such as Computer Science, Information Systems. Computer Engineering, Mathematics, Computational Mathematics, among others.
- Minimum GPA of 2.80

The student applies for admission to the GCIAS (as a non-seeking degree) to work towards the Certificate. The student that intends to enter the graduate program in Computer Science with a specialization in ITMIA (after completing the GCIAS) has to apply for admission to this program with the established requirements.

- Two courses approved in the GCIAS can be validated towards the MS CS (thesis option) ITMIA specialization.
- Five courses approved in the GCIAS can be validated towards the MCS (non-thesis option) ITMIA specialization.
- Graduate students that are currently enrolled in any of the other ECECS Department Master Degrees or MS CS specializations and have approved the prerequisites can obtain the GCIAS by completing the required 18 credits. Prerequisites must be approved.
- Students in a Master in Business Administration program with a Track in Computer Information Systems or Information Systems can enroll in the GCIAS program if they have completed the prerequisites of admission for the certification.

Graduation Requirements for the GCIAS

Students must complete the following requirements for the Graduate Certificate in Information Assurance and Security (GCIAS):

- Complete a total of 18 credits in six courses specified for the GCIAS.
- Have a minimum GPA of 3.00 when completing the 18 credits.

CAREER OPPORTUNITIES

Work activities include using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information; keeping up-to-date technically and applying new knowledge to your job; observing, receiving, and otherwise obtaining information from all relevant sources; analyzing information and evaluating results to choose the best solution and solve problems; developing, designing, or creating new applications, ideas, relationships, systems, or products; providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person; compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data; identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts; developing specific goals and plans to prioritize, organize, and accomplish your work; entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic form.

CURRICULAR STRUCTURE AND SEQUENCE

Core Courses

The student programs must include 18 credit-hours of core courses specified below:

Course	Title	Credit-Hours
CECS 6005	Principles of Information Security	3
CECS 6015	IT Auditing and Secure Operations	3
CECS 6035	Contingency Planning	3
CECS 6045	Law, Investigation and Ethics	3
CECS 7570	Computer Security	3
CECS 6130	Data Communication Networks	3

XVI. COMBINED BACHELOR'S MASTER'S DEGREE PROGRAM

Polytechnic University of Puerto Rico, has designed the combined bachelor's-master's degree program. The objective is to provide the talented PUPR undergraduate students the opportunity to complete the combined bachelor's-master's degree in a reduced time period, after completing 105 credit hours of the undergraduate program (excluding the remedial or preparatory courses).

Admission

Conditions for admission to the combined program will be the following:

1. Be an honor student (GPA of 3.25 to 4.00). When the student has a GPA of 2.75 to 3.24 his application may be evaluated and conditionally admitted to the combined program.
2. Complies with the minimum undergraduate number of credit-hours for the combined Bachelor's – Master's Program.
3. Recommended by the corresponding Department Head and Graduate Program Mentor.
4. Be authorized to enroll in graduate courses by the Dean of Graduate School.

Procedure

1. Once the student confirms that he/she qualifies to the combined program, he/she must complete and submit the application to the Graduate School Student Affairs Office. Also the student must include with the application an official academic evaluation analysis.
2. The application is evaluated to verify that the student indeed qualifies to the program.
3. The Department Chairperson and Graduate Program Mentor submit their recommendations to the Dean of Graduate School.
4. The Dean verifies the recommendations and approves or not the student's application. The final decision is notified to the student in a formal letter. Also a copy of the letter is sent to the student file at the Registrar's Office and Financial Aid Office.

General Comments

1. Whenever any of the courses is passed with a grade of "C" or lower, the student is disqualified to continue in the combined program.
2. In the event that the application is denied, the student may appeal the decision, to a committee composed by the Undergraduate Department Head, Graduate Program Mentor, Dean of Graduate School and the Vice President

of Academic Affairs. The decision of the committee is final.

XVII. DECLARATIONS AND CERTIFICATIONS

NON-DISCRIMINATION CLAUSE

Polytechnic University of Puerto Rico does not discriminate against any individuals for reasons of gender, political or religious affiliation, economic or social status, ethnic origin, or for any other reason considered unlawful. This policy applies both in the recruitment of personnel and in the acceptance of students.

STUDENTS' RIGHTS TO REVIEW THEIR RECORDS

Annual Notice to Students

Each year, Polytechnic University of Puerto Rico informs the students about the Family Educational Rights and Privacy Act enacted in 1974. This Law, with which the University will totally comply, was designed to protect the privacy of students' academic records, to establish the students' rights to inspect and review their educational records, and to provide guides in cases where incorrect or misleading information must be corrected through formal or informal hearings. Students will also have the right to file complaints concerning alleged failure by the University in complying with the Law.

Our institutional policy explains in detail the procedure which Polytechnic University of Puerto Rico will follow to comply with the provisions of the Law. This policy can be found in the Library, in the Reference section. There the **Institutional Regulations to Protect the Student' Right to Privacy** may be found.

Questions related to this Law will be referred to the Dean of Student Affairs Office. The student who files a complaint and who considers that the decision granted has been unfair, or does not conform with the dispositions within the Law, may request in writing the mediation of the University President. As an additional recourse, the student who considers that his/her rights have been violated can file a complaint with the Family Educational Rights and Privacy Act Office, Department of Education, Office 4074, Switzer Building, Washington, D.C. 20201. This complaint must be related to alleged deficiencies incurred by Polytechnic University of Puerto Rico in complying with FERPA.

PUBLIC NOTICE DESIGNATING THE DIRECTORY INFORMATION

Through these means, Polytechnic University of Puerto Rico designates the following categories of information about students as Public information or Directory Information. This information may be divulged by Polytechnic University of Puerto Rico for any particular purpose, and at its discretion.

Category I Name, address, telephone number, attendance date, courses.

Category II Institutions previously attended, specialized fields, awards, honors (including Dean's List), and degrees obtained, including dates.

Category III Present and past participation in sports and officially recognized activities, physical appearance (height, weight) of athletes, place and date of birth.

Students who are registered at the present time have the right to request that no information about them be divulged under FERPA. To forbid the University to divulge information, a written request must be sent to the Registrar's Office of Polytechnic University of Puerto Rico at the following address:

Polytechnic University of Puerto Rico
P.O. Box 192017
San Juan, Puerto Rico 00919 2017

The form used to request that no Directory Information be divulged is found in the Registrar's Office. Polytechnic University of Puerto Rico understands that if a student does not make this request to prevent information from being divulged, the information can be made public.

RESERVATION OF THE RIGHT TO MODIFY THE CATALOG

The provisions of the various sections of this Catalog are to be considered directive in character and not as an irrevocable contract between the student and the University. The University reserves the right to make any changes that are deemed necessary or desirable.

APPROVAL OF THE CATALOG

I certify that this Catalog has been approved for distribution for the academic years 2012-13 to 2013-14.

Ernesto Vázquez Barquet
President
August 2010