

# Polytechnic University of Puerto Rico

**GRADUATE CATALOG**

**Academic Years 2020-21 - 2021-22**

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## **I. BOARD OF TRUSTEES**

Vanessa M. Mullet Sánchez, JD, **Chairman**  
Francisco J. Martínez Ubarri, Eng., **Vice Chairman**  
Rafael E. Mullet, JD, **Treasurer**  
Ricardo Lefranc Morales, Arch, **Secretary**  
Irving A. Jiménez Juarbe, JD, **Trustee**  
María M. Meléndez, PhD, **Trustee**  
Luis Fullana Morales, BS in Agronomy, **Trustee**  
Luis E. González Cognet, MD, **Trustee**  
Ricardo Jaén Presno, MD, **Trustee**  
Ernesto Vázquez Barquet, MBA, **Ex Officio**  
Ernesto R. Vázquez Martínez, BSIE, MBA, **Ex Officio**

## **II. ADMINISTRATIVE OFFICIALS**

### **President**

Ernesto Vázquez Barquet, BA, MBA, PhD

### **Executive Vice President**

Ernesto R. Vázquez Martínez, BSIE, MBA

### **Vice President for Academic Affairs**

Miguel A. Riestra, BA, MA, PhD

### **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, School of Architecture**

Carlos Betancourt Llambías, March

### **Associate Dean, School of Architecture**

Diana Rivera Rivera, March

### **Director of Academic Affairs, School of Architecture and Landscape Architecture**

Olga E. Angueira, BArch, MLA

### **Coordinator, Graduate Program, Master in Architectural Conservation and Rehabilitation**

Evelyn Villalobos, BArch, MRM

### **Coordinator, Graduate Program, Master of Landscape Architecture**

Edmundo Colón Izquierdo, BArch, MLA

### **Coordinator, Department of Interior Design**

Minette Morales Abella, BA, MS

### **Dean, School of Arts, Sciences and Education**

Catalina Vicéns, BA, MA, PhD

### **Coordinator, Graduate Program, Master of Science in Education in Mathematics and Natural Sciences**

Milagros Martínez Roche, BA, MA, PhD

### **Head, Department of Mathematics and Science**

Horacio García Correa, BSEE, MEM

### **Head, Department of Socio-Humanistic Studies**

Virginia Dessús, BA, MA, PhD

### **Dean, School of Engineering, Surveying and Geospatial Science**

Carlos González Miranda, BSIE, MSIE, PhD, PE

### **Associate Dean, School of Engineering, Surveying and Geospatial Science**

Cuauhtémoc Godoy, BSIE, MSIE, PhD, PE

### **Head, Department of Biomedical Engineering**

Wilfredo Fariñas Coronado, BSEE, MBME, PhD

### **Head, Department of Chemical Engineering**

Elba Herrera, BS, MS, CHE

### **Head, Department of Civil and Environmental Engineering, and Land Surveying**

Héctor Cruzado, BSCE, MSCE, PhD, PE

### **Associate Director, Department of Civil and Environmental Engineering, and Land Surveying**

Amado Velez, BSCE, MSCE, PE

**Head, Department of Electrical and Computer Engineering, and Computer Science**

Luis M. Vicente López, BS, MSEE

**Head, Department of Mechanical Engineering**

Julio A. Noriega, BS, MS, PhD

**Head, Department of Industrial and Systems Engineering**

María García Sandoval, BSUE, MEMSE, PhD

**Dean, School of Management and Entrepreneurship**

In process

**Coordinator, Associate Degree Programs**

José A. Morales Morales, BS, MBA, PhD

**Administrator, Financial Aid Office**

Sergio Villoldo, BBA, MBA

**Director, Admissions and Promotions Office**

Teresa Cardona, BBA

**Director, Career and Internship Services Program**

Angie Escalante, BSW, MBA

**Director, Department of Athletic Activities**

Roberto Medina Ortiz, BA

**Interim Director, Distance Education Center**

Cuauhtémoc Godoy, BSIE, MSIE, PhD, PE

**Director, Guidance and Counseling Office**

Sheila Vázquez

**Director, Graduate Programs**

Alfredo Cruz, BA, MS, PhD

**Director, Graduate Programs**

Martha Dumois, BSEE, MEM, PhD

**Director, Honors Program**

Wilfredo Torres, BSEE, MEM

**Director, Human Resources Office**

Ana E. Castellano, BBA, MBA

**Director, Information Technology Office**

Pedro Pérez, MIS

**Supervisor, Integrated Student Services Center**

William Peña, BBA, MBA

**Director, Institutional Development and Communications Office**

Lourdes Alcrudo, BBA

**Director, Library**

Digna Delgado López, BS; MLS

**Director, Planning and Development Office**

Miguel A. Riestra, BA, MA, PhD

**Director, Plasma Laboratory**

Ángel González, BSEE, MSEE, PhD

**Director, Student Support Services Program**

José Mojica, BA MA

**Supervisor, Office of Graduate Affairs**

Neysha L. Rivera Bracero

**Legal Counselor**

Irving A. Jiménez Juarbe, BA, MSW, JA

**Outcomes and Student Learning Assessment Office**

Blanca Tallaj Almánzar, BSCE, MSIE

José A. Martínez, BSCE, MSCE, PE

María M. García Sandoval, BSUE, MEMSE, PhD

**University Registrar/ Director Student Exchange Program**

Mayra I. López, BA, MA

### III. INFORMATION DIRECTORY

**Mailing Address:** P.O. Box 192017

San Juan, PR 00919-2017

**Address:** 377 Ponce de León Ave., San Juan, PR 00918

**University Switchboard:** (787) 754-8000 / (787) 622-8000

**Internet Home Page:** <http://www.pupr.edu>

**Graduate School Home Page:** <http://www.pupr.edu/gs>

Fax (787) 763-8919- Office of the President

Fax (787) 753-4465- Accounting Office

Fax (787) 764-8712- Admissions and Promotions Office

Fax (787) 763-8275- Bursar's Office

Fax (787) 294-1816- Continuing Education and Training

Fax (787) 274-8562- Career & Internship Services Program

Fax (787) 625-0414- Distance Education Center

Fax (787) 758-1334- Enrollment Management and Student Services Office

Fax (787) 766-1163- Financial Aid Office

Fax (787) 751-0545- General Services

Fax (787) 758-7933- Graduate School

Fax (787) 771-0012- Health, Safety and Environmental Compliance Office

Fax (787) 753-6569- Human Resources Office

Fax (787) 753-1675- Information Technology Office

Fax (787) 758-3383- Integrated Student Services Center

Fax (787) 758-3522- Institutional Development & Com.

Fax (787) 763-3028- Library

Fax (787) 766-4925- Medical Services

Fax (787) 754-8268- Planning and Development Office  
Institutional Research Office

Fax (787) 754-8821- Purchasing Office

Fax (787) 764-1902- Registrar's Office

Fax (787) 767-0607- School of Architecture

Fax (787) 767-0607- Interior Design Program

Fax (787) 767-0607- School of Landscape Architecture

Fax (787) 754-5931- School of Arts, Sciences and Education

Fax (787) 754-5931- Education Department

Fax (787) 754-5931- Mathematics and Sciences

Fax (787) 756-8647- Socio-Humanistic Studies

Fax (787) 281-8342- School of Engineering, Surveying and Geospatial Science

Fax (787) 771-0010- Chemical Engineering

Fax (787) 773-0098- Civil & Env. Engineering & Land Surveying

Fax (787) 771-0013- Civil & Env. Engineering & Land Surveying

Fax (787) 281-8342- Electrical & Computer Engineering

Fax (787) 765-9207- Industrial Engineering

Fax (787) 771-0011- Mechanical Engineering

Fax (787) 756-7274- School of Management and Entrepreneurship

Fax (787) 763-6867- Security

Fax (787) 767-2921- Sponsored Research Office

Fax (787) 754-8520- Student Support Services Program

Fax (787) 754-8450- Tutoring Services

Fax (305) 418-4325- Miami Campus

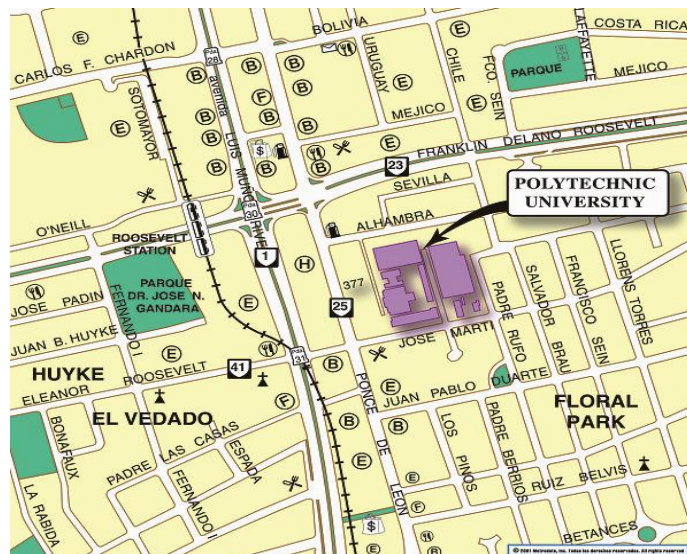
Fax (407) 677-5082- Orlando Campus

## IV. CAMPUS MAP



- |   |  |
|---|--|
| 1. Main Building; University Adm. Offices   | 8. Pavilion Building: (School of Management and Entrepreneurship, Surveying and Geospatial Science Department) |
| 2. Engineering Laboratories Building  | 9. Parking for Faculty, Administration and Visitors  |
| 3. Library  | 10. PUPR - Facility  |
| 4. Amphitheater   | 11. Graduate School  |
| 5. Multi-Purpose Building: (School of Architecture, Graduate School of Landscape Architecture, School of Arts, Sciences and Education, Athletic Activities, Honors Program, Basketball Court, Security Office, Cafeteria) | 12. Medical Services   |
| 6. Fifth Centennial Plaza   | 13. General Services   |
| 7. Student's Parking  | 14. Main University Entrance   |
|   | 15. Alhambra Street  |
|   | 16. Ponce de León Avenue   |
|   | 17. José Martí Street  |

## V. LOCATION MAP



## VI. ACADEMIC CALENDAR

### Academic Terms 2020 to 2022

FA 2020	August 10, 2020	October 31, 2020
WI 2020	November 16, 2020	February 20, 2021
SP 2021	March 8, 2021	May 29, 2021
SU 2021	June 7, 2021	July 16, 2021
FA 2021	August 9, 2021	October 30, 2021
WI 2021	November 15, 2021	February 19, 2022
SP 2022	March 7, 2022	May 28, 2022
SU 2022	June 6, 2022	July 15, 2022

### 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. (4 hours per session) for twelve-week period, equivalent to three semester credit-hours.

Courses during the summer term meet twice a week (4 hours per session) for 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.

## VII. GENERAL INFORMATION

Polytechnic University of Puerto Rico (PUPR) is a private, non-profit, coeducational, nonsectarian institution of Higher Education 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 large private Hispanic Serving Engineering School in the United States and its territories. PUPR offers licensed and accredited programs at the undergraduate and graduate levels.

### UNDERGRADUATE OFFERINGS

#### Associate Degrees

- Associate Degree of Engineering in Software Development
- Associate Degree of in Engineering in Supply Chain and Logistics
- Associate Degree in Land Surveying
- Associate Degree in Mechanical Engineering
- Associate Degree in Product Design

#### Bachelor's Degrees

- Bachelor in Architecture
- Bachelor of Interior Design
- Bachelor in Business Administration with major in Accounting
- Bachelor in Business Administration with major in Construction Management
- Bachelor in Business Administration with major in Entrepreneurship
- Bachelor in Business Administration with major in General Management
- Bachelor in Business Administration with major in Marketing
- Bachelor of Science in Biomedical Engineering
- Bachelor of Science in Chemical Engineering
- Bachelor of Science in Civil Engineering
- Bachelor of Science in Computer Sciences

- Bachelor of Science in Computer Engineering
- Bachelor of Science in Electrical Engineering
- Bachelor of Science in Environmental Engineering
- Bachelor of Science in Industrial Engineering
- Bachelor of Science in Land Surveying and Mapping
- Bachelor of Science in Mechanical Engineering
- Bachelor of Science in Mechanical Engineering in Aerospace Science

### GRADUATE OFFERINGS

#### Certificates

- Graduate Certificate in Digital Forensics
- Graduate Certificate in Information Assurance and Security (GCIAS)

#### Master's Degrees

- Master in Architectural Conservation and Rehabilitation
- Master of Landscape Architecture
- Master of Business Administration with specialization in International Enterprises
- Master of Business Administration in General Management
- Master of Business Administration with specialization in Computer Information Systems (E-Commerce)
- Master of Business Administration with specialization in Computer Information Systems (Data Base)
- Master in Environmental Management
- Master in Engineering Management with specialization in Construction Management
- Master in Engineering Management with specialization in Manufacturing Management
- Master in Engineering Management with specialization in Renewable Resources Management
- Master in Engineering Management with specialization in Environmental Management
- Master in Manufacturing Competitiveness with specialization in Quality Management
- Master in Manufacturing Competitiveness with specialization in Pharmaceutical Products
- Master of Science in Manufacturing Competitiveness with specialization in Quality Management
- Master of Science in Manufacturing Competitiveness with specialization in Pharmaceutical Products
- Master of Science in Manufacturing Engineering with specialization in Industrial Automation
- Master of Science in Manufacturing Engineering with specialization in Pharmaceutical Processes
- Master of Science in Manufacturing Engineering with specialization in Quality Management
- Master of Engineering in Manufacturing Engineering with specialization in Pharmaceutical Processes



- Master of Engineering in Manufacturing Engineering with specialization in Industrial Automation
- Master in Engineering in Manufacturing Engineering with specialization in Quality Management
- Master of Science in Civil Engineering with specialization in Construction Engineering
- Master of Science in Civil Engineering with Specialization in Geotechnology
- Master of Science in Civil Engineering with specialization in Structures
- Master of Science in Civil Engineering in with specialization in Water Resources
- Master of Science in Civil Engineering with specialization in Water Treatment
- Master of Engineering in Civil Engineering with specialization Construction Engineering
- Master of Engineering in Civil Engineering with specialization in Geotechnology
- Master of Engineering in Civil Engineering with specialization in Structures
- Master of Engineering in Civil Engineering with specialization in Water Resources
- Master of Engineering in Civil Engineering with specialization in Water Treatment
- Master of Science in Electrical Engineering with specialization in Communication Systems
- Master of Science in Electrical Engineering with specialization in Digital Signal Processing
- Master of Science in Electrical Engineering with specialization in Power Systems and Renewable Energy
- Master of Engineering in Electrical Engineering with specialization in Communication Systems
- Master of Engineering in Electrical Engineering with specialization in Digital Signal Processing
- Master of Engineering in Electrical Engineering with specialization in Power Systems and Renewable Energy
- Master of Science in Computer Engineering with specialization in Internet Engineering
- Master of Science in Computer Engineering with specialization in Software Engineering
- Master of Engineering in Computer Engineering with specialization in Internet Engineering
- Master of Engineering in Computer Engineering with specialization in Software Engineering
- Master of Science in Computer Science with specialization in Cybersecurity
- Master of Science in Computer Science with specialization in Knowledge Discovery and Data Mining
- Master in Computer Science with specialization in Cybersecurity
- Master in Computer Science with specialization in Knowledge Discovery and Data Mining

- Master of Engineering in Mechanical Engineering with specialization in Aerospace
- Master in Geospatial Science and Technology
- Master of Science in Education in Mathematics and Natural Sciences

### Online Programs

- Master in Engineering Management
- Master of Science in Manufacturing Engineering
- Master of Science in Manufacturing Competitiveness
- Master of Engineering in Manufacturing Engineering
- Master in Manufacturing Competitiveness with specialization In Quality Management
- Master in Business Administration with specialization in Computer Information Systems (E-Commerce)
- Master in Business Administration with specialization in Computer Information Systems (Data Base)

### Doctoral Program

- Doctor of Philosophy in Engineering and Applied Sciences

## LICENSURE AND ACCREDITATIONS

### A. Licensure

#### **Puerto Rico Education Council (PREC)**

P.O. Box 19900

San Juan, Puerto Rico 00910-1900

Telephone: (787) 724-7100

License renewal date: 2020

### B. Accreditations

#### **Middle States Commission on Higher Education (MSCHE)**

3624 Market Street

Philadelphia, PA 19104-2680

Telephone (267) 284-5000

Webpage: [www.middlestates.org](http://www.middlestates.org)

E-mail: [info@msche.org](mailto:info@msche.org)

Spanish: [españolinfo@msche.org](mailto:españolinfo@msche.org)

In 2005, the Middle States Commission on Higher Education reaccredited the institution, and on November 18, 2010, reaffirmed it. In 2010, PUPR submitted the Periodic Review Report and was commended for the evaluation results. PUPR was reaccredited in 2015; the next accreditation will be in 2023.

### **ABET**

111 Market Place, Suite 1050

Baltimore, MD 21202-4012

Telephone: (410) 347-7700

Webpage: <http://www.abet.org>

**The following Bachelor of Science programs are accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>:**

- Biomedical Engineering

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

The Computer Science program is accredited by the Computer Accreditation Commission of ABET, <http://www.abet.org>:

The Land Surveying and Mapping program was accredited by the Applied Science Accreditation Commission of ABET, <http://www.abet.org>:

111 Market Place, Suite 1050  
Baltimore, MD 21202-4012  
Telephone: (410) 347-7700

#### **National Architectural Accrediting Board (NAAB)**

1735 New York Avenue, NW  
Washington, DC 20006  
Telephones: (202) 783-3007, (202) 783-2822  
Webpage: <https://www.naab.org/>

In 2009, NAAB accredited the Bachelor of Architecture. The next accreditation visit will be in 2024.

#### **Landscape Architectural Accreditation Board (LAAB)**

636 Eye Street, NW  
Washington, DC 20001-3736  
Telephone: (202) 898-2444  
Fax: (202) 898-1185  
Webpage: [www.asla.org](http://www.asla.org)

The Landscape Architectural Accreditation Board granted accreditation to the Master of Landscape Architecture (First Professional Degree) in 2011. The next expected accreditation visit will be in 2022.

### **ACADEMIC ALLIANCES**

Currently, PUPR has academic alliances with the following universities:

- Instituto Tecnológico de Santo Domingo (INTEC)  
Ave. Los Próceres, Calle Gala,  
Postal 342-9 y 249-2, Santo Domingo
- Fundación Ciudad del Saber  
Clayton, Ancón  
Ciudad de Panamá
- Universidad Latina de Panamá  
Ciudad de Panamá
- Universidad Tecnológica Centroamericana (UNITEC)  
Tegucigalpa, Honduras

### **MISSION, VISION AND GOALS**

Polytechnic University of Puerto Rico fosters learning, scholarship, and service in the core area of liberal arts, and in the professional fields of architecture, business, education, land surveying and engineering.

#### **Preamble**

Polytechnic University of Puerto Rico is a private, non-profit university providing access to education through its main campus in San Juan, PR, and branch campuses in Miami and Orlando, FL. Also, PUPR works in partnership with the Instituto Tecnológico de Santo Domingo in the Dominican Republic.

#### **Mission**

"As an institution of higher education, the mission of the Polytechnic University of Puerto Rico is to provide opportunities to individuals from diverse backgrounds and in different locations using multiple methods of delivery to cultivate their potential for leadership, productivity, competitiveness and critical thinking, through exposure to intellectual, scientific, humanistic and technological advancement, with the purpose of contributing to regional and global sustainability."

#### **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 empathic 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 serve as a catalyzer of a symbiotic relationship between the United States and the Latin American nations."

#### **Goals**

The following goals guide Polytechnic University in meeting its mission:

- To contribute to regional and global socioeconomic development, sustained by a capable and committed faculty and through the formation of competitive professionals in the fields of architecture, applied sciences, business, engineering, math and science education.
- To provide access to higher education through on-campus and at a distance programs of study in compliance with guidelines that comprise hallmarks of quality.
- To instill in PUPR graduates a genuine interest to search for solutions to the challenges associated with the needs and aspirations of society.
- To promote the dissemination of knowledge through the teaching-learning process and through publications, and to develop an interest in applied research.
- To adapt current and develop new programs of study that respond to the needs and realities of PUPR constituents and to society in general.



- To foster the linkage between PUPR and industry, government, commerce, professional associations, as well as with other universities.
- To promote teaching and learning best practices supported by “state of the art” technology.
- To achieve long-term sustainable growth in financial resources.
- To promote global and socio-cultural exposure of the PUPR community.
- To continuously seek innovative ways to increase student retention and graduation rates, and to reduce students’ time to degree attainment.

## OUTCOMES AND STUDENT LEARNING ASSESSMENT

The Office of Outcomes and Student Learning Assessment is in charge of the institutional learning assessment program. The objective of this program is to: a) “improve” the performance of all academic programs and administrative offices; b) “prove” by providing evidence that the expected outcomes have been achieved, and c) “inform” or disclose the gathered data to guide the decision-making process institution-wide.

The assessment to “improve” is a short-term cycle, and it is driven by the faculty members or key stakeholders. The development stage starts with the design and planning of courses, course components, and curricula or project/program. During this stage, several improvements should be incorporated while the program or project is implemented. This formative mode of assessment leads to improvements on a continuous basis.

In contrast to the assessment to “improve,” the assessment to “prove” is a long-term cycle. The development stage requires of statistical data and final results from already implemented models. The analysis of the data will generate inferences and implications. This summative assessment will provide evidence of the project.

Following the assessment to “prove” the effectiveness of the program, it should identify important stakeholders. The data gathering and its analysis are used to guide the decision-making process, increasing the likelihood of dissemination of information and the institutionalization of the changes made as a result of the assessment of the outcomes.

The assessment of an academic program will be based on the accreditation criteria issued by the corresponding agencies and the institutional mission and academic objectives. The Office of Outcomes Assessment understands that assessment to “improve,” assessment to “prove” and the information disclosure are fundamental stages for the development of an effective outcomes assessment program. The teaching and learning outcomes assessment process impact directly upon the mission, vision and goals of the institution. It is an extremely relevant tool to confirm these are met.

## PROFESSIONAL AFFILIATIONS

**Board of Examiners of Engineers, and Surveyors of Puerto Rico.** Graduates of Civil Engineering, Industrial Engineering, Electrical Engineering, Mechanical Engineering, Environmental Engineering, Chemical Engineering, Computer Engineering, Architecture, Landscape Architecture, and Land Surveying and Mapping curricula qualify to take the examinations required for a professional license.

**Board of Examiners of Architects, Landscaping Architects** Graduates of Architecture and Landscape Architecture curricula qualify to take the examinations required for a professional license.

**Board of Examiners of Certified Public Accountants** Graduates of BBA in Accounting qualify for the Certified Public Accountant (CPA) examination.

**U.S. Citizenship and Immigration Services**

**Department of Education of Puerto Rico**

**Department of Social Services of Puerto Rico** (Vocational Rehabilitation)

**Veterans Administration**

## 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.

## 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 has 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  
5550 North Econlockhatchee Trail  
Orlando, Florida USA 32825
- c. Instituto Tecnológico de Santo Domingo  
(INTEC)(Learning Site)  
Ave. Los Próceres, Calle Gala,  
Postal 342-9 y 249-2, Santo Domingo

### **LIBRARY**

The library of Polytechnic University of Puerto Rico is an academic unit with the mission to offer a physical and virtual space where, through the access to information resources and services and with the guidance and support of information professionals, the academic community can interact, develop skills, exchange ideas, discover new sources and create new knowledge resulting in an empowering lifelong learning experience. This statement is consonant with the university's mission, and all library services are directed towards achieving it.

The library collection is specialized in areas of Engineering, Land Surveying, Architecture, Landscape Architecture, Education, Management and Entrepreneurship, and support the university's academic programs. The collection also includes over 160,000 books and serial volumes which are catalogued and searchable through the online catalog. The resources are organized in open stacks, and students can browse and choose from a variety of books, videos, and journals. The library offers services and resources on site as well as online. The library is subscribed to thousands of online resources including full-text electronic books and periodicals. Remote access to online resources is available through the library's website and blog. All textbooks and core reference books listed in the syllabi are available for use within the library, as a service to students and in compliance with PUPR's mission.

Library service hours include weekends and holidays totaling 82 hours weekly. Study areas and computer facilities are open 24/7 providing students adequate, comfortable and secure space for individual or team study. There are scanning, printing and photocopy services. Carrels and rooms for individual or group studying are distributed throughout the three levels of the building. Services for students with disabilities are offered at the Center for Technological Assistance on the first floor. Special software and equipment are available for students with hearing or visual impairments. Students with special needs can reserve rooms for individual tutoring and study. The library has Wi-Fi and internet access, and some study rooms are equipped with large monitors and VGA cables to facilitate laptops connection for teamwork assignments.

The library houses: reading and lounge areas, group-study rooms, computers with access to engineering software, copying, printing and scanning facilities. The second floor is a glass enclosed area that invites to individual study and research. It contains the reference, cartography, periodicals and rare books collections. Facilities also include an open space area with

tables, conference rooms for faculty, staff, or students meetings, information literacy laboratories equipped with video projectors, smart boards, computer equipment and computer stations for students and large capacity rooms for academics activities for up to 150 people.

The Information Literacy Program is based on the standards established by the Association of Academic and Research Libraries of the American Library Association. Workshop and orientation are offered at the premises to groups or individuals or online. The Program promotes the development of skills that position students to become life-long learners. A librarian is the program coordinator and works with faculty and department directors creating activities to integrate into the courses across the curriculum for the development of information literacy skills. Information Literacy is one of the eight Institutional Learning Goals.

Professional librarians, as faculty members, are active in the educational process. Along with the library staff, they work together to offer users specialized information assistance and services such as interlibrary loans, information literacy, and bibliographic search, among others. The library also has presence in the web 2.0 for direct communication with students. A blog is kept up-to-date with information and recommended links to reliable sources.

### **DISTANCE EDUCATION**

#### **Distance Education Center at Polytechnic University (known in Spanish as CEDUP)**

CEDUP is responsible for the management, design, and development of projects arising from the academic offering using distance education as its teaching methodology, in all three PUPR campuses. The institution provides through **its Distance Education Center**, an ongoing program of orientation, training, and technical support services for students taking online/hybrid courses and faculty teaching distance courses.

CEDUP supports the online academic programs through its human and technological resources. The Center has specialists in the use and management of the Blackboard platform, Instructional Systems Design, Graphic Design, Multimedia Integration, and Instructional Technology. The Center works as a production site of course development where sound instructional design principles are used along with Quality Matters™ Standards resulting in courses that meet distance education programs excellence Standards.

The online/hybrid courses provide interaction between faculty and learners, and among learners through activities that encourage critical thinking and problem solving, as defined in the course objectives. The interaction between learners and the instructor and between learners takes place through diverse media; feedback to students is constructive and timely. The learning modules incorporate multimedia teaching technology to create images with the content, audio, video or capsules with educational content expert, computer graphics and interactivity tools.

The institution's Learning Management System (Blackboard) is used to organize an online learning environment that provides the means to track users, assess performance, deploy content, and access general administrative functions such as management of user's records and enable the creation of learning content; use of interactive features such as threaded discussions, and discussion forums.

Student support services include training on how to use Blackboard to successfully complete an online/hybrid course. Prior to enrolling in an online/hybrid course, students must attend one of the *Blackboard Students Workshop* offered by CEDUP multiple times every academic term. Additional training and technical support are provided to students regarding academic integrity tools and any other technical aspect associated with successfully participating in institutional online/hybrid courses available through Blackboard. The institution continually improves software and hardware to support greater access and uptime, including portal and servers reliability.

### **Academic Integrity in Distance Education**

Polytechnic University of Puerto Rico *seeks to foster a spirit of honesty and integrity. Any work submitted by a student must represent an original work produced by that student.* Consequently, to maintain the academic integrity in distance learning courses, the University has developed a *Policy and Procedure to Support the Academic Integrity of Online Courses*. The Policy and Procedures seek to verify and ascertain the identity of a student enrolled in an online/hybrid course, as well as monitoring performance of students who take remote exams, as required by the Higher Education Opportunity Act of 2008.

### **Distance Learning Students**

Every student who wants to register for online courses is required to possess basic knowledge for the use of programs such as word processors, presentation creation, and e-mail management. Also, the student must have skills in searching for information from webpages with a navigator or browser.

It is also the student's responsibility to verify the [minimum systems requirements to access course information residing in Blackboard](#), read the [Policy to Support the Academic Integrity of Online Course](#) and install the tools needed to verify and ascertain the identity of the student enrolled in the online/hybrid course ([Respondus™ Lockdown Browser](#)), among others.

### **State Authorization for Online Programs and Courses**

The State Authorization Reciprocity Agreement (SARA) is an agreement among member states, districts and territories that establishes comparable national standards for interstate offering of postsecondary distance education courses and programs. It is intended to make it easier for students to take online courses offered by postsecondary institutions based in another state. PUPR has been approved by Puerto Rico Council of Education (CEPR in Spanish) to participate in the National Council for State Authorization Reciprocity Agreements.

### **Complaint Process**

It is the goal of PUPR to provide students with an expeditious, fair, equitable, and consistent procedure for resolving their academic grievances. The purpose of an academic grievance is to give students a fair review and an opportunity to be heard. Students are expected to follow the procedures established by the college or academic department in which they are pursuing a course of study; however, academic grievances regarding a course grade must be filed with college or academic department unit in which the course is offered.

Students residing in other states while enrolled in a course offered by PUPR are encouraged to utilize the [internal complaint](#) or review [policies and procedures](#), typically initiated within the academic department, before filing a complaint with their state agency or agencies. See Institution's Home State SARA Portal Entity listed at <https://www.nc-sara.org/state-portal-entity-contacts>.

### **EDUCATIONAL TECHNOLOGY CENTER**

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

- Computer support for student body and faculty, to assist them in the performance of their academic endeavors and projects.
- Faculty and administrative personnel training on computer use.
- Technological and computer support as requested by the different academic departments.

The ETC is organized in four areas:

- Engineering Graphics Laboratory for computer assisted design.
- AutoCAD Laboratory for multiple purposes and the use of the latest versions of AutoCAD.
- Main Computer Area - Computers with all the latest engineering applications.
- Computer Classrooms for the different institutional courses.

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, especially 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.

### **CAREER & INTERNSHIP SERVICES PROGRAM**

The Career and Internship Services Program was created in November of 1989. It serves as a liaison between government agencies and private industries, and Polytechnic University students and alumni, facilitating professional work experiences. The program allows students, in most cases, to receive economic

revenues and earn a three-credit elective course through the internship. The work assignment must have prior approval from the Career & Internship Services Program Director.

The Career and Internship Services Program is available to students in their third, fourth, and fifth year of study and at the graduate level who accomplish the minimum requirements for the project.

The primary objective of our office is to facilitate the integration of the academic education and the workplace. The Program offers different job opportunities as students continue pursuing their academic degrees. On the other hand, the Placement Office has the mission of helping students, graduation candidates and alumni to obtain professional experiences related to their study fields and interests.

## **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.

### **DEPARTMENT OF ATHLETIC ACTIVITIES**

The Department of Athletic Activities is responsible for planning and coordinating sports events, besides offering recreational activities to the student body.

The institution participates in the Inter University Athletic League (LAI, by its Spanish acronym). This organization has among its members the largest campuses of the different public and private universities in Puerto Rico and the Virgin Islands. PUPR participates in several sports such as volleyball, beach volleyball, basketball, tennis, university relay race, cross-country running, track and field, heptathlon and decathlon, judo, wrestling, and table tennis.

## **INSTITUTIONAL DEVELOPMENT AND COMMUNICATIONS OFFICE**

The Institutional Development and Communications Office objectives are to coordinate, manage, develop and provide service in various areas: Communications, Public Relations and Advertising, Website and Graphic Design, Social Media, Alumni Association, Institutional Events and Fundraising management for donations and scholarships. It aims to strengthen the administrative, faculty, students, alumni, and academic community.

### **ALUMNI OFFICE**

The Alumni Association was re-opened in mid-2012 to reinforce the link between alumni and the University. The Association is located at the Institutional Development and Communications Office. The Office is responsible for maintaining communication between alumni and Alma Mater.

### **HEALTH SERVICES**

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 Plan sponsored by the institution is offered by a physician in his private office located at José Martí Street adjacent to the university campus.

### **SECURITY OFFICE**

Pursuant to Public Law 101 – 542 “Student Right to Know and Campus Security Act of 1990,” Polytechnic University of Puerto Rico created the Security Office. This office is responsible for creating, promoting and maintaining academic and working conditions on campus, free of criminal acts. Pacific coexistence among all the university components is essential for achieving a teaching/learning environment free from all forms of violence. Such atmosphere will benefit students, faculty members, visitors, suppliers and officials from various agencies who participate in our operations.

This environment will be monitored on a continuous basis, without interruption, by a closed-circuit television network. There are cameras installed in all of the common area corridors of all buildings, entrances, exits, computer rooms, library, laboratory rooms and campus entrances. The office provides to all students, faculty members, and employees with an identification card that is required to gain access to the campus and services.

The Security Office offers the following services:

- Installation and operation of 24 hours a day, seven days a week monitoring system.
- Implementation of the vehicle access control system at the campus.
- Management of the identification card system of employees and students.
- Seminars about the campus security system for students, employees, and visitors.

- Provision of security measures for diverse activities within the campus.
- Gathering of security information data and publication of the Annual Statistical Report.
- Assistance with malfunctioning vehicles.
- Distribution of a Security Handbook or Manual.
- Escorts to students and employees, if required.

To disclose crime statistics of incidents occurring within the university campus and in adjacent areas such as streets or avenues close to the institution. The statistics must be compiled by the Office of Security in its Incident Reports and with information or data provided by the Puerto Rico Police. The Clery Act requires reporting felonies in seven major categories; these are the following:

1. Criminal Homicide
  - a. Murder and nonnegligent manslaughter
  - b. Negligent manslaughter
2. Sexual Offenses
  - a. Forced
  - b. Non forced
3. Robbery
4. Aggravated Assault
5. Burglary, where:
  - a. There is evidence of domicile violation (intrusion), which may be forced or not involving force.
  - b. Illegal entry must be of a structure - it has four walls, a roof and a door.
  - c. There is evidence that the entry was made in order to commit a felony or robbery.
6. Motor Vehicles Theft
7. Arson

Schools are also required to report statistics for the following categories of detentions or referrals for a campus disciplinary action (if a detention was not made):

1. Violations Alcoholic Beverage Act
2. Violations Alcoholic Beverage Control Act
3. Illegal Possession of Weapons

Hate crimes should be reported by category of prejudice, including race, gender, religion, sexual orientation, ethnicity and disability. Statistics for four additional crime categories are also needed if the offense is classified as a hate crime:

1. Larceny-theft.
2. Simple assault.
3. Intimidation
4. Destruction/damage/vandalism of property

### REGISTRAR'S OFFICE

The Registrar's Office is primarily concerned with custody of the student's academic record. Given the office's mission of providing registration services, there are several related services that must be attended to assure the integrity of the academic records and recording systems. The related services that are performed by this office are: Registration, Readmission, Withdrawal, Mid-term and Final grades, Certification,

Transcripts, Academic Calendar, Graduation Application, and others.

### 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.

### STUDENTS REGULATIONS

The Students Regulations document establishes the norms that rule student's behavior. Administrative personnel also use it as a guide to offer students adequate counseling when situations arise. It determines the rights, obligations, and responsibilities of students to promote an academic environment of tolerance, respect and order with the support of the academic community. Students Regulations Article VI establishes the acts that constitute an infringement of institutional norms that can result in disciplinary sanctions to the student.

### ACADEMIC DISHONESTY AND PLAGIARISM

The University seeks to foster a spirit of honesty and integrity. Any work submitted by a student must represent an original work produced by that student. Any source used by a student is to be documented through normal scholarly references and citations, and the extent to which any sources have been used must be apparent to the reader. The University, further, considers a dishonesty the resubmission for a subsequent course, partially or entirely of work already submitted and graded for a previous course. It is the student's responsibility to seek clarification from the course instructor about how much help may be received in completing an assignment or exam or project or what sources may be used. Students found guilty of academic dishonesty or plagiarism shall be liable for sanctions up to and including dismissal from the University.

### STUDENT GRIEVANCE PROCEDURES

Polytechnic University of Puerto Rico, Committed to Academic Excellence, establishes institutional policies that serve as guides for the well-being of the academic community. To promote these policies, several procedures have been established to allow students to know where to file a claim through the appropriate institutional constituencies.

Promotion of these policies is done through the following media: brochures, catalog, and [PUPR web page](#). Among the policies are:

1. [Blackboard System Policy and Procedures](#)
2. [Campus and Workplace Violence Prevention Policy](#)
3. [Crisis Intervention Protocol](#)
4. [Cyberbullying Policy](#)
5. [Drug and Alcohol Policy](#)
6. Change of Program
7. [Grade Review Policy](#)
8. Guide for Institutional Policies
9. [Harassment Prevention on Online Communication](#)
10. [Information Manual](#)
11. [Information Technology Acceptable Use Policy](#)
12. Institutional Policy
13. [Institutional Security Policy](#)



14. [Netiquette Policy](#)
15. [Policy and Procedure to Support Academic Integrity of Online Courses](#)
16. [Procedures to File a Complaint](#)
17. [Sexual Assault Policy](#)
18. [Sexual Harassment Policy](#)
19. [Student Rules and Regulations](#)
20. [Suicide Prevention Protocol](#)

## 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 lose 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 Director/Coordinator 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 MASTER'S DEGREES AND GRADUATE CERTIFICATES

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 (Not required for PUPR Alumni).

4. Submit a copy of the Birth Certificate or valid passport.
5. Submit the Demographic Information form (Optional document that PUPR uses for statistical purposes).
6. 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 Director or Coordinator and Dean of the Graduate School. The procedures and criteria for reconsideration are established by the Committee taking into account the applicant's job experience and professional licensing. 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

Polytechnic University of Puerto Rico (San Juan, Miami, and Orlando campuses) is authorized by the Immigration and Naturalization Services (INS) to issue a Certificate of Eligibility for Nonimmigrant Student Status (Form I-20) for qualified international students who are not citizens of the United States of America or permanent residents.

Following admission acceptance, the applicant must submit all documentation required by the INS, and established in the Applicant's Checklist. Afterward, the Admissions Office issues and delivers the Form I-20 to admitted students. The admitted students then deliver the completed Form I-20 to the Bureau of Immigration and Citizenship Services (BICS) of their country of origin in the petition of a Student Visa Number. Subsequent to the BICS authorization of a Student Visa Number, admitted students return this Form I-20 to the Admissions Office. Applicants are classified as international students only after receipt of all required documentation and paid registration fees for the first academic term of full-time enrollment.

### International Applicants with Form I-20

1. Fill the application for admission.
2. Pay one hundred fifty dollars (\$150.00). 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 degree equivalency certification for that degree certified by an accredited evaluation firm (World



Education Services, Inc.; Educational Evaluation, Inc. etc.). The academic equivalency 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. 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.
5. Aliens must submit a copy of immigration status.
6. Submit the Demographic Information form (Optional document that PUPR uses for statistical purposes).

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, are 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 prerequisites 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 Director or Coordinator 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 coursework. 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 Director/Coordinator 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 Director/Coordinator 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 the Graduate School.

### **Prerequisite for a graduate program taken outside PUPR**

Students may take undergraduate prerequisite courses required as part of the graduate program curriculum at institutions different than PUPR as long as: ① The 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.

### **STUDENTS WITH VETERAN'S BENEFITS**

Students with veteran's benefits should provide the Certificate of Eligibility and the DD-214 form. If the student needs assistance to complete this document, he/she must contact the Veterans Coordinator in the Registrar's office.

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

## **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	\$245.00
• Tuition per graduate credit-hour for Online program	\$250.00
• Tuition per graduate credit-hour for Landscape Architecture	\$260.00
• Tuition per graduate credit-hour for Education	\$280.00
• Tuition per Doctoral credit-hour	\$450.00

#### **Graduate General Fees**

• Graduate General Fee	\$280.00
• Graduate General Fee – Online Programs	\$300.00
• General Fee June/July Term	\$140.00
• Doctoral General Fee	\$300.00

#### **General Fees**

Application for Graduate Admission (non-refundable)	\$ 50.00
Application for International Graduate Admission (non-refundable)	\$150.00
Application for Non-Degree Seeking Admission (non-refundable)	\$ 75.00
Application for Graduate Certificate (non-refundable)	\$ 75.00
Readmission	\$ 25.00
Deferred Payment	\$ 65.00
Late Registration	\$ 60.00
Drop/Withdrawal Fee Per Course	\$ 15.00
Academic Evaluation Fee	\$ 10.00
Change of Academic Program	\$ 20.00
Transcript	\$ 9.00
ID-Card	\$ 15.00
Duplicate ID-Card	\$ 16.00
Access to Parking	\$ 65.00
Graduation Fee	\$190.00
Late Graduation Fee	\$215.00
Graduation Fee Doctorate	\$450.00

Certification	\$ 5.00
Copy of the Registration Report	\$ 4.00
Returned Check Processing	\$ 55.00
Collection Fee	\$ 50.00
Duplicate Diploma	\$ 65.00
Graduate Seminar Fee	\$425.00
Graduate Design Fee	\$275.00
Graduate Lab Fee	\$275.00
Thesis Fee	\$235.00
Design Project Fee	\$235.00
Thesis Extension Fee	\$235.00
Project Extension Fee	\$210.00
Doctoral Seminar Fee	\$875.00
Doctoral Comprehensive Exam Fee	\$ 2,000.00
Doctoral Dissertation Extension	\$ 2,500.00
Late Charge on pending balances	2 % 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 may opt to defer payment for thirty (30) days at a cost of \$65.00 (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:

- Tuition and fees due from previous terms of study must be paid in full, prior to the student registering for the new term.
- Any balance remaining after 30 days will be subject to a 2% monthly surcharge.
- Balances remaining unpaid after 180 days will be subject to an additional collection fee.

Students who request loans or veteran benefits must either consult 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.

### REFUND POLICY

The Bursar's 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 Calendar.

### INSTITUTIONAL REFUND POLICY

For any withdrawal (partial or total) requested by a student

	Percentage of Refund
During regular registration process	100 %
During first week of classes in each term	100%
During second week of classes in each term*	33% Tuition and Laboratory Fees
Census Date calculated on the last day of week 2**	
During third week of classes through the withdraw deadline of each term	0.00%

\* General Fees are non-refundable.

\*\*Census date is the cutoff date for aid calculation.

### FINANCIAL DELINQUENCY

Students failing to pay their debt to PUPR 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.

### FINANCIAL AID OFFICE

The Financial Aid Office provides information to students and their families regarding the available financial aid programs as well as the application process and eligibility requirements. Its mission is to provide accurate and clear consumer information to help students explore the different financial aid resources that can help them obtain the necessary funding to reach their academic goals.

Polytechnic University of Puerto Rico participates in the following financial aid programs from federal, state, institutional and private sources:

- Federal Direct Loan Program
- Federal Direct Loan Program for Graduate Students (Graduate PLUS)
- Private Scholarships

The availability of the above programs will depend on the total funds allotted to the institution each academic year.

### 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.

### GENERAL ELIGIBILITY REQUIREMENTS

To be eligible to receive financial aid from most federal, state, and institutional programs, the student must:

- Be enrolled as a regular student
- Be working towards a degree in an eligible program
- Be a U.S. citizen or eligible non-citizen with valid Social Security Number
- Have a high school diploma or its equivalent
- Meet the Standards of Satisfactory Academic Progress
- Demonstrate financial need (except for some loans)
- Register with the Selective Service, if male between the ages of 18 and 25
- Certify that the federal student aid will only be used for educational purposes. The student must also not be in default or owe money on a federal grant.
- Have no history of certain drug convictions

In addition to the above basic eligibility requirements, the student could be required to meet additional requirements such as minimum enrollment credits, minimum GPA, state residency status among others, depending on the financial aid program. For the eligibility requirements of a specific program, contact the Financial Aid Office.

### APPLICATION PROCESS

To determine student's eligibility for federal aid, the student must complete the Free Application for Federal Student Aid (FAFSA). Some financial aid programs, such as state grants, student loans, and federal work-study require an additional application.

The student must reapply for financial aid every year. Since some federal and state funds are limited, students are encouraged to apply as soon as possible after October 1 of every year. New students should apply for financial aid at least two months before the first day of classes for the period for which they will enroll. Regular students must submit their application before the end of December.

Follow these steps to complete your FAFSA:

1. Obtain an FSA Id for yourself at [www.fsaaid.ed.gov](http://www.fsaaid.ed.gov). If you are a dependent student, one of your parents will need an FSA Id to sign the FAFSA. If you already have an FSA Id, you will use it to renew your FAFSA every year.
2. Collect the following information:
  - Your social security number.
  - Your driver's license number (if applicable).
  - Prior Year Income tax returns, W-2 forms and other records of income earned for yourself and your spouse (if married).
  - Evidence of untaxed income during the prior year such as Child Support, veteran's non educational benefits, among others.

- Information about savings, investments as well as business and farm assets for yourself and your spouse, if applicable
  - PUPR's School Code: 014255
3. Complete the FAFSA at [www.studentaid.gov](http://www.studentaid.gov). FAFSA is free! You should not pay for completing this application. If you need assistance to complete the FAFSA, contact the Financial Aid Office.
  4. After the FAFSA application is processed by the Department of Education, the Financial Aid Office will receive a report with the student and parent information. If your application is selected for verification, the Financial Aid Officer will request the student to provide documents to confirm the information submitted in your FAFSA. No financial aid disbursement will be processed until the verification process is completed.
  5. If you are going to apply for Federal Loans, you may complete your loan application at <http://www.pupr.edu/services/solicitud-de-prestamo/>. Be sure to complete your FAFSA also.

### TRANSFER STUDENTS

Financial aid awards cannot be transferred automatically from one post-secondary institution to another. The student must correct the FAFSA application to include Polytechnic University's Code: 014255. After the Financial Aid Office receives your FAFSA results, we can determine your eligibility for the available financial aid programs.

Transfer students with previous student loans can defer paying loan payments if enrolled at least half-time. The deferment will not be automatically granted with enrollment. To defer a student loan, the student must complete an In-School deferment form and submit it to the Registrar's Office. The deferment form is available at [www.pupr.edu](http://www.pupr.edu).

### AWARDING PROCESS

The student's eligibility for financial aid programs will be determined after the FAFSA application is received, and the verification process is completed, if selected. The student's Expected Family Contribution (EFC), and the cost of attendance (COA), will be considered when preparing the award package. The student will not be considered for a Student Loan or the Federal Work-Study program unless proper program application has been completed. For supplemental aid programs, priority will be given to students with economic need, in order of application processing date.

The student will receive an Award Letter listing the student aid programs awarded for the academic year. Initial student aid awards are offered based on full-time enrollment. Awards may be then adjusted, if applicable, to actual enrollment after the add/drop period for each trimester. Other sources of assistance such as merit awards and private and institutional scholarships will be taken into consideration when preparing the student's award package.

**\*\*Students repeating a course may not be eligible for financial aid for that specific course.**

## FINANCIAL AID DISBURSEMENTS

Financial aid funds are credited to the student's institution account to cover tuition costs and fees. The student's enrollment status and eligibility for the financial aid program will be verified every trimester before disbursing any money. If there is an excess after funds are paid, a check will be issued to refund the student. If the financial aid is not sufficient to cover all charges, the students is responsible for paying the outstanding balance.

The following are some of the reasons why the student's aid disbursement may be delayed or cancelled:

- Application submitted after deadline
- Not providing all required documentation before deadline
- Not completing the Entrance Counseling and/or Master Promissory Note for Direct Loan borrowers
- Not keeping the minimum academic workload
- Not making Satisfactory Academic Progress towards the program degree
- Being in default on a student loan or owing an overpayment to any Title IV financial aid program

## STUDENT AID CANCELLATION AND REFUSALS

Students may refuse to accept any financial aid awarding. For this purpose, the student may notify the Financial Aid office in writing to refuse an awarded aid prior to it being disbursed. If the student aid has already been disbursed, the student is required to notify in writing within fourteen days of the credit.

Students who do not officially withdraw (unofficial total withdrawal) only earn 50% of the federal funds received. The student would be responsible for any pending balances due to the return of Title IV funds.

## RETURN OF FINANCIAL AID

Students who drop or withdraw might have to repay portion or the total amount of financial aid received. Students that enroll but do not attend to class will also be required to repay any received financial aid. If an over award occurs, the student's award package will be reduced which may result in a repayment. To avoid over awards, students must notify the Financial Aid Office of any potential awards such as private scholarships, vocational rehabilitation benefits, etc., that were not included in the Award Letter. \*\*Refer to the Federal Financial Aid Return Policy for more information on the calculation procedure and for an example of the calculation.

## STANDARD OF SATISFACTORY ACADEMIC PROGRESS FOR STUDENTS WITH FINANCIAL AID

The Standard of Satisfactory Academic Progress of the Financial Aid Office establishes the evaluation criteria to determine the student's academic progress, which is one of the eligibility requirements to participate in student financial aid from Federal, State, Institutional and Private Programs.

The minimum federal components to measure the satisfactory academic progress require three specific measures: qualitative, quantitative, and maximum timeframe to receive Federal aid. These three components provide a measure of the reasonable progress the student should have to complete the academic career successfully.

## Evaluation Criteria for Graduate Students

- Qualitative Measure – One of the elements of the Satisfactory Academic Progress Standard is the qualitative measure. This component consists of the grade point average (GPA) and the total accumulated credits at the end of the academic year. Polytechnic University of Puerto Rico adopts the retention rate (qualitative measure) according to the following chart:

Master's and Doctoral Degrees	
Total Earned Credits*	Minimum GPA Required
0 – 9	2.50
10 – 18	2.80
19 +	3.00

\*Total Earned Credits includes transferred credits and completed credits at PUPR.

Credits transferred from other colleges or universities are not taken into consideration to calculate the GPA, but they are considered to calculate the student's level or year.

- Quantitative Measure – The second element of the Satisfactory Academic Progress Standard is the quantitative measure. This component compares the number of credits attempted by students in the institution, versus the number of approved credits. The student must approve at least 66% of all credits attempted at PUPR. This measure will be cumulative.
- Maximum timeframe to receive payments from federal financial aid – All students must complete the graduation requirements within a maximum equivalent to 1.5 times (150%) of the program degree credits required. All courses attempted at our institution will be included. Transfer credits are also included in this measure. Students who will be unable to complete their degree within the maximum 150% timeframe, will not be eligible to receive financial aid at the moment the school determines that the student will not comply with this provision, not when the student arrives at the 150% timeframe.
  - Maximum timeframe will be determined using credit-hours
    - The maximum time must be 150% of the credit-hours required to complete the program degree.
    - All attempted credits, even those in which the student did not receive financial aid, count towards the established maximum.
    - This policy includes and measures students who are enrolled half-time or less than half-time.

- All courses attempted in the institution will be included. Transferred courses will also be included to measure the maximum timeframe.
- Changes of Major or School (e.g. from Engineering to Architecture), will be measured with the new concentration requirements (total required credits). All courses taken at PUPR, including credits from previous Major/School and credits from the new Major/School will be included.

#### **Example:**

The Accounting MBA Program requires 42 credits to complete the curriculum.

Maximum timeframe  
(42 credits x 150% = 63 attempted credits)

#### **PROBATION OR SUSPENSION**

The student Satisfactory Academic Progress process is evaluated once a year, at the end of the academic year (June).

If the student does not meet one of the evaluation criteria of the Satisfactory Academic Progress policy, the student will be classified with a status of probation or suspension.

The Financial Aid Office will notify the student about the status.

#### **PROBATION STATUS**

A student which does not satisfy the Satisfactory Academic Progress policy for the first time is put on a probation status. While on probation, the student does not qualify for any Federal, State, or Institutional aid programs.

Students on probation are able to appeal the probation status, and if approved, could be eligible to receive Federal, State and Institutional aid.

#### **PROCEDURE FOR APPEALING A PROBATION STATUS**

1. To complete the Appeal Form, the student must visit [www.pupr.edu](http://www.pupr.edu). The form must be completed in all its sections.
2. The Academic Progress Appeal Form and supporting documentation must be received in the Financial Aid Office before the stated deadline.
3. Once submitted, the appeal will be evaluated by the Satisfactory Academic Progress Committee.
  - a. If approved continue to step #4
  - b. If denied, the student will not be eligible for Federal, State nor Institutional aid, until the student complies with the Satisfactory Academic Progress Standard.
4. Plan to improve your academic progress:
  - a. Once the appeal is approved, the student will be referred to meet with the Mentor, Academic Dean or Counselor, to establish an academic plan for the following term. The academic plan will be established at the beginning of each trimester.
  - b. Sign the academic plan agreement with the Mentor, Academic Dean or Counselor.

- c. Submit the established academic plan to the Financial Aid Office, to reactivate your financial aid.
5. The academic plan will be evaluated every trimester by the Financial Aid Office personnel. While the student complies with the academic plan, the student can continue to be eligible to receive Federal, State and Institutional aid as long as the student meets the other requirements to receive financial aid. If the student does not meet any of the terms set forth in the academic plan, the student will lose all the Federal, State and Institutional aid until the student complies with the Satisfactory Academic Progress Standard.

#### **SUSPENSION STATUS**

A student that does not overcome the probation status, falls in a suspension status. A student in a suspension status does not qualify for Federal, State nor Institutional aid. Students in suspension status cannot appeal to the Satisfactory Academic Progress Committee.

A student in a suspension status may be eligible to receive Federal, State, and Institutional aid funds when the student complies with the Satisfactory Academic Progress Standard.

#### **DEFINITIONS**

- Attempted Credits – Enrolled credits at PUPR in which the student has obtained grades of I (with grades), A, B, C, D, F or W, WF, NR, including all courses repetitions.
- Academic Progress – Is the measure which shows whether a student is complying with the three criteria of the Satisfactory Academic Progress Standard (Qualitative, Quantitative, and Timeframe).
- Academic Term – Typical academic term during which regular courses are offered, and which consists of 12 weeks, beginning on the first day of school and ending on the last day of final examinations. In summer, the academic term is reduced to 6 weeks, doubling the weekly contact hours.
- Academic Year – Consists of three academic terms that begin in August and end in May. The summer term is optional.
- Courses with W Grade – Course from which the student withdraw official and voluntarily. These courses will be considered in the calculation of the quantitative measure.
- Earned Credits - Credits of courses attempted at PUPR which obtained grades of A, B, C or D with the exception of specific cases defined by the Department.
- Expired credits – Courses approved seven or more years ago in this or other institution will expire at the date of applying for readmission except for those validated by the Department Director and the Faculty Dean. The student must repeat all courses declared outdated or must take other equivalent courses of the existing curriculum, with the approval of the Department Director and the Faculty Dean. These courses are considered for the calculation of the quantitative measure.
- Financial Aid Probation – Classification given to a student who at the end of any academic year, does not comply with the Standards of Satisfactory Academic Progress.



This student will not qualify for Federal, State or Institutional aid while in this status. The student can appeal this decision and could qualify for aid if the appeal is approved. Once approved, the student must comply with all requirements of every academic plan, which must be prepared every term.

- Grade Point Average (GPA) – The measure of academic merit achieved by the student. It is calculated by dividing the total number of accumulated honor points by the number of credits in which the student has received final grades, including F's and WF's, which have not been removed.
- No Satisfactory Academic Progress (NPAS – suspension) – Classification that is given to the student who at the end of his Financial Aid Probation period does not overcome the academic deficiencies or has not completed the Academic Plan as agreed. The student does not qualify for any Federal, State or Institutional aid.
- Provisional Grades (Incompletes) – If the Professor gives an incomplete in a course, the student must complete the requirements of the course within the established date in the next academic term. The Professor will remove the incomplete within the established date. If the incomplete is not removed, it will become the provisional grade until the professor changes the grade. Provisional grades are considered in the calculation of the qualitative and the quantitative measures of the Satisfactory Academic Progress Standard.
- Repeated Courses – Courses that the student has been enrolled two or more times. For the purpose of determining the Grade Point Average, only the highest grade will be used. Repeated courses will be considered in the quantitative measure of the Satisfactory Academic Progress Standard.
- Transferred credits – Credits taken at other institutions of higher education recognized by accrediting agencies, that were approved with A, B or C, and which are accepted by the Department Director or by the authorized Dean, in compliance with the standards of PUPR.

### **STUDENT'S RIGHTS AND RESPONSIBILITIES**

The student has the right to receive the following information from the Financial Aid Office:

- Available financial aid programs.
- Application process, deadlines and eligibility requirements.
- Awarding and disbursement procedures.
- What financial aid must be repaid, the terms and schedules for repayment.
- The terms and conditions of any employment that is part of the financial aid award.
- What is the criterion of maintaining Satisfactory Academic Progress and how to reestablish eligibility?
- Institution's refund policy for the students that withdraw from school.

It will be the student's responsibility to:

- Comply with deadlines.
- Provide all required documents in a timely manner.
- Provide the Financial Aid Office with information on changes in family's household, income or enrollment status.
- Inform the Financial Aid Office of any outside scholarships, tuition assistance, VA benefits or any other benefits that the student will be receiving during the academic year.
- Use any financial aid received from Federal, State or Institutional funds, for expenses related to their education.
- Notify any change in name, social security, citizenship status, address, phone number or email address.
- Understand and comply with the policies regarding refunds, repayments and satisfactory academic progress.
- Complete the Exit Counseling for Federal Student Loan program, before departure from college or if registering as less than half time student in any term.

### **PRIVACY NOTICE**

The Financial Aid Office ensures the confidentiality of students' records. For this reason, confidential information will not be released by email or phone to students. In addition, no information will be released to any third party, unless legally required to do so, without written authorization from the student. This includes parents, spouses, siblings or friends.

## **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 CURRICULUM SEQUENCE CONTINUITY**

Polytechnic University of Puerto Rico provides students with a program curriculum sequence aligned with the academic time length and course prerequisites. The student is responsible for following the curriculum sequence to accomplish the graduation requirements within the corresponding time schedule. If the student is not able to follow the curriculum sequence, he/she must coordinate and develop the most effective program sequence with his/her Program Director/Coordinator to comply with the graduation time-schedule. The department is in charge of providing courses based on the program curriculum sequence. If the course has low student enrollment, the department will develop course alternatives for students that are in compliance with the program curriculum sequence.

## ACADEMIC PROGRAM CONTINUITY

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

## 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 three summer sessions. 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 online courses. Online 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 an Add/Drop 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 Director/Coordinator 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 Director/Coordinator 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 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 required 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 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 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 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.

The Engineering and Applied Sciences PhD degree requires three regular academic terms of residence.

## WITHDRAWAL FROM COURSES

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 PUPR 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

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 (1 honor point per credit-hour)
F	Failure (0 honor points per credit-hour)
I (Grade)	Incomplete (points will be equivalent to the grade that accompanies the Incomplete)
WF	Non Authorized Withdrawal (0 honor point per credit-hour)

### GRADE POINT AVERAGE OR GRADE INDEX

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

- 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).
- 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.
- These products are added (S); and identified as honor points.
- 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

<b>T</b>	Transferred
<b>AU</b>	Audit (class audited only)
<b>R</b>	Repeated course
<b>W</b>	(Withdrawal) Indicates that the student, after obtaining proper authorization from PUPR's Officers, receives permission to withdraw from a course without penalty.
<b>WM</b>	Military Withdrawal
<b>P</b>	Pass, only for specified courses
<b>NP</b>	Not passed, only for specified courses
<b>E</b>	Expired course (course no longer offered)
<b>S</b>	Satisfactory, only for specified courses
<b>NS</b>	Not satisfactory, only for specified courses
<b>CE</b>	Course Exemption

### FACE-TO-FACE 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 (2) weeks of the academic term are automatically disqualified from charging tuition fees to federal funds and are responsible for their payment. This course will be identified with an "NR" (No Record/Show). The instructor via email the names of all such students to the Registrar's Office. ([Policy of Class Attendance](#))

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 for health or other reasons. In this case, the student is responsible for contacting the instructor and for all work, completed or assigned.

### ONLINE CLASS ATTENDANCE

Student attendance in online courses is defined as active participation in the course as described in each course syllabus. The faculty members must certify that students are actively attending an online course, or a hybrid course according to the procedures established by the Center for Distance Education. Students will be required to complete at least one (1) of the following activities during the first two (2) weeks of the academic term for each online or hybrid course.

1. Submit an assignment online;
2. take an online assessment;
3. participate in an online discussion about academic matters;
4. complete an online interactive tutorial or computer-assisted instruction that is trackable; or
5. initiate contact with the faculty member to ask a question about the academic subject studied in the course.

Students who fail to complete any of these activities during the first two (2) weeks of the academic term are automatically disqualified from receiving federal funds for tuition and fees and are responsible for their payment. This course will be identified with an "NR" (No Record/Show). The instructor will submit via email the names of all such students to the Registrar's Office.

On occasions the student may not be able to access the online/hybrid course for health or other reasons. In this case, the student is responsible for contacting the instructor, provide documentation that supports the need for late submission of a graded activity.

As a component of course attendance, students are expected to check their course email regularly (preferably daily), course announcements, and discussion forums. The student is responsible for checking updates related to the course. Log on at least three (3) times a week – it is recommended to complete weekly assignments, assessments, discussions, or other weekly

deliverables as directed by the instructor and outlined in the course syllabus.

## **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**

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 – It 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 PUPR 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**

<b>Transfer Credit-hours (1)</b>	<b>Credit-hours Passed at PUPR (2)</b>	<b>Total Credit-hours Accumulated at PUPR</b>	<b>Minimum Grade Point Average</b>
		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 at PUPR. 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/her Director/Coordinator 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 PUPR for one academic year before qualifying for readmission, and courses taken at another institution will not be transferred.

#### **D. Right to Appeal**

Every student has the right to appeal the probation or suspension, issued by the Registrar's Office. The student may send an online request for reconsideration to the Academic Achievement Committee, within ten (10) labor days after notification of the decision. The student must go to [www.pupr.edu](http://www.pupr.edu), to complete the Appeal for Probation Form and supporting documentation, if needed, and carefully follow the instructions.

The request for reconsideration should state clearly the decision referred to, give a brief statement of facts, and, state and justify the basis for the requested change or restitution. Once the

Academic Achievement Committee makes the decision, it will be final.

#### **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**

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 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 the Graduate School, the President of PUPR and the Board of Trustees.
4. Students completing graduation requirements in any academic term are invited to participate in the summer commencement exercises.
5. Students should have taken the final credit-hours for the degree at 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. PUPR 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.

### **CERTIFICATIONS AND TRANSCRIPTS**

Whenever a student files an application with the Registrar's Office for a program of study certification, 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 (3) months 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 a change of 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 of 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 OF SPECIALIZATION**

Student must complete the Change of Specialization form available at the Graduate Affairs Office.

### **APPOINTMENT OF GRADUATE SCHOOL RESEARCH ASSISTANTSHIPS AND TEACHING ASSISTANTSHIPS**

The Graduate School publicizes assistantships, screens applications and submits recommendations to the Graduate Council for its final approval regarding research assistantships (RA) and teaching assistantships (TA).

General guidelines and applications for RA or TA can be obtained at the Graduate School Deanship or Graduate School Website: [www.pupr.edu/academics/graduate-school/](http://www.pupr.edu/academics/graduate-school/).

## **XIII. GENERAL GRADUATE ACADEMIC INFORMATION**

### **DEGREES OFFERED**

#### **Master's Degrees in Architecture**

Master in Architectural Conservation and Rehabilitation  
Master of Landscape Architecture

#### **Master's 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 of Engineering in Mechanical Engineering  
Master in Computer Science  
Master in Geospatial Science and Technology  
Master in Manufacturing Competitiveness

#### **Master's Degrees in Management**

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



## **Master's Degree in Science and Education**

Master of Science in Education in Natural Sciences and Mathematics

## **Graduate Certificate**

Graduate Certificate of Information Assurance and Security  
Graduate Certificate in Digital Forensics

## **Doctoral Degree**

Doctor of Philosophy in Engineering and Applied Sciences

### **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 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 webpage.

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 GENERAL COURSES**

PUPR offers several graduate courses that are available for all active students in the Graduate School. These courses are designed to integrate both, technical and soft skills, necessary for today's demands in the challenging working environment.

The courses are identified with the letters GMP (Graduate Master's Programs) as part of the course.

### **GRADUATE PROGRAM DIRECTORS**

Graduate Program Directors are faculty members who verify that administrative and academic requirements are met by all graduate students.

Also, these faculty members are responsible for establishing more detailed academic requirements for their programs.

The functions and responsibilities of Graduate Program Directors 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 Director/Coordinator 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's 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 institutional 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 Doctoral Degree, related to the contents of the Thesis' research. The second member must have a Doctoral Degree. The third member must have either a Doctoral 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 relative of the student. This policy is put in place to avoid any conflict of interest.

5. The Graduate Program Director 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 with the Design Project work.

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

Students whose research topics are enhanced from a design project level to a thesis level (innovation), and they have the recommendation and approval of the Chairperson must register at least the thesis course. These students must comply with the

Thesis requirements to complete their academic work.

### **Option III. Without Thesis or Project**

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**

### **ARCHITECTURE PROGRAMS**

The Graduate Program of Architecture offers two degrees: Master in Architectural Conservation and Rehabilitation, and Master of Landscape Architecture.

#### **MASTER IN ARCHITECTURAL CONSERVATION AND REHABILITATION**

The Architectural Conservation and Rehabilitation program at Polytechnic University of Puerto Rico prepares leaders in the documentation, technology, and conservation of historic structures, sites, neighborhoods to protect our built environment and heritage.

#### **PROGRAM PHILOSOPHY AND OBJECTIVES**

The Master's Degree Program in Architectural Conservation and Rehabilitation encourages and offers individuals, from diverse backgrounds, the opportunity to learn about the field of preservation in one of the oldest countries in the New World. Puerto Rico's rich built environment – resulting from its five

hundred years of architectural heritage – will serve as a laboratory providing myriad opportunities to experience historic preservation firsthand.

The mission of the Master of Architectural Conservation and Rehabilitation at Polytechnic is to prepare leaders in the documentation, technology, and conservation of historic structures, sites, and neighborhoods. Students will acquire the diverse skills necessary for their professional careers to face the multiple challenges posed today at protecting our built environment addressing the built heritage of Puerto Rico and the Caribbean Region.

The School of Architecture at ARQPOLI have developed a fundamental understanding of the issues of historic preservation since the foundation of the school in 1995 with the course ARCH 3010 Intermediate Design I a design studio related to structures of historic significance.

Furthermore, in 2001 with the inauguration of the *Architectural Conservation Laboratory* (by former Dean Jorge Rigau, FAIA; and architect and former professor Beatriz Del Cueto, FAIA) the advanced technology preservation courses; ARTE 0451, Architectural Conservation Laboratory and ARTE 0410, Preservation Technology were available to students. In addition to these courses, two more classes on conservation topics were developed, ARCT 0430 Conservation Theory and SOHU 2020 Archeology for Architects expanding the offerings at the school of architecture. These courses serve today as preparatory for Architecture students interested in pursuing a master's degree in conservation.

Also, more recently through the *Architectural Conservation Laboratory*, we have developed two workshops to advance and support diverse topics and contemporary issues regarding preservation. The Architectural Documentation Workshop directly expose students to the documentation of historic buildings using the standards of the National Park Service (NPS) Heritage Documentation Program (HABS, HALS, and HAER.) As part of these workshops, students have had the opportunity to participate in the NPS – Heritage Documentation Program Peterson Prize Student Drawing Competition, winning First Place two years in a row (2014 and 2015).

#### **Objectives of the Program:**

To implement our philosophy and vision, the M.ARCO Program has established the following goals:

- Understanding of the history of the design environment; including the history of architecture, urban development, landscape architecture and material culture.
- Understanding the history and theory of historic preservation.
- Ability to perform documentation and recording techniques used in preservation and archeology.
- Field application of knowledge, including communication skills and hands-on experience.
- Ability to understand issues of appropriateness, restoration, rehabilitation, in-fill, exterior and interior concerns at a variety of scales, and their effect on buildings, neighborhoods, communities, and landscapes.

- Ability to understand the history, evaluation, and conversation in the normal range of building materials and systems.
- Ability to understand marketing principles, private and public finance, property management, and budget preparation.
- Comprehend the constitutional law, preservation case law, federal, state, and local regulatory legislation and administration.

### GRADUATE PROFILE & OUTCOMES

The graduate program intends to develop professionals with the necessary knowledge to work on multidisciplinary projects related to architectural conservation and rehabilitation. Students completing the M.ARCO degree will be able to acquire knowledge and skills to:

- Recognize how historical events and precedents have served as vital tools to support planning and design solutions and reactions.
- Comprehend spatial, formal, compositional, and technological expression as understood today.
- Identify key architectural styles, materials, and technologies, as well as historical references.
- Outline significant features and characteristics of vernacular architecture.
- Distinguish basic philosophical, methodological, and practical approaches to address conservation, restoration, rehabilitation, and adaptive reuse projects.
- Identify tools for coming to terms with theoretical, contextual, and pragmatic issues conducted simultaneously in architectural conservation.
- Develop a sense for strong arguments for debating and/or defending contemporary conservation stances as developed throughout history.
- Demonstrate proper establishment methods for analyzing structures, by differentiating from structural and esthetical conditions, and understanding the diverse techniques for assessing building conditions.
- Recognize the difference between primary and secondary sources of historic, construction and architecture relevance to place them within the larger context of their place and time.
- Work on an architectural conservation project, by demonstrating the application of research and survey, and the use of preservation technologies while working on a real project.
- Identify problems, define their scope, investigate their origin in order to articulate and propose solutions for the preservation of specific structures and their environment.
- Examine the role of theories and debates concerning the preservation of the built environment, planning, its legal underpinnings, interpretation, and advocacy.
- Prioritize current political, and economic issues affecting preservation in the public realm.
- Understand technical vocabulary, be knowledgeable and proficient regarding traditional construction technologies, and contemporary building preservation of traditional building materials.

- Comprehend diagnostic techniques and possible architectural conservation philosophical alternatives.
- Acknowledge compatibility in design as well as in any intervention procedure and construction materials between historic and contemporary interventions.
- Understand historic preservation principles and theories in the United States, and Puerto Rico, including how to assess the National Register of Historic Places, National Historic Landmark and the local Register Sites and Historic Zones managed by the Puerto Rico Planning Board.
- Comprehend the delicate balance that ensues preserving irreplaceable historic places.
- Appreciate the intricacies and complexities of the planning and execution of federally assisted projects designed to pursue economic growth and development and to conserve historic properties.

### CAREER OPPORTUNITIES

The conservationist is responsible for the protection of the built historic heritage, which includes all the buildings with heritage and cultural value that have been nominated or must be nominated by the different offices and agencies, whether public or private. Besides, the conservationist performs the historical, graphic and photographic documentation of the structure and the supervision or direction of projects that are carried out in these structures so that the interventions comply with the standards and norms of conservation.

The alumni of the Graduate Program on Architectural Conservation and Rehabilitation at Polytechnic University of Puerto Rico will serve as an important resource and base of support for the graduate department and to the heritage conservation of Puerto Rico. After graduation, the professionals in conservation could serve as staff and conservation officers in private and public local and state major preservation organizations, and preservation societies such as: *Instituto de Cultura Puertorriqueña* (ICP), *Oficina Estatal de Conservación Histórica* (OECH-SHPO), *Para la Naturaleza*, National Trust for Historic Preservation, National Park Service, and many more. Furthermore, alumni could serve as mentors for current graduates and help promote historic preservation education throughout workshops and other events.

### PROGRAM REQUIREMENTS

#### Admissions Requirements

- All applicants must have a bachelor's degree from an accredited institution, (or its equivalent from a foreign institution), with a minimum grade-point average of 2.75. There is no restriction on the applicant's previous field of study, we encourage diversity.
- Graduate Application Form
- A non-refundable admission fee
- Official transcripts

#### Graduation Requirements

In addition to the general graduation requirements specified in the institutional catalog, candidates to the Master's in Architectural Conservation and Rehabilitation must:

- Complete the plan of study with at least the minimum number of 39 credit hours of graduate courses.
- The student must comply with all this with a minimum grade point average of 3.00.
- Complete a Practice or Internship approved by the Head of the Department.
- Present and defend a thesis project

### DEGREE OFFERED

The Architectural Conservation and Rehabilitation Program includes a two-year master's degree (M.ARCO) curriculum.

A final project is required for all candidates. This project consists of three (3) credits-hours were the students must demonstrate all the knowledge acquired in the program. The project shall be directed by a member of the faculty, which also acts as the student's graduate committee chairperson. The purpose of this final project 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 Architectural Conservation and Rehabilitation focuses on:

- History courses, theory of conservation and architectural preservation
- Courses on the history of the city and the vernacular architecture of Puerto Rico and the Caribbean
- Courses on documentation, research, analysis of the built environment and conservation proposal
- Course on preservation technology
- Architectural Conservation Laboratory
- Course on laws, economics and regulations in architectural conservation
- Archeology courses in architecture and cultural landscapes
- Courses on the conservation of materials and special topics in historical preservation

### CURRICULAR STRUCTURE

The curriculum reaches maturity with a final project. Courses, credit-hours, and the curricular sequence are presented in the following table:

#### M.ARCO CURRICULAR SEQUENCE

##### Year I

##### Fall Trimester

Course	Title	Credit-Hours
ARCO 6110	Conservation History and Theory	3
ARCO 6112	Vernacular Architecture in Puerto Rico and the Hispanic Caribbean	3

ARCO 6250	Archeology of Architecture*	3
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##### Winter Trimester

Course	Title	Credit-Hours
ARCO 6130	Preservation Research and Survey	3
ARCO 6220	Preservation Technology	3

##### Spring Trimester

Course	Title	Credit-Hours
ARCO 6132	Documentation and Analysis of the Built Environment	3
ARCO 6224	Material Conservation Seminar*	3

##### Summer

Course	Title	Credit-Hours
ARCO 6142	Preservation Internship **	3
ARCO 6140	Preservation Practicum**	3

#### Year II

##### Fall Trimester

Course	Title	Credit-Hours
ARCO 6210	Conservation Studio	3
ARCO 6222	Architectural Conservation Laboratory	3
ARCO 6260	Special Topics in Historic Preservation*	3

##### Winter Trimester

Course	Title	Credit-Hours
ARCO 6230	Preservation Law and Economics	3
ARCO 6252	Cultural Landscapes*	3

##### Spring Trimester

Course	Title	Credit-Hours
ARCO 6120	History and Theory of Cities: A Comparative Method	3
ARCO 6310	Architectural Conservation Final Project	3

##### Elective Courses\*

Six (6) credit-hours from the Architectural Conservation and Rehabilitation program offerings.

##### Summer Practice or Internship\*\*

Optional and must be approved by the Head of the Department. (3 credit-hours)

Each student must verify prerequisites before registering.

### COURSE DESCRIPTION

#### ARCO 6110 - Conservation History and Theory

(cross-listed as ARCT 0430) Three credit-hours.

Two two-hour lecture periods per week. Prerequisite: None

Ideas and theories linked with preservation ideals are presented and debated upon. Aspiration versus realization within the conservation field becomes the background against which the history of building and rebuilding is examined.

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**ARCO 6112 - Vernacular Architecture in Puerto Rico and the Hispanic Caribbean**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6120**

This class explores the history of the built environment from the perspective of cultural change, looking closely at vernacular cultural landscapes throughout Puerto Rico and the Caribbean, their Spanish and American influence while attempting to understand their place in the regional, national and global contexts.

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**ARCO 6120 - History and Theory of Cities: A Comparative Method**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6120**

This class provides an introduction to the history and theory of modern urban development, and planning. Building upon urban planning theory as well as urban social science (geography, sociology, political science, history), the course explores the emergence, development and transformation of cities.

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**ARCO 6130 - Preservation Research and Survey**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6110**

This course proposed methods for researching historic structures and sites using archival and physical evidence, documenting structures through professional reports, architectural photography, and preliminary drawings.

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**ARCO 6132 - Documentation and Analysis of the Built Environment**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6110, 6130**

This course explores various methods used for building condition assessment within a specific subject(s) of study within a built environment. Through field notes, photographic documentation and critiques students work in the understanding and interpretation in order to propose a final outcome.

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**ARCO 6140 - Preservation Practicum (by approval)**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisites: ARCO 6110, ARCO 6130, ARCO 6220**

This course focuses in practical experience in the broad aspects of architectural conservation through the supervised application of concepts previously learned.

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**ARCO 6142 - Preservation Internship (by approval)**

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**Three credit-hours. Hours lecture will be coordinated with the faculty during the internship. Prerequisite: ARCO 6110, ARCO 6130, ARCO 6220 | Corequisite: None**

The Preservation Internship is a three-credit course intended for graduate students who elect not to complete the Preservation Practicum Course. Students interested could apply for an internship with an organization engaged in historic preservation (this can be a public agency, nonprofit or private firm). The student will formulate a plan of work and a series of pedagogical goals to satisfy both the practical needs of the project and the academic requirements for the course.

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**ARCO 6210 - Conservation Studio**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6110, ARCO 6130, ARCO 6132**

This course concentrates on documenting, analyzing, and planning for the preservation of buildings and their settings as a basis for understanding the technical, theoretical, and procedural aspects of conservation.

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**ARCO 6220 - Preservation Technology**

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**(cross-listed as ARTE 0410) Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6110, ARCO 6112**

Technical aspects pursuant to historic preservation are discussed and demonstrated through laboratory problems. Materials used in restoration, rehabilitation, and conservation projects are tested and weathered to consider short and long-range effects of their use.

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**ARCO 6222 - Architectural Conservation Laboratory**

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**(cross-listed as ARTE 0451) Three credit-hours. Two two-hour lecture periods per week. Pre-requisite: ARCO 6110, ARCO 6130, ARCO 6132**

Through a series of field and scientific laboratory exercises, the student expands the knowledge of traditional building materials. The course includes class lectures, site visits, documentation, condition survey, and collection of field samples and laboratory experiments.

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**ARCO 6224 - Material Conservation Seminar**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6110**

The course will introduce to the theory and conservation practice of traditional historic building materials with an emphasis in brick, wood, stone, glass, terracotta, gypsum, wrought iron, tin plates, quicklime mortars, as well as cement and early types of reinforced concrete.

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**ARCO 6230 - Preservation Law and Economics**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: None**

The course provides an introduction to historic preservation, laws and economic issues in the United States of America and Puerto Rico. It addresses historic preservation economic and social benefits.

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**ARCO 6250 - Archeology of Architecture**

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**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: None**

This course covers the basic principles of the archeology of architecture and its application of heritage structures intervention from a multidisciplinary perspective.

#### **ARCO 6252 - Cultural Landscapes**

**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: None**

The course will provide an introduction to cultural landscapes and an understanding of its histories and theories.

#### **ARCO 6260 - Special Topics in Historic Preservation**

**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: ARCO 6110**

The course examines special areas, topics or issues in architectural conservation and rehabilitation. Taught by a specialist from within the field being studied or as an alternative methodology. Course topics may range from architectural styles, trends or types of construction, to current preservation challenges and developments such as code compliance for historic buildings, historic sites and case studies of specific endangered properties in the region.

#### **ARCO 6310 - Architectural Conservation Final Project**

**Three credit-hours. Two two-hour lecture periods per week. Prerequisite: Student must have completed all required courses, studio and practicum**

This course focuses on the development of a final, comprehensive project in architectural conservation. Projects may be research or site-based at an advanced level of complexity and challenge. The project should synthesize.

#### **PROGRAM FACULTY**

**ANGUEIRA ANDRACA, OLGA** – Lecturer; **Master of Landscape Architecture**; Harvard Graduate School of Design Cambridge, MA (2004); **Bachelor of Architecture**, Minor in English-Creative Writing; University of Miami, School of Architecture Coral Gables, FL (2001).

**BARBERÀ GINÉ, ALEIX** – Lecturer; **Ph.D.** Cleaning of Architectural Monuments, Universidad Politécnica de Cataluña (Current); Postgraduate Specialization in Virtual Restoration, Universidad de Alicante (2017); **Master in the Direction of Conservation and Restauration Projects**, Universidad de Barcelona (2013); **Master in Cultural Management**, Universitat Oberta de Catalunya (2012); **Master in Restauration of Architectural Monuments**; Universidad Politécnica de Cataluña (2012); Postgraduate specialization in new technologies applied to museography, Universidad de Alcalá de Henares (2012); Postgraduate in Expert Museum Education, Universidad de Alcalá de Henares (2012); Postgraduate in Techniques not destructive applied to the Conservation of Historical Heritage, Universidad Pablo de Olavide (2011); Postgraduate of Expert in Preventive Conservation, Universidad de Alcalá de Henares (2011); **Bachelor in Conservation and Restoration of Cultural Assets**, Escuela Superior de Conservación y Restauración de Bienes Culturales de Catalunya (2010).

**COLÓN RODRÍGUEZ, YARA MAITE** –Lecturer III, History; **PhD** History and Theory of Architecture; Universidad Politécnica de Cataluña (2010); MA History, Art, Architecture and City; Universidad Politécnica de Cataluña (2002); BA, University of Puerto Rico (2001).

**GALA AGUILERA, SANTIAGO** – Lecturer; **Master of Architecture**; Architecture Faculty, University of Puerto Rico, (2007); **Bachelor's Degree in Environmental Design**; Faculty of Architecture, University of Puerto Rico, (1999).

**LOPEZ, CARMEN MARLA** – Lecturer; **M.A., Historic Preservation**, Savannah College of Art and Design (2010); **B.A., Architecture**, Florida A&M University, Tallahassee, FL (1992).

**MARTÍNEZ CASTAÑEDA, IMANDRA** – Lecturer; **Ph.D.** History of Puerto Rico and the Caribbean, Centro de Estudios Avanzados de Puerto Rico y el Caribe (in progress); **MA Archeology of Architecture**, Centro de Estudios Avanzados de Puerto Rico y el Caribe (2016); **BArch.** Architecture, Instituto Superior Politécnico José Antonio Echevarría (2000).

**MARTÍNEZ MARTÍN, MARÍA MERCED** – Lecturer II, Architecture; **MArch.** Architecture; Escuela Técnica Superior de Arquitectura, Barcelona (2003); **B. Architecture and Urbanism**; Escuela Técnica Superior de Arquitectura, Barcelona (2003).

**MORALES, MINETTE** – Lecturer; **MS Interior Design**; Pratt Institute (2014); **BA Photography**, Plastic Arts School (2011); Associate Degree in Interior Design, San Juan School of Interior Design (2000).

**OJEDA O'NEILL, PABLO** – Lecturer; Post-Degree in Restoration of Historical Monuments; Architectural Association School of Architecture, London England (1983); Master of Architecture; Architecture Faculty, University of Puerto Rico (1981); Bachelor's in Environmental Design; Faculty of Architecture, University of Puerto Rico (1979).

**ORTIZ COLOM, JORGE** – Lecturer; Ph.D. with Specialty in History of Puerto Rico and the Caribbean, Center for Advanced Studies of Puerto Rico and the Caribbean, San Juan, PR (2017); Master of Architecture, University of Puerto Rico (1981); Bachelor's in Environmental Design; Faculty of Architecture, University of Puerto Rico (1980).

**RIGAU PÉREZ, JORGE** - Professor, Architecture; MA History; University of Puerto Rico, Río Piedras, PR (1993); BArch. Architecture; Cornell University, Ithaca, NY (1975).

**RODRÍGUEZ LÓPEZ, JORGE** – Lecturer; Ph.D. Degree in American Anthropology. Specialized in Caribbean Archaeology; Complutense University of Madrid (2008); ABD Diploma Ph.D. Program, Department of American History II, American Anthropology; Complutense University of Madrid (2003); B.A. Degree in History, University of Puerto Rico, Cayey Campus (1999).

**ROVIRA PONS, PERE** – Lecturer; Bachelor's in fine arts with Specialty in Conservation and Restauration of mural painting, sculpture in stone and historical-artistic elements associated with architecture and archaeological sites (1988).



**VALLS ALECHA, ANTONI** – Lecturer; Master in Restauration of Architectural Monuments, Universidad Politécnica de Cataluña (2015); BArch. Architecture, Escuela Técnica Superior de Arquitectura, Barcelona (2013).

**VELÁZQUEZ FIGUEROA, JUAN C.** – Auxiliary Professor, Architecture; MA Fine Arts Sculpture; Universidad Complutense de Madrid, Spain (1988); BA, Escuela de Artes Plásticas de Puerto Rico (1985).

**VILLALOBOS RIVERA, EVELYN M.** – Lecturer; Master in Restauration of Architectural Monuments, Universidad Politécnica de Cataluña (2018); BArch. Architecture, Polytechnic University of Puerto Rico (2016).

### 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's 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 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's 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.

### **Prerequisite Structure**

Candidates to the first professional degree (MLA III) should have completed the subsequent prerequisite 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 prerequisite 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 prerequisite 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. Prerequisite: 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. Prerequisites: 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. Prerequisite: 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. Prerequisite: 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. Prerequisite: 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. Prerequisite: 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. Prerequisite: 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. Prerequisites: 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. Prerequisites: 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.

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**LA 6310 - Plant Material and Establishment**

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**Three credit-hours. Prerequisites: 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.

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**LA 6320 - Soils**

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**Three credit-hours. Prerequisites: 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.

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**LA 6330 - Advanced Plant Material and Establishment**

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**Three credit-hours. Prerequisite: 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.

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**LA 6410 - Environmental Resources**

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**Three credit-hours. Prerequisite: 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.

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**LA 6420 - Site Engineering**

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**Three credit-hours. Prerequisite: 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.

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**LA 6430 - Site Construction**

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**Three credit-hours. Prerequisite: 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.

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**LA 6440 - Ecology and Technology**

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**Three credit-hours. Prerequisite: 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.

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**LA 6510 - Professional Practice and Ethics**

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**Three credit-hours. Prerequisites: 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.

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**LA 6610 – Modes of Representation**

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**Three credit-hours. Prerequisites: 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.

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**LA 6611 – Computer Representation for Landscape Architects**

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**Three credit-hours. Prerequisites: 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.

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**LA 6640 – Special Topics: Sculptural Landscape**

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**Three credit-hours. Prerequisite: 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.

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**LA 6640 C – Special Topics: COOP**

**Three credit-hours. Prerequisite: 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 professional experiences.

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**LA 6650 – Gardens: Types, typologies and design approaches**

**Three credit-hours. Prerequisites: 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.

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**LA 6710 – Representation: Tools & Techniques**

**Three credit-hours. Prerequisites: 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.

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**LA 6800 – Design Thesis**

**Six credit-hours. Prerequisites: 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.

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**LA 6801 – Design Thesis Extension**

**Zero credit-hour. Prerequisite: LA 6800. One four-hour studio period per week.**

This course provides students the opportunity to continue and complete design thesis work.

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**GMP 6010 – Professional Writing and Presentations**

**Three 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. This course presents the steps required for developing an effective presentation. Students will strengthen their presentation skills through a series of presentations required as part of the course.

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**GMP 6050 – Professional Internship through COOP Program**

**Three credit-hours. Prerequisite: 12 credits approved and Program Director's Approval. One four hours session per week.**

A planned, work experience in which the student is employed in a job directly related to the student's academic program. The student is assigned a Faculty Advisor as well as a Supervisor in the place of employment. A work agreement is established between the student, the Supervisor and the Faculty Advisor at the beginning of the term. Both the Faculty Advisor and the Supervisor will monitor the progress of the student.

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**GMP 6510 – Research Methodology**

**Three credit-hours. Prerequisite: 18 credits approved. One four hours session per week.**

This course provides students the tools required to conduct original research in the areas of engineering, technology, and related fields, including, but not limiting to, problem statement, objectives development, literature review, and determination of the methodology.

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**PROGRAM FACULTY**

**Angueira Andraca, Olga**, Lecturer II – **Master in Landscape Architecture**, Harvard University, Graduate School of Design, 2004; **BArch**, University of Miami, 2001.

**Areces Mallea, Alberto**, Lecturer III – **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**, Lecturer II – **Master of Landscape Architecture**, Polytechnic University of Puerto Rico, 2010; **Bachelor of Arts**, Escuela de Artes Plásticas, 2001.

**Colón Arizmendi, Edmundo**, Lecturer II – **BS in Civil Engineering**, University of Puerto Rico, Mayagüez Campus, 1974.

**Colón Izquierdo, Edmundo**, Lecturer II – **Master in Landscape Architecture**, Harvard University, Graduate School of Design, Massachusetts, 2006; **BArch**, Polytechnic University of Puerto Rico, Hato Rey, Puerto Rico, 2004.

**Lorenzo Torres, José**, Lecturer II – **Master of Architecture in Urban Design**, Harvard University, Graduate School of Design, Massachusetts, 2005; **BArch**, Polytechnic University of Puerto Rico, 2001.

**Rigau Pérez, Jorge**, Professor – **Master of Arts, History**, University of Puerto Rico, Río Piedras, Puerto Rico, 1993; **BArch**, Cornell University, Ithaca, New York, 1975.

**Sánchez Nieves, Roberto L.**, Lecturer II – **Master of Landscape Architecture**, Polytechnic University of Puerto Rico, 2010; **Bachelor of Arts, Education**, University of Puerto Rico, 2001.

**Suárez Toro, Jaime**, Lecturer IV – **Master of Arts, Design**, Columbia University, New York, New York, 1970; **BArch**, Catholic University of America, Washington, DC, 1969.

**Terrasa Soler, José Juan**, Lecturer II - **Master in 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**, Assistant Professor – **Master of Fine Arts**, Complutense University, Madrid, Spain, 1988; **Bachelor of Fine Arts**, School of Fine Arts, San Juan, Puerto Rico, 1985.

## ENGINEERING PROGRAMS

### 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 Director 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 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's degree 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's degree according to two program alternatives. One leads to the Master of Science in Civil Engineering degree and the other to the Master of Engineering in Civil Engineering degree.

Following are the requirements for each alternative, both require a minimum GPA of 3.00/4.00.

### Alternative 1: Master of Science Degree - Thesis Requirement

- Approve a minimum of 24 credit-hours in graduate courses (Level 6000) in the major area. Two of the courses must be GMP 6510 – Research Methodology 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 Director.
- 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's 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 Director.
- 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's Project.

## Thesis and Master's Project 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 Director.

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 Director and the Graduate School.

## Master's Project

In the Master's 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's Project.

## 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
GMP 6510	Research Methodology	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.

### 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 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 6378	Advanced Reinforced Concrete Design	3
CE 6380	Nonlinear Behavior of Concrete Structures	3
CE 6385	Advanced Steel Design	3
CE 6395	Nonlinear Analysis of Soil-Structure Interaction	3

### Geotechnical Engineering Courses

#### Required Course

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

#### Other Courses

Course	Title	Credit-Hours
CE 6100	Soil Shear Strength	3
CE 6110	Earth Retaining Structures	3
CE 6114	Shallow Foundations	3
CE 6120	Deep Foundations	3
CE 6140	Slope Stability	3
CE 6150	Seepage & Drainage	3
CE 6230	Groundwater Hydrology	3
CE 6270	Sedimentation Engineering	3

Course	Title	Credit-Hours
CE 6335	Advanced Foundations	3
CE 6395	Nonlinear Analysis of Soil-Structure Interaction	3
CE 6430	Remediation in Contaminated Subsurface Environments	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 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. Students can take a maximum of 6 credit-hours in elective courses.

### Thesis and Project Courses

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

### 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 equipment 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 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 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 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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**CE 6315 - Analysis of Plates and Shells**

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**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.

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**CE 6320 - Advanced Strength of Materials**

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**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 on elastic foundations. Applications to cylindrical shells. Two-dimensional theory of elasticity. Matrix formulation.

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**CE 6325 - Principles of Structural Stability**

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**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.

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**CE 6330 - Advanced Topics in Structural Engineering**

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**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.

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**CE 6335 - Advanced Foundations**

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**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.

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**CE 6340 - Advanced Bridge Design**

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**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.

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**CE 6345 - Design of Reinforced Masonry Structures**

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**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.

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**CE 6350 - Dynamics of Structures**

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**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.

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**CE 6355 - Advanced Earthquake Engineering**

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**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.

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**CE 6357 - Wind Engineering**

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**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.

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**CE 6360 - Bridge Inspection, Rehabilitation, Repair and Management**

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**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.

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**CE 6370 - Finite Element Methods in Engineering**

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**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.

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**CE 6378 - Advanced Reinforced Concrete Design**

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**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.

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**CE 6380 - Non Linear Behavior of Concrete Structures**

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**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.

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**CE 6385 - Advanced Steel Design**

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**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.

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**CE 6395 - Nonlinear Analysis of Soil-Structure Interaction**

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**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.

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**CE 6410 - Water And Wastewater Treatment Applications**

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**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.

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**CE 6420 - Fate and Transport of Contaminants in Soils**

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**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.

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**CE 6430 - Remediation in Contaminated Subsurface Environments**

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**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.

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

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**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.

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**CE 6450 - Biological Wastewater Treatment Processes**

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**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.

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**CE 6512 - Value Engineering**

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**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.

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**CE 6520 - Construction Contracting and Procurement**

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**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.

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**CE 6530 - Schedule Impact Analysis**

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**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.

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**CE 6532 - Construction Cost Control**

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**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.

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**CE 6540 - Construction Equipment Administration**

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**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).

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**CE 6542 - Construction Material Management**

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

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

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**CE 6544 - Hazardous Material Management**

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**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).

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**CE 6550 - Construction Inspections**

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**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.

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**CE 6560 - Construction Safety Planning & Regulations**

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**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.

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**CE 6570 - Modern Construction Materials**

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**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.

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**CE 6580 - Temporary Structures in Construction**

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**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.

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**CE 6585 - Site Planning and Design**

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**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 supply systems, stormwater and sanitary sewer systems design principles are issues to be presented.

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**CE 6901 - Master's Thesis Dissertation**

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**Six credit-hours. Prerequisite: Graduate Program Director's Approval. One four hours session per week.**

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

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**CE 6902 - Extension of Master's Thesis Dissertation**

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**Zero credit-hours. Prerequisite: Graduate Program Director's Approval. One four hours session per week.**

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

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**CE 6905 - Master's Project, "Final Project"**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. One four hours session per week.**

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

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**CE 6906 - Extension of Master's Project, "Final Project"**

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**Zero credit-hours. Prerequisite: Graduate Program Director's 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.

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**CE 6999 - Special Topics in Civil Engineering**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. One four hours session per week.**

Special topics in any areas of civil engineering.

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**GMP 6010 - Professional Writing and Presentations**

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**Three 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. This course presents the steps required for developing an effective presentation. Students will strengthen their presentation skills through a series of presentations required as part of the course.

**GMP 6050 – Professional Internship through COOP Program**

**Three credit-hours. Prerequisite: 12 credits approved and Program Director's Approval. One four hours session per week.**

A planned, work experience in which the student is employed in a job directly related to the student's academic program. The student is assigned a Faculty Advisor as well as a Supervisor in the place of employment. A work agreement is established between the student, the Supervisor and the Faculty Advisor at the beginning of the term. Both the Faculty Advisor and the Supervisor will monitor the progress of the student.

**GMP 6510 – Research Methodology**

**Three credit-hours. Prerequisite: 18 credits approved. One four hours session per week.**

This course provides students the tools required to conduct original research in the areas of engineering, technology, and related fields, including, but not limiting to, problem statement, objectives development, literature review, and determination of the methodology.

**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.**, Triana Văia 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; Civil and Environmental Engineering and Surveying Department Head; **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.

**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.

**González Miranda, Carlos J.** – Professor; Dean, School of Engineering, Surveying and Geospatial Science; **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.

**Molina Bass, Omar I.** – Lecturer 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 South Florida, 2006; **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; Dean, Graduate School; **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.

**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.** – Associate 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 IN COMPUTER ENGINEERING**

The Electrical and Computer Engineering and Computer Science Department at 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 two areas of specialization for the M.S.Cp.E or the M.Eng.Cp.E; Software Engineering, and Internet Engineering.

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 Master's Degrees 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's degrees.

Graduates of this master's degree 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 prerequisite 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.

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 the specialization 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, 12 credit-hours of the specialization courses, 9 credit-hours of one of the emphasis areas, 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 or 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, Advanced DataBase System, 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, 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, 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, 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.

### 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

### Specialization Courses for the Software Engineering (SE) and Internet Engineering (IE) Areas of Interest (12-credits each)

In order to make an additionally competent Software Engineering Area of Interest we recommend the following four courses of 3 credits each (for a total of 12-credits):

Course	Title	Credit-Hours
CECS 6430	Advanced Software Architecture	3
CECS 6750	Software Testing	3
CECS 7510	Software Engineering II	3
CECS 7520	Human Computer Interaction	3

In order to make an additionally competent Internet Engineering Area of Interest we recommend the following four courses of 3 credits each (for a total of 12-credits):

Course	Title	Credit-Hours
CIS 6715	E-Commerce and Web Information Systems	3
CECS 7130	Advanced Computer Networks	3
CECS 7520	Human Computer Interaction	3
CECS 7560	Internet Engineering II	3

### Emphasis Areas (9 credits each)

Non-thesis option students are required to one of the three Emphasis Areas (9 credits each. Not Required for Thesis option):

The courses that encompass each of the Emphasis Areas are as follows:

#### Database and Secure Operations (9 credit-hours)

Course	Title	Credit-Hours
CECS 6015	IT Auditing and Secure Operations	3
CECS 6035	Contingency Planning	3
CECS 7240	Database Security	3

### Digital Evidence & Auditing (9 credit-hours)

Course	Title	Credit-Hours
CECS 6015	IT Auditing and Secure Operations	3
CECS 6045	Law, Investigation, and Ethics	3
CECS 6046	E-Discovery and Digital Evidence	3

### Big Data (9 credit-hours)

Course	Title	Credit-Hours
CECS 7410	Parallel and Distributed Processing	3
CECS 7412	Fundamentals of Big Data Analytics	3
CECS 7414	Big Data Analytics Programming and Applications	3

### Thesis and Project Courses

Non-thesis option students are required to complete the Final Project (3 credits) after completing the required Core (15-credits) and their respective Specialization Courses (12-credits) the student may opt for one of these three Emphasis Areas (9 credits. Not Required for Thesis option) for a total of 39 credits are required for the Final Project Option:

#### Project:

CECS 7900	Project for MCpE	3
CECS 7901	Project Extension for MCpE	0

Thesis option students are required to complete the Thesis (6 credits) after completing the 15-credits core courses, 12-credits specialization courses. The Emphasis areas (9 credits each is not required for Thesis option)

#### Thesis:

CECS 7971	Thesis for MSCpE	6
CECS 7972	Thesis Extension for MSCpE	0

## MASTER IN COMPUTER SCIENCE

The Computer Science Program of the Electrical and Computer Engineering and Computer Science Department at Polytechnic University of Puerto Rico offers a Master's 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 two main areas of interest to be offered in this program are: Cybersecurity, and Knowledge Discovery and Data Mining (KDDM). Combining core courses with recommended recommended specialization courses for each area of interest 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's 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 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's degree to begin taking graduate courses from the Master in Computer Science (MCS/MCS) programs.

#### **Graduation Requirements**

A candidate for the Master's 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; Specialization: 12 credit-hours; Emphasis: 9 credit-hours; Project Course: 3 credit-hours; Total: 39 credit-hours.

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

Core: 15 credit-hours; Specialization: 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 two main areas to be offered in this program are: Cybersecurity (CybSec), Knowledge Discovery and Data Mining (KDDM).

### Cybersecurity (CybSec) Area of Interest

The Cybersecurity 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.

#### 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 (15 credit-hours)

Course	Title	Credit-Hours
CECS 6005	Principles of Information Security	3
CECS 6010	Advanced Design and Analysis of Algorithms	3
CECS 6030	Computational Theory	3
CECS 6230	IT Operations	3
CECS 7235	Computer Forensics	3

### Specialization Courses for the Cybersecurity (CySec) and Knowledge Discovery and Data Mining (KDDM) Areas of Interest (12-credit hours each)

In order to make an additionally competent Cybersecurity Area of Interest we recommend the following four courses of 3 credits each (for a total of 12-credits):

Course	Title	Credit-Hours
CECS 6605	Advanced Database Systems	3
CECS 7230	Network Security	3
CECS 7237	Advanced Computer Forensics	3
CECS 7570	Computer Security	3

In order to make an additionally competent Knowledge Discover and Data Mining Area of Interest we recommend

the following four courses of 3 credits each (for a total of 12-credits):

Course	Title	Credit-Hours
CECS 6430	Advanced Software Architecture	3
CECS 6605	Advanced Database Systems	3
CECS 7530	Data Mining and Data Warehousing	3
CECS 7550	Artificial Intelligence	3

### Emphasis Areas (9 credits each)

The courses that encompass each of the Emphasis Areas are as follows:

#### Database and Secure Operations (9 credit-hours)

Course	Title	Credit-Hours
CECS 6015	IT Auditing and Secure Operations	3
CECS 6035	Contingency Planning	3
CECS 7240	Database Security	3

#### Digital Evidence & Auditing (9 credit-hours)

Course	Title	Credit-Hours
CECS 6015	IT Auditing and Secure Operations	3
CECS 6045	Law, Investigation, and Ethics	3
CECS 6046	E-Discovery and Digital Evidence	3

#### Big Data (9 credit-hours)

Course	Title	Credit-Hours
CECS 7410	Parallel and Distributed Processing	3
CECS 7412	Fundamentals of Big Data Analytics	3
CECS 7414	Big Data Analytics Programming and Applications	3

### Requirements for the Thesis and Non-thesis options

Non-thesis option students are required to complete the Final Project (3 credits) after completing the required Core (15-credits) and their respective Specialization Courses (12-credits) the student may opt for one of these three Emphasis Areas (9 credits. Not Required for Thesis option) for a total of 39 credits are required for the Final Project Option:

#### Project:

CECS 7950	Project for MCS	3
CECS 7951	Project Extension for MCS	0

Thesis option students are required to complete the Thesis (6 credits) after completing the 15-credits core courses, 12-credits specialization courses. The Emphasis areas (9 credits each is not required for Thesis option)

#### Thesis:

CECS 7980	Thesis for MS CS	6
CECS 7990	Thesis Extension for MS CS	0



## MASTER IN ELECTRICAL ENGINEERING

The Master's 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 three areas of interest for the M.S.E.E or the M.Eng.E.E: Digital Signal Processing, Communication Systems, and Power Systems and Renewable Energy (Only Non-Thesis Option).

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's 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.

### **Power Systems and Renewable Energy (Only Non-Thesis Option)**

The purpose of this new area is to offer current topics such as the development of alternative energy and renewable sources, conservation and management of energy, green building, distributed generation systems, and generation, transmission and distribution in traditional power systems.

### **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**

##### **Prerequisite Courses**

Course	Title	Credit-Hours
EE 3002	Signals & Systems	3
EE 5720	Digital Signal Processing	3
ENGI 2210	Probability and Statistics	3
MATH 3310	Differential Equations	3

##### **Core Courses**

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

### Digital Signal Processing Core Courses

Course	Title	Credit-Hours
EE 6010	Mathematical Methods for Signal Processing	3
EE 6020	Stochastic Processing	3
EE 6030	Linear Systems	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 6760	Digital Communications	3
EE 6770	Satellite Communication Systems	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
EE 7772	Wireless Communication	3
EE 7780	Special Topics in Digital Signal Processing	3

### Computer Engineering Science Oriented Electives

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

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

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

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.

### Communication Systems Area

#### Prerequisite Courses

Course	Title	Credit-Hours
EE 3002	Signals & Systems	3
EE 4704	Communication & Wireless Systems I	3
EE 4710	Random Processes	3
EE 5714	Communication & Wireless Systems II	3
EE 5720	Digital Signal Processing	3
ENGI 2210	Probability and Statistics	3
MATH 3310	Differential Equations	3

### Core Courses

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

#### Communication Systems Core Courses

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

### Communication Systems Oriented Electives

Course	Title	Credit-Hours
EE 6030	Linear Systems	3
EE 6720	Pattern Recognition	3
EE 6770	Satellite Communication Systems	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
EE 7772	Wireless Communication	3
EE 7780	Special Topics in Digital Signal Processing	3

### 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

### Computer Engineering Science Oriented Electives

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

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

Note: EE 4720 Digital Signal Processing and EE 4716 Digital Communication Systems are required courses for the Communication Systems track and therefore are requisites for all the courses offered within this area.

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

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.

### Power Systems and Renewable Energy Area

#### Prerequisite Course

Course	Title	Credit-Hours
EE 4400	Power Systems Analysis II	3

#### Core Courses

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

#### Power Systems and Renewable Energy Core Courses

Course	Title	Credit-Hours
EE 6010	Mathematical Methods for Signal Processing	3
EE 6400	Direct Energy Conversion and Renewables	3
EE 6402	Market, Environmental and Public Policy Issues of Energy Systems	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).

#### Power Systems and Renewable Energy Oriented Electives

Course	Title	Credit-Hours
EE 6410	Smart Grids and Distributed Generation	3
EE 6412	Energy Management	3
EE 6420	Power Systems Transients	3
EE 6422	Power Systems Dynamic Stability	3
EE 6424	Power Systems Operation, Control and Planning	3
EE 7410	Drives and Controls for Energy Conservation and Alternate Sources	3
EE 7420	Advanced Electrical Power Quality	3
EE 7422	Grounding Systems	3

#### Elective courses at the advanced undergraduate level

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

#### Power Systems and Renewable Energy Advanced Undergraduate Electives

Course	Title	Credit-Hours
EE 4422	Electric Power Quality	3
EE 4432	Power System Protection	3
EE 4436	Distribution System Design	3
EE 4464	Generation Control Systems	3
EE 4502	Power Electronics	3

#### Electives Related to the Thesis and Non-thesis Options

Course	Title	Credit-Hours
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 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. 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 Director's 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.

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**CECS 6015 - IT Auditing and Secure Operations**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. 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.

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**CECS 6030 - Computational Theory**

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**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.

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**CECS 6035 - Contingency Planning**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. 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.

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**CECS 6045 - Law, Investigation, and Ethics**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. 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.

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**CECS 6046 - Electronic Discovery and Digital Evidence**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. One four hours session per week.**

This course will give the students an in-depth understanding of the current IT management and e-business litigation practices involving e-Discovery and Digital Forensics. Students will gather the necessary skills to take a leading role in the management team to work with the legal counsel, auditor and department managers to prepare and implement an effective Incident Response Strategy to address various IT-business and legal problems.

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**CECS 6120 - Computer Architecture**

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**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.

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**CECS 6130 - Data Communication Networks**

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**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.

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**CECS 6150 - Object Oriented Design**

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**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.

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**CECS 6230 - IT Operations**

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**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.

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**CECS 6430 - Advanced Software Architecture**

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**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.

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**CECS 6510 - Software Engineering I**

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**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.

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**CECS 6605 - Advanced Database System Design**

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**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.

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**CECS 6750 - Software Testing**

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**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.

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**CECS 6760 - Internet Engineering I**

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**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.

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**CECS 7130 - Advanced Computer Networks**

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**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.

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**CECS 7230 - Network Security**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. 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.

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**CECS 7235 - Computer Forensics**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. 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.

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**CECS 7237 – Advanced Computer Forensics**

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**Three credit-hours. Prerequisite: CECS 7235. One four session per week.**

Advanced topics in computer forensics concerned mainly with file system forensics, hard drives, usb drives, removable media, CD-ROMs and flash drives will be covered. Accessing data from cell phones and PDA's. Recovery of deleted data from DOS, NTFS, MAC, and other widely used file systems. Data carving techniques. Case studies and open source tools.

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**CECS 7240 - Database Security**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. 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.

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**CECS 7410 - Parallel and Distributed Processing**

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**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.

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**CECS 7412 - Fundamentals of Big Data Analytics**

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

Students will learn how to process big data on platforms that can handle the big V's of Big Data: volume, velocity, variety and veracity. The Data Analytics Lifecycle will be studied, including data discovery, data preparation, and data modeling. Map Reduce, Hadoop and other Big Data solution frameworks will be discussed. A review of basic data analytics methods using R and statistical methods including clustering, association rules, regression, classification, time series, among others will be covered. In-database analytics will also be covered in the course.

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**CECS 7414 – Big Data Analytics Programming and Applications**

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

This course is an introduction to Data Science and how we can integrate R and Python programming into the Big Data environment. First part of the course introduces the basics of R and Python before applying them to Big Data analytics. The different phases of the Data Science Methodology will be

studied. Students will learn to prepare and explore data for analysis. Statistical methods and other concepts will be studied such as: Naïve Bayes Classification, Neural Networks, Clustering, regression modeling, dimension reduction, generalized linear modeling, and association rules. Students will also learn how to evaluate models for modeling data and to use decision trees. Students will also explore Hadoop-based tools for storage, retrieval, and analysis of large quantities of data in a variety of formats. Students will learn how to analyze Big Data using the best applications and technology available and affordable for organizations and easily apply R or Python to Hadoop and MapReduce. Students will be prepared to tackle enormous datasets of structured and unstructured data by applying the Hadoop subprojects.

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**CECS 7510 - Software Engineering II**

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**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.

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**CECS 7520 - Human Computer Interaction**

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**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.

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**CECS 7530 - Data Mining and Data Warehousing**

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**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.

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**CECS 7550 - Artificial Intelligence (AI)**

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**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.

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**CECS 7560 - Internet Engineering II**

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**Three credit-hours. Prerequisites: CECS 6760. 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.

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**CECS 7570 - Computer Security**

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**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.

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**CECS 7900 – Project for Master in Computer Engineering**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. 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.

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**CECS 7901 – Project Extension for Master in Computer Engineering**

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**Zero credit-hours. Prerequisites: Graduate Program Director's Approval. 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.

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**CECS 7950 - Project for Master in Computer Science**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. 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 Director's Approval.**

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 is 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 Director's 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 Director's 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.

### **CECS 7980 - Thesis MSCS**

**Six credit-hours. Prerequisites: Graduate Program Director's 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 Director's Approval. 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.

### **EE 5714 - Digital Communication Systems**

**Three credit-hours. Prerequisites: EE 4704. Corequisite: 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.

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**EE 6020 - Stochastic Processes**

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**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.

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**EE 6030 - Linear Systems**

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**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.

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**EE 6400 - Direct Energy Conversion and Renewables**

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

Theory of direct energy generation and storage based on chemical reaction charged carriers, semiconductors and/or renewable sources. Overview of thermoionic, thermoelectric, photovoltaic, fuel cells, wind and magnetohydrodynamic (MHD) devices and systems. Commercial and industrial applications.

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**EE 6402 - Market, Environmental and Public Policy Issues of Energy Systems**

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

Study of worldwide primary sources and electricity markets, distribution chain, and deregulation. Social interaction, public opinion, security, changing environmental regulations and economic considerations for public policy development and power systems design. Regional, national and international case studies.

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**EE 6410 - Smart Grids and Distributed Generation**

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**Three credit-hours. Prerequisite: EE 6400. One four hours session per week.**

Smart grids design, including distributed generation and microgrid systems. Study of microsources, storage and interface devices. Analysis of economic, control, reliability, systems integration, and grid interconnection issues.

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**EE 6412 - Energy Management**

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

Available energy resources for residential, commercial and industrial use. Conservation programs and techniques. Bill analysis and energy audits. Development of energy conservation measures (ECMs) for lighting, HVAC, motors and other systems. Cost estimation and engineering economics for decision making.

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**EE 6420 - Power Systems Transients**

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

Analysis of overvoltage conditions caused by lightning, faults and switching transients. Study switching sequence and source impedance effects in lumped and distributed lines and systems. Design insulation requirements and coordination.

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**EE 6422 - Power Systems Dynamic Stability**

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**Three credit-hours. Prerequisite: EE 4400. One four hours session per week.**

Analysis of power system dynamic behavior. Study of voltage and frequency instability, machine governing systems. Motor starts. Design required contingencies. Small and large systems applications.

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**EE 6424 - Power Systems Operation, Control and Planning**

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

Analysis of power plant characteristics for real time operation, economic dispatch, and unit commitment and scheduling. Load forecasting, and state estimation and optimization of power grids. Applications to Energy management systems (EMS).

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**EE 6632 - Non Linear Control**

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**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.

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**EE 6660 - Advanced Robotic Manipulators**

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**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.

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**EE 6720 - Pattern Recognition**

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**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.

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**EE 6740 - Intelligent Control**

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**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.

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**EE 6760 - Digital Communications**

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**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.

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**EE 6770 - Satellite Communication Systems**

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**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.

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**EE 7410 - Drives and Controls for Energy Conservation and Alternate Sources**

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**Three credit-hours. Prerequisite: EE 4520 and EE 6400. One four hours session per week.**

Analysis of DC and AC motor speed and frequency drives. Converter topologies and devices for wind, photovoltaic and power factor correction applications.

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**EE 7420 - Advanced Electrical Power Quality**

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**Three credit-hours. Prerequisite: EE 4422. One four hours session per week.**

Event classification by causes, effects, standards, susceptibility curves, and distortion indexes. Harmonic analysis and modeling systems and components under non sinusoidal conditions to assess voltage distortion. Study the effects of power factor correction capacitor resonance, sags, swells, transients and flicker on power systems. Measurement and mitigation. Equipment electromagnetic interference (EMI) and electromagnetic compatibility (EMC). Case studies for commercial and industrial facilities.

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**EE 7422 - Grounding Systems**

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**Three credit-hours. Prerequisite: EE 4422. One four hours session per week.**

Analysis of stray voltages and currents. Study of single and multiple point grounding systems, grounding grids and lightning overvoltage. Safety and performance standards. Soil resistivity and resistance measurements. Applications to substation design.

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**EE 7712 - Image Processing**

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**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.

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**EE 7716 - Computer Vision**

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**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.

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**EE 7730 - Speech Processing**

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**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.

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**EE 7740 - Algorithms for Digital Signal Processing**

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**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-Hadamard 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.

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**EE 7772 - Wireless Communications**

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**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

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**EE 7780 - Special Topics in Signal Processing**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. 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.

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**EE 7790 - Project for Master in Electrical Engineering**

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**Three credit-hours. Prerequisites: Graduate Program Director's Approval. 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.

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**EE 7791 - Project Extension for Master in Electrical Engineering**

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**Zero credit-hours. Prerequisites: Graduate Program Director's 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.

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**EE 7800 - Thesis**

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**Six credit-hours. Prerequisites: All Core Courses and Graduate Program Director's Approval. 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.

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**EE 7801 - Thesis Extension**

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**Zero credit-hour. Prerequisites: EE 7800. Graduate Program Director's 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.

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**GMP 6010 - Professional Writing and Presentations**

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**Three 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. This course presents the steps required for developing an effective presentation. Students will strengthen their presentation skills through a series of presentations required as part of the course.

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**GMP 6050 - Professional Internship through COOP Program**

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**Three credit-hours. Prerequisite: 12 credits approved and Program Director's Approval. One four hours session per week.**

A planned, work experience in which the student is employed in a job directly related to the student's academic program. The student is assigned a Faculty Advisor as well as a Supervisor in the place of employment. A work agreement is established between the student, the Supervisor and the Faculty Advisor at the beginning of the term. Both the Faculty Advisor and the Supervisor will monitor the progress of the student.

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**GMP 6510 - Research Methodology**

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**Three credit-hours. Prerequisite: 18 credits approved. One four hours session per week.**

This course provides students the tools required to conduct original research in the areas of engineering, technology, and related fields, including, but not limiting to, problem statement,

objectives development, literature review, and determination of the methodology.

### ELECTRICAL AND COMPUTER ENGINEERING AND COMPUTER SCIENCE DEPARTMENT PROGRAM FACULTY

**Cruz Triana, Alfredo** – Professor; Graduate Program Director; **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.*

**Duffany, Jeffrey** – Professor, **Ph.D.**, Computer and Information Engineering, Stevens Institute; **MS** Electrical Engineering, Columbia University.

**González Lizardo, Ángel** – 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.*

**Jordán Conde, Zayira** – Associate Professor; Human Computer Interaction; **PhD**, Iowa State University, Iowa, 2010; **MA**, Iowa State University, 2004; **BA** Iowa State University, 2001. **ACM.** E-mail: zjordan@upr.edu

**Nevárez Ayala, Félix J.** – Lecturer III (Orlando Campus); Computer Engineering; **PhD** in Engineering & Applied Sciences, Mechanical Engineering, Polytechnic University of Puerto Rico (Candidate); **MEngME**, Polytechnic University of Puerto Rico, 2015; **MSEE**, University of Puerto Rico, Mayagüez Campus, 1995; **BSEE**, Polytechnic University of Puerto Rico, 1992; **BS Physics**, University of Puerto Rico, Mayagüez Campus, 1989. E-mail: fnevarez@upr.edu

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

**Solá Sloan, 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.*

**Torres Batista, Nelliud D.** – Associate Professor; **DBA**, Management Information Systems, Turabo University, 2011; **MS** Information System, EDP College of Puerto Rico, 1995; **B.S.** Computer Science, University of Puerto Rico, Bayamón Campus, 1984.

**Vicente López, Luis M.** – Associate Professor; **Ph.D.**, Electrical and Computer Engineering, University of Missouri, Columbia, MO, 2009. **M.S.E.E.**, Florida International 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 Vasilevich, 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's degree 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 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 through 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's 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 identified deficiencies.

#### **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 nine (9) credit-hours, distributed among three (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 must select a total of 9 credit-hours, distributed among three (3) courses of three credit - hours each. The student may substitute up to two Application courses from other graduate programs if he or she has the prerequisites.

#### **Research Project**

The student must prepare a proposal for his/her Master's Research Project after approving 12 credits and the Research Methodology course (GMP 6510). The proposal must be approved by the student advisor. The student must conduct the Master's Research Project under the supervision of the advisor, who is the chairperson.

Through the Master's Research Project, students must demonstrate expertise of geospatial science and techniques, and the ability to apply them in a cohesive manner. The Master's 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's 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's Research Project.

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

## **GEOSPATIAL SCIENCE AND TECHNOLOGY CURRICULUM STRUCTURE AND SEQUENCE**

### **Core Courses**

<b>Course</b>	<b>Title</b>	<b>Credit-Hours</b>
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**

<b>Course</b>	<b>Title</b>	<b>Credit-Hours</b>
GEOM 6637	Photogrammetry	3
GEOM 6638	Geospatial Programming Fundamentals	3
GEOM 6639	Geospatial Technology Project Management	3

### **Geospatial Applications Courses**

(Select 9 Credits from the following)

<b>Course</b>	<b>Title</b>	<b>Credit-Hours</b>
GEOM 6644	Web Mapping Applications	3
GEOM 6646	Environmental Assessment & Geospatial Technology	3
GEOM 6648	Business Geography	3
GEOM 6650	Surface Water Hydrology for GIS	3
GEOM 6652	GIS Transportation Engineering	3

### **Research Courses**

<b>Course</b>	<b>Title</b>	<b>Credit-Hours</b>
GMP 6510	Research Methodology	3
GEOM 6690	Master's Research Project	3
GEOM 6691	Master's Research Project Extension (If necessary)	0

## **LABORATORIES**

The Surveying and Geospatial Science 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 Surveying and Geospatial 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 6630 - Geospatial Modeling & Analysis**

**Three credit-hours. Prerequisites: 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. Prerequisites: 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.

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**GEOM 6634 - Cartography, Map Design & Geovisualization**

**Three credit-hours. Prerequisites:** 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.

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**GEOM 6637 - Photogrammetry**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One four hours session per week.

This course focus on the principles and techniques of Photogrammetry using aerial and terrestrial photography. The stages of planning, flight design, and the terrestrial controls in Photogrammetry surveys are covered. Applications of photogrammetry in GIS are also discussed.

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**GEOM 6638 - Geospatial Programming Fundamentals**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. 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.

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**GEOM 6639 - Geospatial Technology Project Management**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One four hours session per week.

This course covers the guiding principles, methods, implementation and management of spatial databases.

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**GEOM 6644 - Web Mapping Applications**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. 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.

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**GEOM 6646 - Environmental Assessment and Geospatial Technology**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. 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.

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**GEOM 6648 - Business Geography**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. 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.

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**GEOM 6650 - Surface Water Hydrology for GIS**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One four hours session per week.

GIS and mathematical models are integrated to develop spatial information to practice water resources planning, management and engineering with the development of sustainable solutions.

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**GEOM 6652 - GIS for Transportation Engineering**

**Three credit-hours. Prerequisites:** GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One four hours session per week.

Geographic information systems are used to support the planning, design and management of the transportation infrastructure.

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**GEOM 6690 - Master's Research Project**

**Three credit-hours. Prerequisites:** GMP 6510 and Program Director/Coordinator approval. One four hours session per week.

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

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**GEOM 6691 - Master's Research Project Extension**

**Three credit-hours. Prerequisites:** GEOM 6690 and Program Director/Coordinator 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. Prerequisite: 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.

### **GMP 6010 – Professional Writing and Presentations**

**Three 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. This course presents the steps required for developing an effective presentation. Students will strengthen their presentation skills through a series of presentations required as part of the course.

### **GMP 6050 – Professional Internship through COOP Program**

**Three credit-hours. Prerequisite: 12 credits approved and Program Director's Approval. One four hours session per week.**

A planned, work experience in which the student is employed in a job directly related to the student's academic program. The student is assigned a Faculty Advisor as well as a Supervisor in the place of employment. A work agreement is established between the student, the Supervisor and the Faculty Advisor at the beginning of the term. Both the Faculty Advisor and the Supervisor will monitor the progress of the student.

### **GMP 6510 – Research Methodology**

**Three credit-hours. Prerequisite: 18 credits approved. One four hours session per week.**

This course provides students the tools required to conduct original research in the areas of engineering, technology, and related fields, including, but not limiting to, problem statement, objectives development, literature review, and determination of the methodology.

### **PROGRAM FACULTY**

**Acosta Hernández, Javier** – Associate Professor; **M.S.**, Information Systems, Inter American University, 2008; **B.S.**, Civil Engineering, University of Puerto Rico, 1992.

**Matos Flores, Raúl** – Associate Professor, **Ph.D.** (Candidate), Cartography, GIS and Remote Sensing doctoral program, Universidad de Alcalá, Madrid, 2012; **M.S.**, Geographic Information Systems, Huddersfield University, Great Britain, 2002; Master in Planning, Concentration: Urban Planning, University of Puerto Rico, 1997; **B.A.**, Geography, University of Puerto Rico, 1991.

**Romero González, Víctor** – Assistant Professor; **Ph.D. (Candidate)**, Topographic Engineering and Photogrammetry,

Universidad Politécnica de Madrid, 2004; **M.S.**, Environmental Management, Metropolitan University of Puerto Rico, 2006; **B.S.**, Land Surveying, Polytechnic University of Puerto Rico, 1994.

**Villalta Calderón, Christian A.** – Associate 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 IN MANUFACTURING COMPETITIVENESS**

The Master's Degree 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's Degree 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 39 credit-hours including the following:

1. Eighteen (18) credit-hours in core courses. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
2. An additional minimum of 3 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
3. 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 39 credit-hours including the following:

1. Eighteen (18) credit-hours in core courses.
2. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
3. An additional minimum of 6 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
4. 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 18 credit-hours, distributed among 6 courses, 3 credit-hours each.

### 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's 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 (18 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
GMP 6010	Professional Writing and Presentations	3

### 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

Course	Title	Credit-Hours
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 (18 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement <sup>(1)</sup>	3
MMP 6002	Operations Planning and Control <sup>(1)</sup>	3
MMP 6006	Lean Manufacturing	3
MMP 6008	Foundations in Quality Learning and Assurance	3
MMP 6052	Managerial Finances and Cost Accounting <sup>(2)</sup>	3
GMP 6010	Professional Writing and Presentations	3

#### 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<sup>(3)</sup>

Course	Title	Credit-Hours
GMP 6050	Professional Internship through COOP Program	3
GMP 6510	Research Methodology	3
MMP 6145	Lean Six Sigma	3
MMP 6162	Medical Devices Technology I	3
MMP 6518	Project Management	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's degree in Industrial Engineering must substitute this course with an elective course with MMP code.

(2) Students with a Bachelor's 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's Degree 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's Degree 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 39 credit-hours including the following:

1. Fifteen (15) credit-hours in core courses.
2. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
3. An additional minimum of 6 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
4. 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 39 credit-hours including the following:

1. Fifteen (15) credit-hours in core courses.
2. A minimum of 12 credit-hours (four courses) in the area of specialization chosen by the student.
3. An additional minimum of 9 credit-hours in elective courses to be chosen from the Manufacturing Graduate Program offerings.
4. 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 15 credit-hours, distributed among 5 courses, three credit-hours each.

#### **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 Director/Coordinator. 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 (15 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement <sup>(1)</sup>	3
MMP 6002	Operations Planning and Control <sup>(1)</sup>	3
MMP 6005	Process Engineering <sup>(2)</sup>	3
MMP 6006	Lean Manufacturing	3
GMP 6010	Professional Writing and Presentations	3

### 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 (15 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement <sup>(1)</sup>	3
MMP 6002	Operations Planning and Control <sup>(1)</sup>	3
MMP 6005	Process Engineering <sup>(2)</sup>	3
MMP 6006	Lean Manufacturing	3
GMP 6010	Professional Writing and Presentations	3

### 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 (15 credit-hours)

Course	Title	Credit-Hours
MMP 6000	Advanced Statistics and Quality Improvement <sup>(1)</sup>	3
MMP 6002	Operations Planning and Control <sup>(1)</sup>	3

MMP 6006	Lean Manufacturing	3
MMP 6008	Foundations in Quality Learning and Assurance	3
GMP 6010	Professional Writing and Presentations	3

### 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<sup>(3)</sup>

Course	Title	Credit-Hours
GMP 6050	Professional Internship through COOP Program	3
GMP 6510	Research Methodology	3
MMP 6145	Lean Six Sigma	3
MMP 6162	Medical Devices Technology I	3
MMP 6518	Project Management	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's degree in Industrial Engineering must substitute this course with an elective course with MMP code.

(2) Students with a Bachelor's 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**

### **GMP 6010 – Professional Writing and Presentations**

**Three 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. This course presents the steps required for developing an effective presentation. Students will strengthen their presentation skills through a series of presentations required as part of the course.

### **GMP 6050 – Professional Internship through COOP Program**

**Three credit-hours. Prerequisite: 12 credits approved and Program Director's Approval. One four hours session per week.**

A planned, work experience in which the student is employed in a job directly related to the student's academic program. The student is assigned a Faculty Advisor as well as a Supervisor in the place of employment. A work agreement is established between the student, the Supervisor and the Faculty Advisor at the beginning of the term. Both the Faculty Advisor and the Supervisor will monitor the progress of the student.

### **GMP 6510 – Research Methodology**

**Three credit-hours. Prerequisite: 18 credits approved. One four hours session per week.**

This course provides students the tools required to conduct original research in the areas of engineering, technology, and related fields, including, but not limiting to, problem statement, objectives development, literature review, and determination of the methodology.

### **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.

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#### **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.

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#### **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.

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#### **MMP 6006 - Lean Manufacturing**

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

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.

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#### **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 identifying ongoing goals for certified partnerships.

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#### **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.

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#### **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.

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#### **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.

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#### **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.

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#### **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.

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#### **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.

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#### **MMP 6143 - Process Control**

**Three credit-hours. Prerequisite: None. 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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**MMP 6550 - Ergonomics and Human Factors in the Workplace**

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**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.

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**MMP 6552 - Industrial Safety and OSHA Regulations**

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**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.

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**MMP 6558 - Machine and Process Characterization**

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**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.

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**MMP 6560 - Organizational Behavior**

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**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.

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**MMP 6564- Process Validation and Technology Transfer**

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**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.

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**MMP 6570 - Design and Implementation of Statistical Sampling Plans**

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**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.

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**MMP 6599 - Special Topics in Manufacturing**

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**Three credit-hours. Prerequisite: Graduate Program Director/Coordinator approval. One four hours session per week.**

Special topics in any of the areas of specialization in manufacturing.

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**MMP 6700 - Design Project**

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**Three credit-hours. Prerequisites: All core and specialization courses and Graduate Program Director/Coordinator 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.

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**MMP 6701 - Design Project Extension**

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**Zero credit-hours. Prerequisites: MMP 6700 Graduate Program Director/Coordinator approval. One four hours session per week.**

This course provides the student the opportunity to continue the development of his/her applied design project.

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**MMP 6800 - Master's Thesis**

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**Six credit-hours. Prerequisites: All core and specialization courses and Graduate Program Director/Coordinator 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.

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**MMP 6801 - Master's Thesis Extension**

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**Zero credit-hours. Prerequisites: MMP 6800 and Graduate Program Director/Coordinator 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.

## 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 Muñiz, Judith** – Lecturer IV - **Ed.D.**, Curriculum and Teaching, University of Puerto Rico, Río Piedras Campus, 1999; **Ed.M.**, Pedagogy (Education), University of Puerto Rico, Río Piedras Campus, 1974; **B.S.**, Pedagogy (Education), University of Puerto Rico, Río Piedras Campus, 1970.

**Dávila Aponte, Edwin** – Assistant Professor – **Ph.D.**, Entrepreneurship Development, Inter American University of Puerto Rico, Río Piedras Campus, 2006; **MBA** Accounting, Inter American 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, Cuauhtémoc** – Professor; Associate Dean, School of Engineering, Surveying and Geospatial Science, 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, Ángel** – Associate Professor, Director of 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 Miranda, Carlos** – Professor; Dean, School of Engineering, Surveying and Geospatial 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, Inter American 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.

**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.

**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.*

**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 of 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, computational fluid dynamics (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, turbomachinery, 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, 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.

In addition, the program prepares graduates for academic careers that can fill the demand for professors in related areas of instruction. It also 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.

The main objective of the programs is to fill the major 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, develop, 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 possess 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 prerequisites may apply after the evaluation of the application by the Program Director. 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 bachelor's program to be able to take the necessary prerequisites. 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. Six credits hours (2 courses) of core courses.
2. A minimum 24 credit hours (8 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 Director and the student's advisor.

The program is intended to be flexible; students can petition the Program Director 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 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. In addition, a course in

research methodology techniques is included as a core course. This course will provide students with the tools required to develop their research proposal. Core courses have a total of 6 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 24 credit-hours.

#### Design Project

Students must prepare a design project in a topic that has been approved by faculty and the program Director/Coordinator. 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
GMP 6510	Research Methodology	3

#### General Courses

(Must select 24 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
MMP 6000	Advanced Statistics and Quality Improvement	3
MMP 6130	Six Sigma	3
GMP 6010	Professional Writing and Presentations	3
GMP 6050	Professional Internship through COOP Program	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 a design project, and to organize and evaluate themselves creatively in the areas of Energy/Thermal/Fluids, or Design/Materials/ Manufacturing, or Aerospace. The student must prepare/conduct a design project, after the completion of all the courses in the core and area of specialization courses components, 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 equipment 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 equipment include tension testing machines, brinell 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. Equipment 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 their characteristics and applications.

**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 eighteen (18) publications in the recent past, eight (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 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. The consequences of this variation in temperature and pressure are considered. The conservation of mass, first and second law of thermodynamics and Newton's laws of motion of subsonic and supersonic flows are studied and analyzed. The students will apply the basic concepts of gas dynamics to analyze sound waves in an arbitrary fluid and then develop working equations for a perfect gas in bounded and unbounded phenomena.

### **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.

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**ME 6170 - Alternative and Renewable Energy Technologies**

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**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.

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**ME 6200 - Advanced Solid Mechanics**

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**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.

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**ME 6220 - Fracture Mechanics**

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**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.

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**ME 6240 - Tools, Tooling, and Machine Tool Design**

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**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.

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**ME 6250 - Advanced Manufacturing Simulation**

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**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.

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**ME 6260 - Introduction to Composite Materials**

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**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.

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**ME 6270 - Fundamentals of Tribology and Surface Layer Technology**

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**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.

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**ME 6300 - Advanced Aerospace Structures**

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**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 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.

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**ME 6330 - Finite Element Analysis**

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**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.

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**ME 6340 - Vibration Systems**

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**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.

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**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.

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**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.

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**ME 6390 - Special Topics in Mechanical Engineering**

**Three credit-hours. Prerequisite: Graduate Program Director/Coordinator approval. One four hours session per week.**

Special topics in any areas of Mechanical Engineering.

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**ME 6400 - Design Project for Master in Mechanical Engineering**

**Three credit-hours. Prerequisites: Graduate Program Director/Coordinator 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.

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**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.

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**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.

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**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.

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**GMP 6010 - Professional Writing and Presentations**

**Three 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. This course presents the steps required for developing an effective presentation. Students will strengthen their presentation skills through a series of presentations required as part of the course.

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**GMP 6050 - Professional Internship through COOP Program**

**Three credit-hours. Prerequisite: 12 credits approved and Program Director's Approval. One four hours session per week.**

A planned, work experience in which the student is employed in a job directly related to the student's academic program. The student is assigned a Faculty Advisor as well as a Supervisor in the place of employment. A work agreement is established between the student, the Supervisor and the Faculty Advisor at the beginning of the term. Both the Faculty Advisor and the Supervisor will monitor the progress of the student.

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**GMP 6510 - Research Methodology**

**Three credit-hours. Prerequisite: 18 credits approved. One four hours session per week.**

This course provides students the tools required to conduct original research in the areas of engineering, technology, and related fields, including, but not limiting to, problem statement, objectives development, literature review, and determination of the methodology.

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**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 Campus, 1995.

**Cecchini Brigi, Andrés** – Associate Professor, **Ph.D.** Civil Engineering, University of Puerto Rico, Mayagüez, 2014, **M.S.** Mechanical Engineering, University of Puerto Rico, Mayagüez, 2005, **B.S.** Mechanical Engineering, Universidad Nacional de Río Cuarto, Córdoba, Argentina, 2001.

**González Lizardo, Ángel** – 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; Mechanical

Engineering Department Head; **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.

**Peláez 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.

**Salgado Mangual, Rafael** – Professor, **Ph.D.**, Mechanical Engineering and Industrial Organization, Universidad Carlos III de Madrid, Spain, 2008; **M.S.**, Mechanical Engineering and Industrial Organization, Universidad Carlos III de Madrid, Spain, 2005; **B.S.** Mechanical Engineering, University of Puerto Rico, Mayagüez Campus, 2003.

**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.

## MANAGEMENT PROGRAMS

### 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 online 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-after 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.

##### 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.

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	Human Resources Management	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 must enroll the following project course to apply the critical thinking skills acquired in the CIS concentrations.

Course	Title	Credit-Hours
CIS 6900	Project in Computer Information Systems	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 of specialization:

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 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. The elective courses for the *CIS* students are:

Course	Title	Credit-Hours
CECS 6015	IT Auditing and Security Operations	3
CECS 6035	Contingency Planning	3
CECS 7240	Database Security	3

In addition to the current list of electives courses, students could select as an elective any course with CECS code as recommended by the Graduate Program Director.

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 Works Management (MEM Online Only)
- Renewable Resources Management (MEM On-campus Only)

## 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	Human Resources Management	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, 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

Students can choose among four emphasis areas: 1) Construction Management; 2) Environmental Management; 3) Manufacturing Management; 4) Public Works Management (for MEM Online Only) or; 5) Renewable Resources Management. As an alternative the students could combine courses of any of the four emphasis areas to finish the curriculum with a general emphasis. 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. The student must choose up to 9 credit-hours from the following courses:

Course	Title	Credit-Hours
MEM 6410	Construction Management	3
MEM 6170	Cost Estimate and Contracting	3
MEM 6710	Professional Ethics and Public Policy	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 9 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 (For MEM Online Only)

To 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

### **Renewable Resources Management (For MEM On-campus Only)**

Provide knowledge that will enable engineers to become managers and executive personnel with adequate abilities in renewable resources and energy systems.

Students in this emphasis will have the capacity to integrate advanced resources technology available with current environmental issues and policies.

Course	Title	Credit-Hours
EE 6402	Market, Environmental and Public Policy Issues of Energy Systems	3
EPM 6850	Management for Sustainable Future	3
ME 6170	Alternative and Renewable Energy Technologies	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	Human Resources Management	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
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### Elective Courses

MEnvM students could select the 6 credit-hours in electives from any course labeled as EPM, GMP, 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: None. 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: None. One four hours per week.**

Basic 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 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 and 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.

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**CIS 6725 - Applied Artificial Intelligence for Business**

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

Principles and techniques related 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.

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**CECS 6015 - IT Auditing and Security Operations**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. 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.

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**CECS 6035 - Contingency Planning**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. 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.

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**CECS 7240- Database Security**

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**Three credit-hours. Prerequisite: Graduate Program Director's Approval. One four hours 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.

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**CIS 6900 - Project in Computer Information Systems**

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**Three credit-hours. Prerequisite: All core courses and specialization courses approved. One four hours session per week.**

The main objective of this course is to pursue a research study on a current computer systems information or to define a business-related problem that has a solution through the development of a computer systems application. Areas of current interest include, but not limited to: object oriented database systems, high performance parallel database systems, query optimization and advanced 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 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.

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**EE 6402 - Market, Environmental and Public Policy Issues of Energy Systems**

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

Study of worldwide primary sources and electricity markets, distribution chain, and deregulation. Social interaction, public opinion, security, changing environmental regulations and economic considerations for public policy development and power systems design. Regional, national and international case studies.

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**EPM 6800 - Solid Waste Management**

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**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.

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**EPM 6810 - Environmental Regulations**

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**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.

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**EPM 6820 - Environmental Impact Assessment**

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**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.

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**EPM 6850 - Management of Sustainable Future**

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**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.

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**EPM 6900 - Environmental Management Applications**

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**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's degree 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.

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**GMP 6010 - Professional Writing and Presentations**

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**Three 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. This course presents the steps required for developing an effective presentation. Students will strengthen their presentation skills through a series of presentations required as part of the course.

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**GMP 6050 - Professional Internship through COOP Program**

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**Three credit-hours. Prerequisite: 12 credits approved and Program Director's Approval. One four hours session per week.**

A planned, work experience in which the student is employed in a job directly related to the student's academic program. The student is assigned a Faculty Advisor as well as a Supervisor in the place of employment. A work agreement is established between the student, the Supervisor and the Faculty Advisor at the beginning of the term. Both the Faculty Advisor and the Supervisor will monitor the progress of the student.

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**GMP 6510 - Research Methodology**

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**Three credit-hours. Prerequisite: 18 credits approved. One four hours session per week.**

This course provides students the tools required to conduct original research in the areas of engineering, technology, and

related fields, including, but not limiting to, problem statement, objectives development, literature review, and determination of the methodology.

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**MBA 5600 - Managerial Economics**

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**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.

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**MBA 5700 - Managerial Marketing**

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**Three credit-hours. Prerequisite: None. 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.

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**MBA 5800 - Leadership**

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**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.

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**MBA 6830 - Operations Management**

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**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.

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**MBA 6900 - Strategic Management**

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**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 the 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.

#### **ME 6170 - Alternative and Renewable Energy Technologies**

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

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.

#### **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.

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**MEM 6610 - Productivity Management**

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**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.

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**MEM 6710 - Professional Ethics and Public Policy**

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**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.

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**MEM 6820 - Business And Construction Law**

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**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.

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**MEM 6910 - Air Quality**

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**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, (Intergovernmental 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.

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**MEM 6915 - Water Quality**

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**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.

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**MEM 6940 - Introduction to Pollution Protection of the Earth System**

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**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.

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**MGM 5500 - Managerial Accounting**

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**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.

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**MGM 5700 - Probabilities and Statistical Methods**

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**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.

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**MGM 5800 - Supply Chain Management and Logistics**

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**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.

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**MGM 6070 - Human Resources Management**

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**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.

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**MGM 6560 - Management of Information Systems**

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**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.

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**MGM 6620 - Managerial Finances**

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**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.

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**MGM 6690 - Decision Making Techniques**

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**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.

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**MIE 7010 - International Business Operations**

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**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.

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**MIE 7020 - International Business Strategies**

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**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.

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**MIE 7110 - International Finances**

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**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.

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**MIE 7120 - Business Law In Global Perspective**

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**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.

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**PROGRAM FACULTY**

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**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.

**Cruz Triana, Alfredo** – Professor; Graduate Program Director; 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 J.** – Professor; Civil and Environmental Engineering and Surveying Department Head; **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, Inter American University of Puerto Rico, Río Piedras Campus, 2006; **M.B.A.** Accounting, Inter American 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 Miranda, Carlos J.** – Professor, Dean School of Engineering, Surveying and Geospatial 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 González, 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 Ortiz, 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.** – Lecturer 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.** Civil Engineering, University of South Florida, 2006; **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.**

**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** – Professor, Dean Graduate School; **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 Vargas, Leticia** – Associate Professor, **Ph.D.**, Globalization and Information Technology, Lesley University, Cambridge, Massachusetts, 2004; **C.A.S.**, Graduate Certificate of Advanced Studies, Business Teacher in Higher Education: Accounting and Management of Information Systems, New York University, 1997; **M.B.A.**, Accounting, Inter-American University, San Juan, Puerto Rico, 1979; **B.B.A.**, Accounting, University of Puerto Rico, Río Piedras Campus, 1976.

**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.

**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 Batista, Nelliud D.** – Associate Professor; **DBA**, Management Information Systems, Turabo University, 2011; **MS** Information System, EDP College of Puerto Rico, 1995; **B.S.** Computer Science, University of Puerto Rico, Bayamón Campus, 1984.

**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.** – Associate 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.

## SCIENCE IN EDUCATION PROGRAM

### MASTER OF SCIENCE IN EDUCATION IN MATHEMATICS AND NATURAL SCIENCES

The purpose of the degree of Master of Science in Education is to improve the quality of mathematics and science instruction in

schools in Puerto Rico and to offer a solution to the shortage of secondary school teachers, math and science content knowledge teachers, and elementary and junior college mathematics teachers. The program will provide a strong emphasis on mathematics/science content and the role of mathematical ways of thinking in the teaching and learning of math and science. The program is directly tied to elementary, secondary, and junior college curriculum needs, and is aimed toward currently certified teachers with degrees in non-mathematics fields, to teachers with bachelor's degrees in mathematics and natural sciences who wish to upgrade their command of the field, and to bachelor's degree holders in other fields who wish to enter teaching.

Polytechnic University of Puerto Rico has strong links with the Department of Education of Puerto Rico (DEPR) and accepts Title II-A scholarships. All active, private and public school teachers can apply to the Master's Degree of Science in Education in Mathematics and Natural Sciences at PUPR because the DEPR pays for a total of 24 credits each year.

Students who want to benefit from Title II-A scholarships have to attend their school DEPR Regional Office and fill the scholarship application form. The scholarship also applies to directors, schools superintendents, facilitators, and regional supervisors who wish to improve math and sciences skills and knowledge.

### **PROGRAM PHILOSOPHY AND OBJECTIVES**

The mission of the Science and Education Program is to serve society by preparing professional educators committed to the new educational paradigms, leaders in education with an inquisitive attitude, creative and critical thinkers, with a mastery of pedagogical and conceptual content in their discipline.

The program aims to prepare graduates with a desire and capacity for life-long learning and self-development. The program also seeks to foster students' development of cognitive, affective, research, technological and communication skills. The intention is that candidates become lifelong learners, and consequently, competent and effective teachers. In order to fulfill these objectives the Science and Education Program will:

1. Prepare educational professionals recognized for the quality and significance of their teaching, research, scholarship, service, outreach, and leadership.
2. Provide widely recognized leadership in the improvement of teaching, learning, and the assessment of educational outcomes across the life span through research, scholarship, and technology.
3. Enhance the commitment of faculty, staff, and students to the centrality of diversity, social justice, and democratic citizenship.
4. Provide leadership in the development of collaborative, professional relationships with schools, communities, and workplace settings.
5. Sustain a caring, supportive climate.
6. Enhance the effective and efficient management.

### **Program Expected Outcomes:**

The graduate of the Science and Education Program will:

1. Apply central concepts, tools of inquiry, and structure to provide meaningful learning experiences to students.
2. Engage in thinking, analysis, and problem-solving that reflects scholarly intellectual standards, incorporates sound reasoning, and strives for equity and fairness.
3. Develop an assessment-driven, standards-based instruction. Use the evaluation process to improve the quality and effectiveness of the teaching-learning process.
4. Interpret current research and theory to improve their professional practice constantly.
5. Conduct research to improve practice in professional settings.
6. Recognize, understand, and value diversity of learning styles, intelligences, and talents; as well as diversity related to social, economic, and cultural experiences.
7. Value all students regardless of their race, color, religion, gender or sexual orientation, linguistic ability, ethnic origin or geographical area and to respond to this diversity of learners with the variety of instructional opportunities that promote the development of critical thinking, problem solving, and performance skills of each individual.
8. Engage in reflective practice for continuous professional growth and improvement.
9. Initiate and participate in communities of practice and other collaborations with professionals and community members to mobilize resources to best meet candidate needs and to enhancing professional growth.
10. Understand the context of schools, education, and learning; designs and delivers assessment-driven standards-based curriculum, instruction, training, or administrative practices.

### **CAREER OPPORTUNITIES**

The US National Academies, nonprofit institutions that provide expert advice on science and technology, warned years ago that the United States would continue to lose ground to foreign economic rivals unless the quality of its math and science education were improved.

A highly educated and skilled labor force is what drives innovation and production. The skills derived from a STEM education are the mission-critical elements of the jobs of tomorrow, for they are directly linked to economic productivity and competitive products.

The Master of Science in Education in Mathematics and Natural Sciences offers a solution to the shortage of math and science teachers in Puerto Rico as well as in mainland USA.

The graduate program can supply the demands of highly qualified teachers in math and sciences according to ESEA Flexibility Plan of the Department of Education of Puerto Rico.

The program is directed toward currently certified teachers with degrees in non-mathematics fields, to teachers with bachelor's degrees in mathematics and natural sciences who wish to become math and/or science facilitators.



In addition, directors and school superintendents who wish to advance their knowledge in mathematics and natural sciences can take advantage of this graduate program.

## PROGRAM REQUIREMENTS

### Admission Requirements

Candidates with bachelor's degrees in Education with majors in Math and/or Science from an accredited institution and a minimum general grade point average (GPA) of 2.50/4.00 can apply directly to the program. Candidates with a GPA lower than 2.50 can apply to the program and the Graduate Reconsideration Committee will determine if the admission will be granted.

Students with other bachelor's degrees nonrelated to education can apply for admission and may require completion of undergraduate prerequisite courses as determined by the Graduate Program Director/Coordinator.

### Graduation Requirements

To earn the master's degree, the student must earn 36 graduate credit-hours.

(18 credits in Education - 18 credits in the area of interest)

Credits - Hours	Components
18	Education
18	Secondary Math Teaching or Secondary Natural Science Teaching or Elementary Natural Sciences and Math Teaching (according to the student's area of interest)
36	Total Credits

The students must attain a minimum cumulative grade point average of 3.00/4.00 as graduation requirement.

## DEGREE OFFERED

The Science and Education Program offer graduate instruction leading to the degree of Master of Science in Education in Mathematics and Natural Sciences (M.S. E.d.) Students choose among three specializations: Secondary Math Teaching, Secondary Natural Sciences Teaching, and Elementary Natural Sciences and Math Teaching.

## EDUCATION CURRICULUM

Education Component (18 credits)			
Course	Title	Credits-Hours.	
EDUC 5000	Problem Based Education (PBE)	3	
EDUC 5010	Curriculum Design and Evaluation	3	
EDUC 5020	Research Methods	3	
EDUC 6020	Assessment and Improvement of Instruction	3	

EDUC 6030	Differentiating Instruction and Assessment	3
EDUC 6100	Action Research for Teachers	3

### Secondary Math Teaching Students choose 18 credits of the following courses:

Course	Title	Credits-Hours
MATH 5100	Math Modeling	3
MATH 5200	Advanced Calculus	3
MATH 5500	Advanced Math for Teachers	3
MATH 6020	Rational Numbers and Proportional Reasoning	3
MATH 6030	Measurement, Data, and Geometric Thinking	3
MATH 6040	Algebraic Reasoning, Functions, and Equations	3
MATH 6110	Discrete Mathematics II	3
MATH 6120	Probability and Statistics for Teachers	3
MATH 6130	Probability Models for Teachers	3
MATH 6150	Applied Modern Algebra	3
MATH 6160	Introductory Topology	3
MATH 6180	Modern Geometry for Teachers	3

### Secondary Natural Sciences Teaching Students choose 18 credits of the following courses:

Course	Title	Credits-Hours
SCIE 5010	Fundamental of Environmental Education	3
SCIE 5020	Software Applications and Technology	3
SCIE 6010	Investigating the Living World	3
SCIE 6020	Exploring the Physical World	3
SCIE 6030	Exploring the Earth and Beyond	3
SCIE 6040	Chemistry for teachers	3

### Elementary Natural Sciences and Math Teaching

Course	Title	Credits-Hours
MATH 6020	Rational Numbers and Proportional Reasoning	3
MATH 6030	Measurement, Data, and Geometric Thinking	3
MATH 6040	Algebraic Reasoning, Functions, and Equations	3
SCIE 5010	Fundamental of Environmental Education	3
SCIE 6010	Investigating the Living World	3

SCIE	6020	Exploring the Physical World	3
SCIE	6030	Exploring the Earth and Beyond	3

### Curriculum Sequence Secondary Math Teaching

#### First Year

##### First Quarter

Course	Title	Credits-Hours
EDUC 5000	Problem based education (PBE)	3
EDUC 5010	Curriculum Design and Evaluation	3
MATH 6180	Modern Geometry for Teachers	3

##### Second Quarter

Course	Title	Credits-Hours
EDUC 6010	Educational Research	3
MATH 5200	Advanced Calculus	3
MATH 6160	Applied Modern Algebra	3

##### Third Quarter

Course	Title	Credits-Hours
EDUC 6020	Assessment and Improvement of Instruction	3
MATH 6110	Discrete Mathematics II	3
MATH 6120	Probability and Statistics for Teachers	3

##### Summer #1

Course	Title	Credits-Hours
EDU 6030	Differentiating Instruction	3
EDU 6100	Action Research for Teachers	3
MATH 6150	Introductory Topology	3

### Curriculum Sequence Secondary Natural Sciences Teaching

##### First Quarter

Course	Title	Credits-Hours.
EDUC 5000	Problem based education (PBE)	3
EDUC 5010	Curriculum Design and Evaluation	3
SCIE 5010	Fundamental of Environmental Education	3

#### Second Quarter

Course	Title	Credits-Hours.
EDUC 6010	Educational Research	3
SCIE 5020	Software Applications and Technology	3
SCIE 6010	Investigating the Living World	3

#### Third Quarter

Course	Title	Credits-Hours
EDUC 6020	Assessment and Improvement of Instruction	3
SCIE 6020	Exploring the Physical World	3
SCIE 6030	Exploring the Earth and Beyond	3

#### Summer #1

Course	Title	Credits-Hours
EDUC 6030	Differentiating Instruction	3
EDU 6100	Action Research for Teachers	3
SCIE 6040	Chemistry for teachers	3

### Curriculum Sequence Elementary Natural Sciences and Math Teaching

#### First Year

##### First Quarter

Course	Title	Credits-Hours
EDUC 5000	Problem Based Education (PBE)	3
EDUC 5010	Curriculum Design and Evaluation	3
MATH 6040	Algebraic Reasoning, Functions, and Equations	3

##### Second Quarter

Course	Title	Credits-Hours
EDUC 6010	Educational Research	3
MATH 6020	Rational Numbers and Proportional Reasoning	3
SCIE 6010	Investigating the Living World	3

##### Third Quarter

Course	Title	Credits-Hours
EDUC 6020	Assessment and Improvement of Instruction	3
MATH 6030	Measurement, Data, and Geometric Thinking	3
SCIE 6020	Exploring the Physical World	3

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**Summer #1**

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Course	Title	Credits-Hours
EDUC 6030	Differentiating Instruction	3
EDUC 6100	Action Research for Teachers	3
SCIE 6030	Exploring the Earth and Beyond	3

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**LABORATORIES**

Physics, Chemistry, Microbiology, Mathematics Laboratory, and The Learning Resource Center: Laboratory facilities are available for chemistry, physics, mathematics, microbiology science courses. The facilities include equipment and materials necessary to develop skills by hands-on laboratory experiences.

**EDUCATION COMPONENT  
COURSE DESCRIPTIONS****EDUC 5000 – Problem Based Learning**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course consists of the activity of teaching, learning, and assessment in an environment of troubleshooting, such as systematic teaching method. Moreover, to involve the participants in the acquisition of knowledge and skills through the process of solution, structured around tasks of gradual complexity, real questions, and carefully designed tasks.

**EDUC 5010 - Curriculum Design and Evaluation**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

The study of curriculum design from historical precedent to current models of curriculum construction, implementation, and evaluation.

**EDUC 5020 - Research Methods**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

The study of educational research from a comprehensive perspective. Included are: techniques and concepts of social and behavioral research; writing in the American Psychological Association (APA) format; ethical standards governing educational research; experiences in the use of internal and external critique methods; readings in curriculum, assessment, philosophical and psychological research products; experiences accessing and using archival and web-based data sources; evaluation of descriptive, true experimental and quasi-experimental research designs; identification and use of appropriate parametric and nonparametric statistical analyses; computation and interpreting of effect size tests of practical significance; conducting primary and secondary source literature reviews; demonstration of research designing; and use of portfolio research.

**EDUC 5200 - Teaching and Supervising Pre-Service and In-Service Teachers**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

Study of the role of the practicing professional in the instruction and supervision of pre-service teachers in clinical settings. Variables studied include: the relational roles of the college supervisor, cooperating teacher and pre-service teacher; the developmental process and procedures appropriate for pre-service teachers at various stages of professional development; the roles of the cooperating teacher (model, teacher, demonstrator, coach, critic, evaluator, supporter, mentor). The phases of instruction (planning, implementation and evaluation), and the methods of instruction, including inquiry, direct, interactive and cooperative, individual and group, as they relate to clinical experiences, are utilized as one component of this course. Presentation and evaluation skills used by teachers in in-service situations and in professional conferences are addressed.

**EDUC 6020 - Assessment and Improvement of Instruction**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course examines curriculum, instruction, and assessment in the context of standards based education. It explores theories, methods, and procedures underlying the development and design of curriculum and instruction, the interrelationships among curriculum, instruction, and assessment and presents best practices for developing curriculum and instruction which will meet the needs of an inclusive school. Researched based practices designed to improve student learning for all students and to develop 21<sup>st</sup> Century Skills will be presented. The history of curriculum development and evaluation; the importance of aligning learning theory and learner variables; removal of barriers to student achievement; and how to meet diverse student needs are discussed. Grading, use of assessment data, planning, collaboration are addressed. Students will learn how data driven decision making can lead to improved student achievement. Students will also learn how to integrate technology to improve 21st Century Learning for all students.

**EDUC 6030 - Differentiating Instruction and Assessment**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course focuses on the theories, principles, and practices, which lead candidates to an understanding of ways to create strong and relevant curriculum as well as ways to deliver instruction in flexible ways intended to meet the needs of all learners. Candidates will explore the principles of Understanding by Design (UbD) and Differentiated Instruction (DI) and the application of these principles to the development of fully differentiated lessons.

**EDUC 6100 - Action Research for Teachers**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course introduces students to action research as a method of improving teaching and learning at the postsecondary level. The course will explore the relative strengths and potential challenges of different approaches to classroom research, as well as ethical issues. Participants in this course will engage in explorations of action research in theory and practice in relation to teaching in public schools. Participants will make connections between their theoretical understandings of research and their own emergence as practitioner researchers in educational settings who view themselves as producers of knowledge who can learn about their teaching and their students' learning by studying their own experiences. They will have an opportunity to identify a problem in their practice, make a plan, gather and analyze data as they carry it out, report results, and develop implications for their future teaching practice and action research.

### **MATHEMATICS AND SCIENCES COMPONENT COURSE DESCRIPTIONS**

#### **MATH 5100 - Math Modeling**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course focuses on essential knowledge for teachers about functions. It is organized around five big ideas, supported by multiple smaller, interconnected ideas essential understandings. Taking student beyond a simple introduction to functions, this course will broaden and deepen your mathematical understanding of one of the most challenging topics for students and teachers. This course will help teachers engage students, anticipate their perplexities, avoid pitfalls, and dispel misconceptions. Teachers will also learn to develop appropriate tasks, techniques, and tools for assessing students understanding of the topic. In addition, teachers will use data as a context to support students' learning of these mathematical ideas, this course provides opportunities to explore real-world problems and collect, represent, and interpret data.

#### **MATH 5200 - Advanced Calculus**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: MATH 1370.**

Rigorous development of some central ideas in analysis including limits, continuity and differentiability.

#### **MATH 5500 - Advanced Math for Teachers**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

A seminar course required as a culminating experience for mathematics majors who are seeking certification to teach at the elementary, middle or secondary levels. Students analyze problems from elementary, middle and high school mathematics from an advanced perspective and explicitly make connections between the concepts taught in elementary, middle and secondary and their more abstract analogues encountered in undergraduate mathematical courses.

#### **MATH 6020 - Rational Numbers and Proportional Reasoning**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

Understanding fraction concepts is a critical foundation for learning about proportional relationships and developing algebraic concepts. In this course, teachers learn how to extend students' knowledge of whole numbers and basic operations—addition, subtraction, multiplication, division—to fractions and decimals. Teachers learn instructional practices to help students understand, represent, develop, and engage in rational number operations with meaning, proficiency, and precision. Teachers also investigate ways to foster deep conceptual understandings of ratios, rates, and proportional relationships, thus building in students the critical skill of proportional reasoning. They consider how proportional reasoning builds a bridge to the study of other important mathematical topics, including geometry, measurement, and data, and the use of proportionality as a connecting thread throughout the elementary and middle math curriculum.

#### **MATH 6030 - Measurement, Data, and Geometric Thinking**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: NONE.**

Measurement and geometry are often challenging topics for elementary students, but they represent some of the most visible uses of mathematics in students' day-to-day lives. In this course, teachers learn strategies for connecting these topics to other mathematical concepts, including fractions, decimals, and the number system. In geometry, teachers move beyond strategies for developing a familiarity with basic shapes and their properties to explore higher order tasks that involve geometric thinking, measurement concepts, and proportional relationships.

#### **MATH 6040 - Algebraic Reasoning, Functions and Equations**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course builds on a strong understanding of arithmetic and its properties in the real number system. It provides opportunities for middle mathematics teachers to move beyond traditional teaching of algebra to the idea of algebraic thinking as an important component of all mathematics and everyday life. The use of tools, such as manipulative materials, calculators, and other emerging technological resources, provides teachers with concrete examples of how to incorporate the Common Core State Standards for Mathematics into their teaching. The goal of this course is to deepen teachers' understanding of the role algebra plays in problem solving and decision making and to apply this knowledge to support their students in developing similar knowledge and understandings. Teachers explore a range of topics, including reasoning and proof; various types of functions; multiple uses of variables; pattern recognition; mathematical modeling; estimation; and the development of linear functions from rates, ratios, and proportional reasoning.

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**MATH 6110 - Discrete Mathematics II**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: MATH 4035.**

This course continues the discussion begun in Discrete Mathematics I. Topics in this second course include recurrence relations, graphs, paths and circuits, trees and optimization and matching theory.

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**MATH 6120 - Probability and Statistics for Teachers**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: MATH 1340.**

Probability spaces; random variables and their distributions; repeated trials; probability limit theorem. It also introduces students to the concept of statistics and problem-solving.

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**MATH 6150 - Introductory Topology**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

Introduction to the topological concepts that underlie analysis. Included are metric spaces, topological spaces, separation, compactness, convergence, completeness and connectedness.

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**MATH 6160 - Applied Modern Algebra**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: MATH 6110.**

The course is an introduction to a variety of algebraic structures oriented towards applications. It includes the study of sets and functions, semi-groups and groups, relations and graphs, rings and Boolean algebras, integer domains and bodies.

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**MATH 6180 - Modern Geometry for Teachers**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: MATH 6110, MATH 6160.**

This course consists of the study of transformations and geometric, congruence and similarity, projective geometry, and inversive geometry.

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**SCIE 5010 - Fundamental of the Environmental Education**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course is effort to incorporate basic concept of cohabitation and consideration to environmental resources and their relationships. Take a UNESCO definition of the Environmental Education (Tbilisi Declaration, 1978) as reference; "Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action." It discusses a new methodological approach for those who work with eco-education and addresses mental, emotional, and spiritual dimensions in a holistic manner.

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**SCIE 6010 - Investigating the Living World**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

In this course will have multiple opportunities to develop content knowledge about the characteristics of living things, plants as producers and animals as consumers, cells and organisms, heredity and adaptation, ecosystems, and humans and the environment. Learners will experience a rich multimedia, inquiry-based learning environment as their students ideally would in their own classrooms. The course provides effective teaching methodologies, strategies and tools that can be used when teaching life science concepts.

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**SCIE 5020 - Software Applications and Technology**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

The course is designed to provide skills and literacy in Software Applications and Technology. The outcomes expected upon completion of these courses are: 1. Improvement of teaching skills in the area of software application and technology. 2. The Integration of suitable methodology in classroom, enabling teachers to effectively use basic computational tools and information technology in the learning process of sciences courses. 3. Promote the understanding of the role of Information Technology in the development of science. 4. Value the role of science and technology in the construction of a more just and more humane world.

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**SCIE 6020 - Exploring the Physical World**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course explores concepts of physics through the use of discussions, exercise, projects, demonstrations, simulations, and short experiments. The outcomes expected upon completion of these courses are: develop critical and analytical thinking abilities; Understanding of fundamental physics concepts; enable quantities and qualitative analyses of these physics concepts; develop problem-solving skills; develop and appreciation of physics in everyday life; make observations and measurements, record results, manipulate apparatus and draw conclusions; demonstrate some physical principles (mechanics), learn and appreciate the techniques of careful measurements; collect experimental data, and use his/her reasoning powers to draw logical conclusions about the meaning of these data; understand the limitations and strengths of experiments; develop analysis and correlation skills in critical thinking by establishing appropriate and effective connections between course content and subjects; manage information in a graphical environment and develop practical experience and getting involved with laboratory projects and real data from experiments to complement the theoretical education.

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**SCIE 6030 - Earth Sciences and Beyond**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

For the student to have a better understanding of the natural environment the course will tackle and examine a number of topics: the structure and composition of the earth's surface, subsurface, and deep interior, processes that alter the observed structure of the earth: rock transformation, mountain building, plate tectonics, earthquakes, volcanism, and atmospheric processes, the structure and composition of the atmosphere, the

elements of weather and climate, weather patterns and storms, the earth's relationship to the sun, moon, and other bodies of the solar system, the earth's place in the cosmos.

#### **SCIE 6040 – Chemistry for Teachers**

**Three-credit-hours. Two two-hour lecture periods per week. Prerequisite: None.**

This course explores the fundamental concepts of chemistry through the use of discussions, exercise, projects, demonstrations, simulations, and short experiments. This course emphasizes in Principles of chemistry, principles of stoichiometry, solutions, thermochemistry, atomic and molecular structure, and gases. Central to the course is developing an ability to think critically and analytically, so the class time will include in-class demonstrations, and Interactive concepts test, short experimental practice, data and graphical analysis, website simulations, examples of computational problems, and modeling system. This will be a very interactive environment, so the students are strongly encouraged to ask questions and initiate discussions in class at all times.

#### **PROGRAM FACULTY**

**Capella Casellas, Manuel** - Associate Professor; **Ed.D.**, Management and Supervision, Inter American University, 2006; **M.A.** INEVA, University of Puerto Rico, 1996; B.S. General Program, University of Puerto Rico, 1987.

**Colón Rodríguez, Roberto** - Professor, Education **Ed.D.**, University of Puerto Rico, Río Piedras Campus, 2007; Math. **M.A.**, University of Puerto Rico, Río Piedras, 1989; Math. B. A., University of Puerto Rico, Río Piedras Campus, 1973.

**Dessús Colón, Virginia** - Professor; Socio-Humanistic Studies Department Head; Spanish, **Ph.D.** University of Puerto Rico; **M.A.**, University of Puerto Rico, Río Piedras Campus, 1987; B.A., University of Puerto Rico, Cayey Campus, 1983.

**Diez de Andino Cumpiano, Carolina** - Associate Professor, English, **D.Ed.**, Pennsylvania State University, Pennsylvania, 1994; **M.A.**, Inter American University of Puerto Rico, Metro Campus, 1989; M.A., University of Detroit, Michigan, 1971; B.A., Marygrove College, Detroit, Michigan, 1967.

**Dumoís González, Martha** - Associate Professor; Graduate Program Director; **PhD** in Engineering Projects in progress; Engineering Management **M.E.M.**, Polytechnic University of Puerto Rico, Hato Rey, 1995; Electrical Engineering B.S.E.E., Polytechnic University, 1992.

**Forcino Rubero, Ernesto** - Lecturer I; **Ed. D.**, in progress, UPR, Río Piedras Campus, Education **MA**, Inter American University, Metropolitan Campus, 1996; Mathematics BS, Inter American University, Metropolitan Campus, 1988.

**Forina Alfonso, Dominique** - Associate Professor, Languages; History **Ph.D.**, Centro de Estudios Avanzados de Puerto Rico y el Caribe, 2009; Languages and Foreign Literatures **Ph.D.**, Università degli Studi, Fisciano, Salerno, Italy, 2001; BA, Liceo Linguistico Europeo, "Cristo Re", Salerno, Italy, 1989.

**García Acevedo, Zulma** - Associate Professor; **Ed.D.** in progress, Inter American University, Applied Mathematics **M.S.**, University of Puerto Rico, Río Piedras Campus, 1991; Math. B.S., University of P.R., Cayey Campus, 1986.

**Lara Cotto, Carmen** - Professor; **Ed. D.**, UPR, Río Piedras Campus, 2007. **MA**, Inter American University, Metropolitan Campus, 1983; BA Education and Math, University of Puerto Rico, 1978.

**López Valdés, Rafael** - Professor; Socio-Humanistic Studies, **Ph.D.**, USSR Academy of Sciences, Ethnography Institute, Moscow, 1968; **M.A.**, State University M.V. Lomonosov, Moscow, 1966; B.A., State University M.V. Lomonosov, Moscow, 1966.

**Maldonado Soto, Carmen** - Instructor; **Ed. D.** UPR, Río Piedras, in progress; **MS** Sciences, University of Puerto Rico, Medical Sciences Campus, 1998; Mechanical Engineering BSME, University of Puerto Rico, Mayagüez Campus, 1987.

**Martínez Roche, Milagros** - Assistant Professor; Education Department Coordinator, **Ph.D.** University of Puerto Rico, Río Piedras Campus, 2010, Comparative Literature, **M.A.** 1994, University of Puerto Rico, Río Piedras Campus, Comparative Literature, BA, University of Puerto Rico, Río Piedras Campus, 1988.

**Motta Arenas, María A.** - Associate Professor, Psychology; **Ed.D.** in progress, Inter American University, **M.A.**, Centro Caribeño de Estudios Post-Graduados, San Juan, 1989; B.A., University of Puerto Rico, Río Piedras Campus, 1987.

**Rivera Rivas, María Del Carmen** - Lecturer I; **Ph.D.** in Engineering Projects: Environment, Security, Quality and Communications, Universidad Politécnica de Catalunya, Spain, 2011; Master in Management and Environmental Audit: Environmental Education, Solid Waste Treatment and Recovery of Contaminated Soil, Universidad de Las Palmas de Gran Canaria, Spain, 2005; BS, Biological Science, Inter American University of Puerto Rico, 1986.

**Rosado González, Eduardo** - Associate Professor; Chemistry **M.S.**, University of Puerto Rico, Río Piedras Campus, 1981; Chemistry B.S., University of Puerto Rico, Mayagüez Campus, 1973.

**Ulloa Dávila, Ernesto** - Associate Professor; **Ph.D.** in progress, University of Puerto Rico, Río Piedras Campus. Physics, **M.S.**, University of Puerto Rico, Mayagüez Campus, 1993; Physics B.S., University of Puerto Rico, Mayagüez Campus, 1990.

**Vélez Díaz, Ángel** - Associate Professor; Nuclear Engineering **Ph.D.**, University of Missouri, Columbia, 2010; Engineering Management **M.E.M.**, Polytechnic University of Puerto Rico, Hato Rey, 1996; Electrical Engineering B.S.E.E., Polytechnic University of Puerto Rico, Hato Rey, 1992.

**Vicéns Salas, Catalina** - Professor; Dean, School of Arts, Sciences and Education, Psychology, **Ph.D.**, University of Puerto Rico, Río Piedras Campus, 1996; **M.A.**, University of Puerto Rico, Río Piedras Campus, 1990; BA, University of Puerto Rico, Río Piedras Campus, 1988.

## GRADUATE CERTIFICATES

### Graduate Certificate of 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 one's 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's 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's 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

### Graduate Certificate in Digital Forensics (GCDF)

As society at large becomes more dependent on technology, the vulnerability to data-driven theft and corruption is greater than ever. We operate in a world where cyber criminals constantly invent sophisticated techniques to threaten and defeat the security of organizations; making it important to track threats as they change and evolve. Organizations need to be informed and prepared to minimize current risks and increase their capacity to recover from incidents that threaten and affect information assets. Knowledge in Information Assurance (IA) fields such as cyber security, IT auditing, IT disaster recovery, and digital/computer forensics are becoming a critical need for IT management and IA professionals.

The goal of computer forensics is to examine digital media in a forensically sound manner with the aim of identifying, preserving, recovering, analyzing and presenting facts and opinions about the information.

Because technology changes rapidly, computer specialists must continue to acquire the latest skills. IA professionals can enhance their skills and employment opportunities by earning certifications, which are offered through academic institutions, product vendors, computer associations, and other training institutions. Many organizations offer intermediate and advanced certification programs that pertain to the most recent technological advancements. The GCDF prepares IT professionals to master critical capabilities such as network infrastructure design, advanced digital investigative techniques, and state-of-the-art forensics strategies.

Through formal education and certified training, organizations and IA professionals have the opportunity to learn about the many options for improving the cyber protection of intellectual property, and the recovery of customer data, services, and critical infrastructures; as well as the development of new computer forensics tools and practices. The aim is to increase

the number of people with a formal education in fields that enhance cyber security skills, to meet the nation's cyber security needs.

## PROGRAM OBJECTIVES & GOALS

The primary goal of the Graduate Certificate in Digital Forensics is to help meet the current and future needs of local and national industry and government by providing a talent pool of professionals with expertise in the areas of computer forensics and information assurance.

By providing this graduate level certificate, students and faculty will have the skills and know-how to immerse in advanced subject matters associated with computer forensics, thereby enabling innovation, as opposed to simply teaching fundamentals. On the long run, the goal is to significantly impact IA education by raising awareness in companies and individuals in the area of computer forensics and by giving them the skills they need to function effectively in their jobs.

The main objectives of the digital forensics certificate program can be summarized as follows:

1. Provide a thorough and rigorous introduction to computer forensics, and computer and network security.
2. Provide a quality educational experience that balances classroom theory with practical hands-on lab experience.
3. Enhance opportunities for professional growth and for career advancement for underrepresented groups, especially women and Hispanics.
4. Create a resource for industry and a forum for the free exchange of ideas.
5. Create an infrastructure that supports faculty and student research.
6. Attract more faculty members that specialize in this field of IA.
7. Create competent IA professionals that have a strong knowledge of the law and ethics that are critical for Digital Forensics Investigators.

## GRADUATE PROFILE

Individuals who complete the Certificate will have a thorough understanding of computer/digital forensics principles which they will be able to apply to a wide variety of situations in management, technical areas, or research and development.

If the student specializes in providing evidence of computer crimes to law-enforcement agencies, then knowing the legalities of search and seizure, and the approved techniques for collecting and preserving evidence are mandatory. Students who complete the certificate are expected to have the following skills:

- Experience in computer/digital forensics
- Proficient with forensic techniques and the most commonly used forensic toolsets, such as dtSearch, EnCase, and FTK Suite
- Familiarity with Windows, Macintosh, and Linux Operating Systems
- Familiarity with computer system hardware and software installation and troubleshooting
- Experience with programming languages (e.g. Python)

- Thorough understanding of chain of custody procedures, forensic lab best practices, and evidence handling
- Preserve, harvest, and process electronic data according to the firm's policies and practices
- Perform digital forensic analysis
- Provide creative and innovative solutions for client matters
- High quality oral and writing skills that can present and document complex technical matters clearly and concisely
- Form and articulate expert opinions based on analysis
- Draft expert reports, affidavits, and other expert testimony
- Provide expert testimony in depositions, trials, and other proceedings
- Consult with (and take direction from) supervisors, engagement managers, and clients regarding case investigation and status

### PROGRAM REQUIREMENTS

#### Admission

The admission requirement for the GCDF is a bachelor's degree in a field related to information technologies, computer science, computer and electrical engineering, and IA professionals. Students who have already taken some of the courses that are in the certificate program may complete the certificate by completing the remaining courses.

Prerequisites necessary to apply for enrollment in the GCDF:

- 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 individual applies for admission to the GCDF as a non-degree seeking student to work towards the Certificate. The student that intends to enter the graduate program in Computer Science with a specialization in Information Technology Management and Information Assurance (ITMIA), after completing the GCDF, has to apply for admission to this program with the established requirements.

- Courses approved in the GCDF can be validated towards the MS CS (thesis option) ITMIA specialization. Up to a maximum of 12 credits can be transferred to the Graduate program that has a total of 15 core credits, 12 elective credits, and 6 credits of thesis. This is a total of 33 credits.
- Courses approved in the GCDF can be validated towards the MCS (non-thesis option) ITMIA specialization. Up to a maximum of 18 credits can be transferred to the Graduate program that has a total of 15 core credits, 21 elective credits, and 3 credits for Final Project. This is a total of 39 credits.
- Graduate students that are currently enrolled in any of the other master's degrees or MS CS specializations and have approved the prerequisites can obtain the GCDF 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 (CIS) can enroll in the GCDF program if they have completed the prerequisites of admission for the certification.

### Graduation Requirements for the GCDF

Students must take all 6 of the courses in the Certificate for a total of 18 credits before they can receive the Certificate. The final grade point average must be 2.8 or better to qualify for the Certificate.

### CAREER OPPORTUNITIES

As the need to assure and recover intellectual assets increases, computer and digital forensics has become an exploding field with a staggering number of opportunities for both consultants and employees. The demand is growing in:

- Local, state and federal law enforcement agencies (including military and government intelligence agencies);
- Private security and consulting companies and firms engaged in digital investigations, data recovery, and electronic discovery, forensics software development, and information security;
- Businesses with significant policy auditing requirements for information assurance.

Knowledge and skills are required in a broad range of computer storage devices, operating systems, programming languages and software applications including:

- File formats
- Software drivers
- Networking, routing, communication protocols
- Cryptology
- Reverse software engineering
- Investigative techniques
- Computer forensics tools, such as password crackers, email converters, or the EnCase or Forensic Toolkit (FTK) software applications

The rapid growth in Information Technology career opportunities directly represents an increase in computer related employment as reported by the United States Bureau of Labor Statistics (BLS).

As stated by the BLS: "The demand for increasing efficiency in areas such as networking technology, computing speeds, software performance, and embedded systems will lead to employment growth.

In addition, the **growing emphasis on information security** will lead to new jobs."

### CURRICULAR STRUCTURE AND SEQUENCE

#### Core Courses

The student's program must include 18 credit-hours of core courses specified below:

Course	Title	Credits
CECS 6046	Electronic Discovery & Digital Evidence	3
CECS 6130	Data Communication Networks	3
CECS 7230	Network Security	3
CECS 7235	Computer Forensics	3
CECS 7237	Advanced Computer Forensics	3
CECS 7570	Computer Security	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 talented PUPR undergraduate students the opportunity to complete the combined bachelor's-master's degree in a reduced time period.

Students enrolled in 5-year bachelor's degrees may request admission to this program after completing 105 undergraduate credit-hours (excluding developmental courses.)

Those enrolled in 4-year bachelor's degrees may request admission to this program after completing 72 undergraduate credit-hours (excluding developmental courses.)

### **Admission**

Conditions for admission to the combined program will be the following:

1. GPA of 3.00 or higher. When the student has a GPA of 2.50 to 2.99 his/her application may be evaluated and conditionally admitted to the combined program.
2. Comply with the minimum undergraduate number of credit-hours for the combined Bachelor's – Master's Program.
3. Be recommended by the corresponding department head and graduate program director/coordinator.

### **Procedure**

1. The student must complete and submit the application form.
2. The department chairperson and graduate program director/coordinator recommend the candidate for admission.
3. The application is evaluated to verify that the student indeed qualifies for the program.
4. The dean verifies the recommendations and gives its approval/denial of the student's application.
5. The final decision is notified to the student.

### **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 in writing to a committee composed of the undergraduate department head,

graduate program director/coordinator, dean of the Graduate School and the vice-president for Academic Affairs. The decision of the committee is final.

## **XVII. DOCTORAL PROGRAM DOCTOR OF PHILOSOPHY IN ENGINEERING AND APPLIED SCIENCES**

The Engineering and Applied Sciences Ph.D. degree is an interdisciplinary program; two main areas of study are linked to inspire a research interest. Traditionally, areas of research were focused in the same field of study. It was typical that a student will continue the accomplished undergraduate work in the same field of study for the subsequent master and doctoral degrees.

New knowledge created by specific fields of study evidences that technologies, topics and research are interrelated. It is known, that developments in many fields often come from their interaction with other areas. In addition, globalization, technology, and competition require that professionals become well-rounded and educated in many topics of study.

Engineering and Applied Sciences integrates a strong scientific background with creative as well as realistic applications. Combining a scientific field with an applied subject, results in the use of technical knowledge to solve real-world problems within a satisfactory time frame, with the available resources. Engineering and Applied Sciences professionals combine: (1) strong background in the fields of science and mathematics, (2) capacity to improve conditions of a system or an organization, and (3) ability to optimize the outcomes.

### **PROGRAM PHILOSOPHY AND OBJECTIVES**

Through the Engineering and Applied Sciences Ph.D. degree it is expected that the Institution will: (1) provide students with the capability to continue graduate education, (2) foster and promote an applied research culture, (3) develop critical thinking and a scientific approach in the analysis and solutions of professional and social problems, and, (4) promote the dissemination of knowledge through the teaching-learning process and publications.

Specifically, the goals for this program are to:

- Innovate the local academic offerings at the doctoral level,
- Support the need for flexibility for graduate studies to students who have well-defined education and research aspirations,
- Interconnect established educational majors offered by the university in a degree,
- Produce professionals who can advance scientific and applied theory and practice, and,
- Advance research contributions and applications at the local and regional levels.

The specific objectives for this program are to:

- Demonstrate a comprehensive knowledge of concepts and empirical findings in a chosen research and study area,

- Be able to design, accomplish, and communicate (in both written and oral forms) an original research that makes a contribution to the studied fields, and,
- Develop within each candidate the expertise and skills necessary to be an effective professional in the selected field of study.

### **CAREER OPPORTUNITIES**

Students completing the Engineering and Applied Sciences Ph.D. degree will contribute with additional knowledge in their research areas, achieve the discovery of new perspectives and develop new skills. Although becoming part of the academia is considered the most obvious path for any Ph.D. aspirant, it is expected that the doctoral candidates will bring and build innovation to the industry sector.

Research, knowledge, and academic work performed by a doctoral student often drive important changes in the service, manufacturing, and health industries. Professionals having a Ph.D. degree will aim to contribute to the socio-economic development of Puerto Rico and comparable cultural and geographical areas outside the island.

### **PROGRAM REQUIREMENTS**

#### **Admission Requirements**

Candidates with an undergraduate preparation in Engineering, Sciences and Management or related areas are encouraged to apply for admission. All applicants for the Engineering and Applied Sciences Ph.D. program must have completed a Bachelor's degree from an accredited university with a minimum Grade Point Average (GPA) of 3.00/4.00.

Applicants for Ph.D. program who have not yet obtained a master's degree can be admitted directly into the Ph.D. program.

All applications must include the following information to be considered for admission to the program:

1. Fill the Application for Admission form.
2. Pay an admission fee (non-refundable).
3. Submit directly from all universities or colleges attended, an official academic transcript of all undergraduate and graduate degrees obtained. This document must include the graduation general GPA (Not required for PUPR Alumni).
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. Submit the official score report for the Graduate Record Exam (GRE). In addition to the GRE, all International Applicants must submit an official score report for the Test of English as a Foreign Language (TOEFL).
6. Submit a statement of purpose and research objectives. In this document, the applicant must describe his/her research interests. Other aspects related to the applicant's academic background and professional development may support the admissions committee in evaluating the candidate's motivation and aptitude for continuing doctoral studies. However, those aspects are not critical in

the Committee's decision if are not totally aligned to the research interests.

7. An updated copy of the applicant's Curriculum Vitae or résumé.
8. Submit the Demographic Information form (Optional document that PUPR uses for statistical purposes).

Applicants who have successfully completed all the admission requirements may be invited to hold and interview with a faculty member of the principal area of research interest of the applicant.

#### **Graduation Requirements**

In addition to the general graduation requirements, students must meet the following doctoral degree requirements:

1. Two main areas of study; principal and supplemental.
2. Approved 60 credit-hours of graduate-level course work (this total includes transfer credit-hours). The 60 credit-hours are divided as follow:
  - a. 12 credit-hours correspond to the Principal Area of Study (Engineering). From this total, student's work must reflect 3 credit-hours corresponding to the Applied Mathematics Course of his/her area of study.
  - b. 9 credit-hours correspond to the Supplementary Area of Study: Other Engineering discipline or related area. Related areas are defined as: Computer Science, Geospatial Science and Technology, Management, and Manufacturing Competitiveness.
  - c. 12 credit-hours correspond to the advanced graduate-level course work delineated by the student's Chairperson.
  - d. 3 credit-hours correspond to the doctoral-level course: EAS 8000: Qualitative and Quantitative Research Methods.
  - e. Registration in at least 6 Doctoral Seminar credit-hours.
  - f. Registration in at least 18 Doctoral Dissertations credit-hours.
3. Program of study completed during the first year of the program.
4. Comprehensive examination administered by the Advisory Committee.
5. Ph.D. Candidacy Exam (Doctoral Proposal Presentation) administered by the Advisory Committee.
6. Doctoral Dissertation Defense administered by the Advisory Committee.

### **DEGREE OFFERED**

The degree to be offered will be Engineering and Applied Sciences Doctor of Philosophy (Ph.D.)

### **CURRICULAR STRUCTURE AND SEQUENCE**

For the interdisciplinary Engineering and Applied Sciences Ph.D. degree, the student will complete a minimum of 60 credit-hours of approved course work beyond the bachelor's degree. The curricular structure can be seen as six major blocks. These are: Principal Area of Study, Supplementary Area of Study, Advanced

Graduate Level Courses, Common Courses, Comprehensive Exam and Doctoral Dissertation.

The Principal Area of Study must be in the field of Engineering. The Supplementary Area of Study is defined as another Engineering discipline or a related area such as: Computer Science, Geospatial Science and Technology, Management, and Manufacturing Competitiveness.

Additional advanced graduate level course work delineated by the Chairperson will strengthen the knowledge of the student for the dissertation phase of the doctoral program.

All doctoral students, independently of their research interests, must successfully complete the doctoral course in Qualitative and Quantitative Research Methods; a comprehensive course focused on research qualitative and quantitative methodologies, research proposal writing, and research protocols. Also doctoral students, independently of their research interests, must successfully complete at least 6 Doctoral Seminar credit-hours.

The comprehensive examination is an intensive examination that measure the student's knowledge, ability, skills and expertise in his/her field of knowledge.

A dissertation is required for the Engineering and Applied Sciences Ph.D. degree. All doctoral students, independently of their research interests, are required to complete at least 18 Doctoral Dissertation credit-hours.

### **Principal Area of Study**

The interdisciplinary Engineering and Applied Sciences Ph.D. degree requires a Principal Area of Study in the field of Engineering. A total of 12 credit-hours are included in the Principal Area of Study. As their Principal Area of Study students must choose one of the following disciplines: Civil, Manufacturing, Electrical, Computer or Mechanical Engineering. The Principal Area of Study is composed of four core courses; courses identified as the foundation for pursuing research in the selected area. The student could substitute at most 3 credit-hours (one core course) by another Principal Area of Study graduate course if recommended and approved by his/her advisor.

### **Supplementary Area of Study**

A total of 9 credit-hours are required in the Supplementary Area of Study. The Principal Area of Study must be in the field of Engineering. The Supplementary Area of Study is defined as another Engineering discipline or a related area such as: Computer Science, Geospatial Science and Technology, Management, and Manufacturing Competitiveness. These credit-hours could be distributed between two Supplementary Areas of Study as recommended and approved by the student's advisor.

### **Advanced Graduate Courses**

To further prepare the doctoral student in the foundations needed for his/her research area, an advanced graduate courses component is required as part of the curriculum of the Engineering and Applied Sciences Ph.D. degree. A total of 12 credit-hours are included in the Advanced Graduate Courses

component. Students must choose courses in conjunction with his/her dissertation supervisor to properly reach expectations for the academic knowledge needed to pursue the proposed research.

### **Common Doctoral Courses**

All students pursuing the Engineering and Applied Sciences Ph.D. degree must registered the following doctoral courses:

- EAS 8901 – Doctoral Seminar (1 credit-hour)

This course consists of a series of meetings focusing on issues related to the dissertation, development of a program of research, and the role of the scientist. The topics are selected by the faculty. Students registered in the course may be at various points of their doctoral program. Topics and experiences may include proposal development, grant applications, and dissemination of research findings.

- EAS 8910 - Qualitative and Quantitative Research Methods (3 credit-hours)

The Qualitative and Quantitative Research Methods course will prepare the student in different subjective and objective methodologies for applied research. This course will guide the student in adequately collecting, analyzing, and interpreting data. In addition, the course will discuss topics regarding responsible conduct of research and ethics.

- EAS 9000 - Doctoral Dissertation (6 credit-hours; register 6 credit hours per regular term)

All students pursuing the Engineering and Applied Sciences Ph.D. degree must complete a total of 18 credit-hours of Dissertation. The Doctoral dissertation has five main processes: designing the research proposal, presenting the proposal to the doctoral committee, executing the research, writing the document and successfully defending the design in a meeting open to the university constituents. It is expected that the students complete these five processes while taking these credit-hours.

The Doctoral Dissertation Extension course (EAS 9001) is available for those students that require more time to complete the proposed research. Students are required to register a total of 18 credit-hours. However, they must register only 6 credit-hours per regular trimester after approving the Comprehensive Examination.

### **Comprehensive Examination**

The Comprehensive Examination (EAS 8900) will not count as credit-hours but is a requirement of the doctoral program. The Comprehensive Examination has both an oral and a written component. Once the student successfully completes the written portion of the examination, he/she will continue to the oral segment. All students must pass each section (written and oral) with a minimum percentage of approval of 80%.

The Comprehensive Examination will be administered by the Doctoral Dissertation Advisory Committee. The Committee will inform the student of the specific areas for which the student should study for the written and oral sections of the

Comprehensive Examination. Topics will include areas related to the student's research interests, but may include core courses components from his/her Principal Area and Supplementary areas of study as well.

### CURRICULAR STRUCTURE AND SEQUENCE

Year	Trimester	Course	Credit-Hour
1	Fall	Principal Area of Study	6
		Doctoral Seminar	1
	Winter	Principal Area of Study	3
		Applied Mathematics course (relative to the Principal Area of Study)	3
	Spring	Doctoral Seminar	1
		Supplementary Area of Study	3
		Supplementary Area of Study	3
		Doctoral Seminar	1

Year	Trimester	Course	Credit-Hour
2	Fall	Supplementary area of Study	3
		Qualitative and Quantitative Research Methods	3
		Doctoral Seminar	1
	Winter	Advanced Graduate courses	6
		Doctoral Seminar	1
	Spring	Advanced Graduate courses	6
		Doctoral Seminar	1
3	Fall	Comprehensive Exam	0
	Winter	Doctoral Dissertation	6
	Spring	Doctoral Dissertation	6
4	Fall	Doctoral Dissertation	6
	Winter	Doctoral Dissertation Extension (if necessary)	0
	Spring	Doctoral Dissertation Extension (if necessary)	0

### Principal Area of Study

Discipline	Course Code and Title
Civil Engineering-Structures	CE 6320-Advanced Strength Materials
	CE 6330-Advanced Topics in Structural Engineering
	CE 6350-Dynamics of Structures
	CE 6370-Finite Element Methods in Engineering
	MMP 6000-Advanced Statistics and Quality Improvement
Civil Engineering-Geotechnical	CE 6100-Soil Shear Strength
	CE 6335-Advanced Foundations
	CE 6355 - Advanced Earthquake Engineering

	CE 6370-Finite Element Methods in Engineering
	MMP 6000 – Advanced Statistics and Quality Improvement
Civil Engineering-Water Resources & Water Treatment	CE 6250 – Advanced Hydrologic and Hydraulic Models
	CE 6410 – Water and Wastewater Treatment Applications
	CE 6460 – Water Quality Control and Management
	CE 6210 – Probability and Statistics in Water Resources
	MMP 6000 – Advanced Statistics and Quality Improvement
Civil Engineering-Construction	CE 6520 – Construction Contracting and Procurement
	CE 6530 – Schedule Impact Analysis
	CE 6532 – Construction Cost Control
	CE 6512 – Value Engineering
	MMP 6000 – Advanced Statistics and Quality Improvement
Manufacturing Engineering	MMP 6000 – Advanced Statistics and Quality Improvement
	MMP 6002 - Operations Planning And Control
	MMP 6006 - Lean Manufacturing
	MMP 6130 - Six Sigma
Electrical Engineering	EE 6010 - Mathematical Methods for Signal Processing
	EE 6020 – Stochastic Processes
	EE 6030 – Linear Systems
	EE 6760 – Digital Communications Systems
Computer Engineering	CECS 6150 – Object Oriented Design
	CECS 6120 – Computer Architecture
	CECS 6130 – Data Communication Networks
	CECS 6510 – Software Engineering I
Mechanical Engineering-Thermal And Fluid Mechanics	ME 6014 – Advanced Mathematics
	ME 6100 – Advanced Thermodynamics
	ME 6120 – Advanced Fluid Mechanics
	ME 6360 – Optimization in Engineering Design
Mechanical Engineering – Design	ME 6014 – Advanced Mathematics
	ME 6200 – Advanced Solid Mechanics
	ME 6330 – Finite Element Analysis
	ME 6360 – Optimization in Engineering Design
Mechanical Engineering – Aerospace	ME 6014 – Advanced Mathematics
	ME 6140 – High Speed Aerodynamics
	ME 6300 – Advanced Aerospace Structures
	ME 6350 – Mechanical and Aerospace Control Systems

## Supplementary Area of Study

Discipline	Course Code and Title
Computer Science	CECS 7570 – Computer Security
	CECS 7230 – Network Security
	CECS 7235 – Computer Forensics
	CECS 7530 – Data Mining and Data Warehousing
Geospatial Science And Technology	GEOM 6630 - Geospatial Modeling & Analysis
	GEOM 6710 - Image Acquisition, Analysis and Processing
	GEOM 6634 - Cartography, Map Design and Geovisualization
	GEOM 6646 – Environmental Assessment and Geospatial Technology
	GEOM 6640 - Geospatial Urban and Regional Applications
Business Administration	GEOM 6648 – Business Geography
	MGM 6620 – Managerial Finances
	MBA 5600 – Managerial Economics
	MBA 5700 – Managerial Marketing
Engineering Management	MBA 6830 – Operations Management
	MMP 6000- Advanced Statistics and Quality Improvement
	MGM 6690 - Decision Making Techniques
	MEM 6110 - Engineering Management I
Environmental Management	MEM 6120 - Engineering Management II
	MMP 6000 - Advanced Statistics and Quality Improvement
	EPM 6810 - Environmental Regulations
	EPM 6850 - Management for Sustainable Future
Manufacturing Competitiveness	EPM 6800 – Solid Waste Management
	MMP 6000 - Advanced Statistics and Quality Improvement
	MMP 6002 - Operations Planning And Control
	MMP 6006 - Lean Manufacturing
	MMP 6130 - Six Sigma

## Advanced Graduate Courses

Code	Title
EAS 8130	Theory of Elasticity or Mechanics Solids
EAS 8131	Nonlinear Finite Element Methods
EAS 8140	Sustainable Engineering
EAS 8200	Manufacturing Systems Analysis
EAS 8210	Statistical Modeling for Resources Optimization
EAS 8310	Energy Management
EAS 8320	Modeling and Simulation
EAS 8400	Advanced Optimization and Modeling
EAS 8401	Advanced Vibrations
EAS 8902	Doctoral Independent Study

## Common Doctoral Courses

Code	Title
EAS 8900	Comprehensive Examination
EAS 8901	Doctoral Seminar
EAS 8910	Qualitative & Quantitative Research Methods

EAS 9000

Doctoral Dissertation

EAS 9001

Doctoral Dissertation Extension

## LABORATORIES

Polytechnic University of Puerto Rico has state-of-the-art laboratories to support students in their academic and research activities. Engineering Laboratories are classified by discipline. A general description of each laboratory follows.

### Civil and Environmental Engineering Laboratories

**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 equipment 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 are able to 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 on 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.

## **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 Polytechnic University of Puerto Rico 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.

**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.

## **Industrial Engineering Laboratories**

**Human Factors Laboratory** - This laboratory was designed to provide students 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 and push/pull gauges.

**Methods Engineering and Work Measurement Laboratory** - This laboratory was designed to provide students the opportunity to carry out practical experiments concerning motion and time studies techniques (Stopwatch, Work Sampling and Predetermined Time), workstation design, method improvement, performance rating, allowance factor and learning curve. The laboratory includes Time Study equipment such as: Stopwatch, Random Reminder, MTM equipment and tables, assembly's parts and computer to download manufacturing assemblies and for the utilization of statistical software for time-study data analysis and design software for workstation improvements.

**Operations Management Laboratory** - This laboratory consists of a Windows 2000 network with twenty (20) Intel Pentium III personal computers for student use. This network offers the student the opportunity to access specialized software to tackle manufacturing problems. This laboratory has the equipment and software required to develop the system analysis, solutions development and decision-making skills in the students. The hardware available in this laboratory includes twenty personal computers, and a laser printer. The software in the network includes AutoCAD 2002, Statgraphics Plus for Windows, Witness Simulation software, FactoryCad and FactoryFlow, Microsoft Project, Power Point, Word, Excel, Microsoft Visio and other relevant software.

**Software Instruction Laboratory** - This laboratory is a state-of-the-art facility. It provides seating for 20 students and has been designed especially for teaching purposes. This room is also equipped with computer lab instruction software to provide one-on-one instruction. It consists of a Microsoft 2000 network with twenty Gateway Pentium IV personal computers and a LCD projector. This network offers the faculty the opportunity to teach software-related courses in order to solve manufacturing problems. The different software available in the network includes Statgraphics plus for windows, Witness and Arena simulation Software, Microsoft Project, MS Visio and other relevant software.



## **Mechanical Engineering Laboratories**

**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, brinell 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 equipments. The laboratory is provided with a variety of equipment for teaching lab-based for thermal, fluid science courses and turbo machinery. The facility also includes features such as computer controlled heating and cooling systems that mimic the types of equipment found in the industry. Equipment includes 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 a 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 for a variety of techniques and processes in the manufacturing of engineering components

including, operation of machine tools and welding machines. Prototypes are designed and manufactured by teams with 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 the 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 it is working in collaboration with University of Missouri-Columbia, which provides for the material analysis techniques that are not available at the Polytechnic University of Puerto Rico. The laboratory is also an affiliate of NASA Puerto Rico Space Grant Consortium, which exposes 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 the Polytechnic University of Puerto Rico 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**

### **PRINCIPAL AND SUPPLEMENTARY AREA COURSES**

#### **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.

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**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.

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**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.

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**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 on elastic foundations. Applications to cylindrical shells. Two-dimensional theory of elasticity. Matrix formulation.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**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.

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**CE 6530 - Schedule Impact Analysis**

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**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.

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**CE 6532 - Construction Cost Control**

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**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.

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**CECS 6120 - Computer Architecture**

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**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.

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**CECS 6130 - Data Communication Networks**

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**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.

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**CECS 6150 - Object Oriented Design**

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**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.

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**CECS 6510 - Software Engineering I**

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**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.

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**CECS 7230 - Network Security**

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**Three credit-hours. Prerequisite: Graduate Program Director/Coordinator 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.

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**CECS 7235 - Computer Forensics**

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**Three credit-hours. Prerequisite: Graduate Program Director/Coordinator 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.

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**CECS 7530 - Data Mining and Data Warehousing**

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**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.

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**CECS 7570 - Computer Security**

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**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.

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**EE 6010 - Mathematical Methods for Signal Processing**

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**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.

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**EE 6020 - Stochastic Processes**

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**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.

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**EE 6030 - Linear Systems**

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**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.

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**EE 6760 - Digital Communications**

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**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.

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**EPM 6800 - Solid Waste Management**

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**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.

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**EPM 6810 - Environmental Regulations**

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**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.

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**EPM 6850 - Management of Sustainable Future**

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**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.

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**GEOM 6630 - Geospatial Modeling & Analysis**

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**Three credit hours. Prerequisites: 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.

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**GEOM 6634 - Cartography, Map Design & Geovisualization**

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**Three credit-hours. Prerequisites: 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.

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**GEOM 6640 - Geospatial Urban and Regional Applications**

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**Three credit-hours. Prerequisites: GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One, four hours lecture 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.

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**GEOM 6646 - Environmental Assessment and Geospatial Technology**

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**Three credit-hours. Prerequisites: 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 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.

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**GEOM 6648 - Business Geography**

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**Three credit-hours. Prerequisites: GEOM 5600 or undergraduate course in Geographic Information Systems and MGM 5700 or undergraduate course in Statistics. One, four hours lecture 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.

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**GEOM 6710 - Image Acquisition, Analysis and Processing**

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**Three credit hours. Prerequisites: 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.

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**MBA 5600 - Managerial Economics**

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**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.

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**MBA 5700 - Managerial Marketing**

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**Three credit-hours. Prerequisite: None. 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.

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**MBA 6830 - Operations Management**

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**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.

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**ME 6014 - Advanced Engineering Mathematics**

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**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.

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**ME 6100 - Advanced Engineering Thermodynamics**

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**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.

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**ME 6120 - Advanced Convection Heat Transfer and Fluid Mechanics**

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**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.

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**ME 6140 - High Speed Aerodynamics**

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**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. The consequences of this variation in temperature and pressure are considered. The conservation of mass, first and second law of thermodynamics and Newton's laws of motion of subsonic and supersonic flows are studied and analyzed. The students will apply the basic concepts of gas dynamics to analyze sound waves in an arbitrary fluid and then develop working equations for a perfect gas in bounded and unbounded phenomena.

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**ME 6200 - Advanced Solid Mechanics**

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**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.

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**ME 6300 - Advanced Aerospace Structures**

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**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 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.

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**ME 6330 - Finite Element Analysis**

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**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.

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**ME 6350 - Mechanical and Aerospace Control Systems**

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**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.

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**ME 6360 - Optimization in Engineering Design**

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**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.

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**MEM 6110- Engineering Management I**

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**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

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**MEM 6120 - Engineering Management II**

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**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.

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**MGM 6620 - Managerial Finances**

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**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.

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**MGM 6690 - Decision Making Techniques**

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**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.

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**MMP 6000 - Advanced Statistics and Quality Improvement**

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**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.

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**MMP 6002 - Operations Planning and Control**

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**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.

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**MMP 6006 - Lean Manufacturing**

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**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.

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**MMP 6130 - Six Sigma**

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**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.

## **COURSE DESCRIPTIONS**

### **ADVANCED GRADUATE COURSES AND COMMON DOCTORAL COURSES**

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**EAS 8130 - Advanced Theory of Elasticity**

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

Stresses and strains in Solid Mechanics. Tensor notation and tensor algebra. General formulation for strains and the linearization hypothesis and process. Equilibrium conditions. Elastic constitutive relationships for different states of stresses and strains. General solutions of formulation based on either differential equations (equilibrium or compatibility), or energy principles. Numerical solutions.

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**EAS 8131 - Nonlinear Finite Elements Methods**

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

Material and geometric nonlinearities in Solid Mechanics problems: the phenomenology, the causes, and the analytical approach to take them into account. Static nonlinear analysis by means of the Finite Element Method: FEM formulation, incremental and iterative numerical solutions, modeling and implementation considerations, usage of available software packages, and development of case studies such as multi-component contact problems, problems implying moving boundary conditions, and post buckling plastic analysis, among others.

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**EAS 8140 - Sustainable Engineering**

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

The public discourse about the implications of current patterns of production and consumption of energy, and goods and services more broadly, suggest such patterns are environmentally and economically unsustainable. Engineers can fundamentally change the environmental footprint of modernity. To effect change, engineers require tools to identify better design and operational options. The course considers the actual and growing popularity of sustainability and its implications for the practice of engineering. Several methodologies are featured including, Life Cycle Assessment (LCA), Industrial Ecology (IE) and Industrial Symbiosis, Ecological Footprint and Leadership in Energy and Environmental Design (LEED). The fundamentals of each approach will be presented. Specific topics covered include water and wastewater management, energy use, material selection, and construction.

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**EAS 8200 - Manufacturing Systems Analysis**

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

This course introduces doctoral graduate students to the field of manufacturing systems engineering. Manufacturing Systems Engineering deals with different manufacturing practices (e.g., pharmaceutical, biotechnology, medical devices) and the research and development of systems, processes, machines, tools and equipment. Systems Engineering considers the total system's life-cycle from customer requirements and concept through design and development, system use, system maintenance, and system disposal. Manufacturing systems engineering works to integrate the entire manufacturing process, from production and supply through sales, in order to produce the maximum volume of high-quality product at the lowest cost and in the shortest time.

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**EAS 8210 - Statistical Modeling for Resources Optimization**

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**Three credit-hours. Prerequisite:** MMP 6000. One four hours session per week.

Statistical design and analysis will be applied to the utilization of process resources like materials, labor, equipment and capital. Statistical techniques will be developed and interpreted to obtain the optimal allocation of resources in a process that maximize quality and reduce costs.

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**EAS 8310 - Energy Management**

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

Available energy resources for residential, commercial and industrial use. Conservation programs and techniques. Bill analysis and energy audits. Development of energy conservation measures (ECMs) for lighting, HVAC, motors and other systems. Cost estimation and engineering economics for decision making.

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**EAS 8320 - Modeling and Simulation**

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**Three credit-hours. Prerequisite:** None. Corequisite: CECS

**6010 or Graduate Director/Coordinator approval. One four hours session per week.**

Computer simulation is the discipline of designing a model of an actual or theoretical system, executing the model on a computer and analyzing the results. This course explores systems model design methods and their execution for computer simulation.

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**EAS 8400 - Advanced Optimization and Modeling**

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

This course is intended as advanced course on engineering modeling and design optimization for graduate students in all areas of engineering. The basic idea of the course is to introduce the modeling and optimum design of engineering systems as a systematic and well organized activity. Provides the applications of various recently developed advanced optimization techniques to mechanical design problems. Includes algorithms and computer codes for meta-heuristic optimization techniques. Demonstrates the possibilities for design optimization with advanced optimization techniques using examples of various mechanical elements and devices. Emphasis is on establishing an advanced understanding of modern optimization. Many assignments are open-ended and subject to individual interpretation and creativity.

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**EAS 8401 - Advanced Vibrations**

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

This course covers advanced vibration analysis techniques for mechanical and structural systems. The course includes the application of analytical dynamics techniques such as Hamilton's principle and Lagrange's equations to the response analysis of discrete and distributed-parameter systems. An emphasis in the course is the application of computational techniques to solve the algebraic eigenvalue problem. The course also includes discretization and approximate analysis techniques for complex vibration systems.

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**EAS 8900 - Comprehensive Examination**

**Zero credit-hours. Prerequisite: As per Committee Request.**

The Comprehensive Examination is a requirement of the doctoral program. It has an oral and a written component. Once the student successfully completes the written portion of the examination, he/she will continue to the oral segment. All students must pass each section (written and oral) with a minimum percentage of approval of 80%. The Comprehensive Examination will be administered by the Doctoral Dissertation Advisory Committee. Topics will include areas related to the student's research interests, but may include core courses components from his/her Principal Area and Supplementary areas of study as well.

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**EAS 8901 - Doctoral Seminar**

**One credit-hour. Prerequisite: None. One two hours session per week.**

The Doctoral Seminar implicates an active discussion on a research topic related to the Engineering and Applied Sciences areas. During the seminar graduate students have an

opportunity to present and elaborate in their doctoral dissertation methodology. In addition to graduate students' presentations, faculty members or guest speakers could present their research. Seminars will be organized by the Graduate School.

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**EAS 8902 - Doctoral Independent Study**

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

This is a one-on-one graduate course for doctoral students who wish to study a specific topic within their research area. Graduate students are limited to one Doctoral Independent Study course within the advanced graduate courses component for the Engineering and Applied Sciences Ph.D. degree.

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**EAS 8910 - Qualitative & Quantitative Research Methods**

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

This course presents the difference between qualitative and quantitative research methodologies. Those differences are described within the following specific topics: research objectives, sample, data collection, data analysis, outcomes and final report.

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**EAS 9000 - Doctoral Dissertation**

**Six credit-hours. Prerequisite: EAS 8900, 6 credits in EAS 8901 and Graduate Director/Coordinator Approval. Schedule: By arrangement.**

The purpose of the course is to design, prepare and write the doctoral dissertation. The course deals with specific aspects of the dissertation, such as, designing the research proposal, presenting the proposal to the doctoral committee, executing the research, writing the document and successfully defending the design in a meeting open to the university constituents.

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**EAS 9001 - Doctoral Dissertation Extension**

**Zero credit-hours. Prerequisite: EAS 9000 and Graduate Director/Coordinator approval. Schedule: By arrangement.**

This course provides the student the opportunity to continue the development of his/her doctoral dissertation.

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**PROGRAM FACULTY**

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

**Ayala Cruz, Jorge** – Professor - **Ph.D.**, Management Engineering, Operation Research, Rensselaer Polytechnic Institute, Troy, New York, 1993; **MBA** 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.

**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.

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**Cruzado Vélez, Héctor J.** – Professor; Civil and Environmental Engineering and Surveying Department Head; **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** – Professor, **Ph.D.**, Marine Sciences (Geological Oceanography) University of Puerto Rico, Mayagüez Campus, 2010; **M.S.**, Geology, Saint Louis University, 2003; **B.S.**, Geology, University of Puerto Rico, Mayagüez Campus, 1998.

**Dávila Aponte, Edwin** – Assistant Professor; **Ph.D.**, Entrepreneurship Development, Inter American University of Puerto Rico, Río Piedras Campus, 2006; **M.B.A.**, Accounting, Inter American University of Puerto Rico, Río Piedras Campus, 1999; **B.B.A.**, Accounting, Caribbean University, Bayamón, Puerto Rico, 1986.

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**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, Cuauhtemoc** – Professor; Associate Dean, School of Engineering, Surveying and Geospatial Science, 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, Ángel** – 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.*

**González Miranda, Carlos** – Professor; Dean, School of Engineering, Surveying and Geospatial 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.

**Matos Flores, Raúl** – Associate Professor, PhD (Candidate), Cartography, GIS and Remote Sensing doctoral program,

Universidad de Alcalá, Madrid, 2014; 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.

**Morales Morales, José A.** – Associate Professor, **Ph.D.**, Materials Management, Walden University, Minnesota 1995; **M.B.A.**, Industrial Management, Inter American University, 1984; **B.S.**, Industrial Engineering, University of Puerto Rico, Mayagüez, 1980.

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**Nieves Castro, Rafael A.** – Associate Professor; **Pharm.D.**, Pharmacy, Nova Southeastern University, 2005; **M.S.**, Pharmaceutical Sciences (Medicinal Chemistry), University of Puerto Rico, Medical Sciences, 1997; **B.S.**, Pharmacy, University of Puerto Rico, 1993.

**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.

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**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.

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**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.*

**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.

**Romero González, Víctor** - Assistant Professor; **Ph.D. (Candidate)**, Topographic Engineering and Photogrammetry, Universidad Politécnica de Madrid, 2015; **M.S.**, Environmental Management, Metropolitan University of Puerto Rico, 2006; **B.S.**, Land Surveying, Polytechnic University of Puerto Rico, 1994.

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

**Skrzypinski Romanow, Antoni E.** - Professor, **D.Sc.**, Mechanical Engineering, 1980, **Ph.D.** Mechanical Engineering, 1970, **B.S.** Mechanical Engineering, University of Mining and Metallurgy, Cracow, Poland, 1961.

**Solá Sloan, 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.*

**Torres Plaza, Edgar** - Associate Professor, **Ph.D.**, Pharmacy, University of Sciences, Philadelphia; **M.E.**, Manufacturing Engineering, Polytechnic University of Puerto Rico, 2002; **B.S.**, Chemical Engineering, University of Puerto Rico, Mayagüez, 1998.

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

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## VIII. 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's 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 2020-21 to 2021-22.



Ernesto Vázquez Barquet  
**President**  
**Polytechnic University of Puerto Rico**