

Graduate Catalogue

2018 - 2019



UNIVERSITY OF PUERTO RICO

MAYAGÜEZ CAMPUS

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In addition, UPRM is currently reviewing and restructuring many of its academic programs in an effort to enhance their quality and efficiency. In that process, some of the programs and courses mentioned in this catalogue may be modified, consolidated with other programs or courses, or eliminated. If you have questions about a particular program or course, you should contact the appropriate university college or department.

The UPRM Graduate Catalogue is available at: <http://www.uprm.edu/catalog>

A publication of the Office of the Dean of Academic Affairs.

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Graduate Academic Degrees Offered at UPRM

DOCTOR OF PHILOSOPHY

Applied Chemistry, Bioengineering, Electrical Engineering, Mechanical Engineering, Marine Sciences, Chemical Engineering, Civil Engineering, Computing and Information Sciences and Engineering

MASTER OF BUSINESS ADMINISTRATION

Finance, General Program, Human Resources, Industrial Management

MASTER OF ENGINEERING

Bioengineering, Chemical Engineering, Civil Engineering, Computer Engineering, Industrial Engineering, Electrical Engineering, Materials Science and Engineering, Mechanical Engineering

MASTER OF SCIENCE

Agricultural Sciences

Agricultural Economics, Agricultural Education, Agricultural Extension, Agronomy, Soils, Animal Science, Horticulture, Crop Protection, Food Science and Technology

Arts & Sciences

Biology, Chemistry, Geology, Marine Sciences, Physics, Applied Mathematics, Statistics Mathematics, Pure Mathematics, Teaching Mathematics at Secondary Level, Scientific Computing

Engineering

Bioengineering, Chemical Engineering, Civil Engineering, Computer Engineering, Electrical Engineering, Industrial Engineering, Materials Science and Engineering, Mechanical Engineering

MASTER OF ARTS

Hispanic Studies, English Education, Kinesiology

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HISTORICAL SKETCH

The University of Puerto Rico was created by an act of the Legislative Assembly on March 12, 1903 emerging as an outgrowth of the Normal School, which had been established three years earlier to train teachers for the Puerto Rican school system. In 1908, the benefits of the Morrill-Nelson declared applicable to the island, fostered the rapid growth of the University. Eloquent evidence of that growth was the establishment of the College of Liberal Arts at Río Piedras in 1910 and the College of Agriculture at Mayagüez in 1911.

It was in the College of Agriculture where the Mayagüez Campus as we know it today had its origin. Credit for the establishment of the College is given to the joint effort of D. W. May (Director of the Federal Experiment Station), José de Diego, and Carmelo Alemar. A year later, the school received the name that it bore for 50 years: the College of Agriculture and Mechanic Arts. The strengthening and diversification of the academic programs at Mayagüez were recognized years later when, in 1942, as a result of university reform, the campus was organized with a considerable degree of autonomy into the Colleges of Agriculture, Engineering, and Science under the direction of a vice-chancellor. The expansion continued through the 1950s when many programs flourished in the University. The College of Arts and Sciences and the Nuclear Center were established in Mayagüez. The Colleges of Humanities, Natural Sciences, Social Sciences, and Business Administration emerged in Río Piedras. The Schools of Medicine, Odontology, and Tropical Medicine were established in San Juan.

In 1966, the Legislative Assembly reorganized the University of Puerto Rico as a system of autonomous campuses, each under the direction of a chancellor. The College of Agriculture and Mechanic Arts became the University of Puerto Rico, Mayagüez Campus.

Today, the Mayagüez Campus of the University of Puerto Rico continues its development in the best tradition of a Land Grant institution. It is a co-educational, bilingual, and non-sectarian school comprising the Colleges of Agricultural Sciences, Arts and Sciences, Business Administration, Engineering, and the Division of Continuing Education and Professional Studies.

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The College of Agricultural Sciences includes the Agricultural Experiment Station and the Agricultural Extension Service. At present, the campus population is composed of 13,316 students, 1,181 regular staff members and 625 members of the educational staff.

Accreditations and Affiliations

The Mayagüez Campus of the University of Puerto Rico is fully accredited by the **Council of Higher Education of Puerto Rico**. It holds membership in the **Middle States Commission on Higher Education** since 1946. Our academic programs are accredited by professional entities such as the **National Council for Accreditation of Teacher Education (NCATE)**, **Accreditation Council for Business Schools and Programs (ACSBSP)**, **The American Chemical Society, Accreditation Commission for Education in Nursing, Inc. (Formerly NLNAC)**, and **Accreditation Board for Engineering and Technology (ABET)**.

The Mayagüez Campus of the University of Puerto Rico is a member of **Oak Ridge Associated Universities (ORAU)** since 1966. ORAU is a private, non-profit consortium of 65 colleges and universities that acts as management and operating contractor for the US Department of Energy (DOE).

Vision, Mission

Our Vision

“To be a leading institution in higher education and research, transforming society through the pursuit of knowledge in an environment of ethics, justice, and peace.”

Our Mission

“To provide excellent service to Puerto Rico and to the world by:

- Forming educated, cultured, capable, critical thinking citizens professionally prepared in the fields of agricultural sciences, engineering, arts, sciences, and business administration so they may contribute to the educational, cultural, social, technological and economic development.
- Performing creative work, research and service to meet society’s needs and to make available the results of these activities.

We provide our students with the skills and sensitivity needed to effectively resolve problems and to exemplify the values and attitudes that should prevail in a democratic society that treasures and respects diversity.”

Strategic Objectives

- Objective #1: To institutionalize a culture of strategic planning and assessment
- Objective #2: To lead higher education throughout Puerto Rico while guaranteeing the best education for our students
- Objective #3: To increase and diversify the Institution’s sources of revenue
- Objective #4: To implement efficient and expedient administrative procedures
- Objective #5: To strengthen research and competitive creative endeavors

- Objective #6: To impact our Puerto Rican society
- Objective #7: To strengthen school spirit, pride, and identity

Student Learning Outcomes (SLOS)

By the time of their graduation, UPRM students will be able to:

- a. Become an intentional learner
- b. Demonstrate creative and critical thinking
- c. Communicate effectively
- d. Identify, study, and propose solutions to problems; transform knowledge into action
- e. Apply mathematical, scientific, and technological skills
- f. Apply interpretative and integrative skills
- g. Relate global contexts and issues of importance to Puerto Rico
- h. Show moral autonomy; develop a sense of wellbeing; understand ethical conduct
- i. Practice civic virtues
- j. Value diversity

Organization of the University of Puerto Rico

The University of Puerto Rico is a well-established and mature institution, with a total enrollment of over 61,967 students. The University consists of the Mayagüez Campus, the Medical Sciences Campus, and the Río Piedras Campus, which are dedicated to both undergraduate and graduate education; and eight Campus at Aguadilla, Arecibo, Bayamón, Carolina, Cayey, Humacao, Ponce, and Utuado which provide undergraduate education. Each autonomous institutional unit has a Chancellor as chief administrator and academic officer.

Governing Board

The Governing Board (JG) was created in 2013 as an independent and autonomous body that governs the system of 11 units comprising the University of Puerto Rico. Prior to its creation, these responsibilities were in charge of the former Higher Education Council and the former Board of Trustees (JS).

It is composed of 13 members, namely a regular undergraduate student, a regular graduate student, two tenured professors in the university system, the Secretary of Education, as an ex officio, a broad professional knowledge and experience in the field of finance, a resident of Puerto Rico who has participated with distinction in the social and community leadership, five residents of Puerto Rico featured in artistic knowledge, scientists and professionals, and a citizen residing in Puerto Rico, linked Puerto Rican communities abroad.

Except for the two students and two professors, who are elected, the other members of the Governing Board are appointed by the Governor with the advice and consent of the Senate. All members of the Governing Board serve for staggered terms laid down in the University Act and until their successors are appointed and qualified.

The Governing Board elects its president from among its members. It is responsible for:

- examining and reviewing the budgetary and institutional development plans of the University
- authorizing the institution of new campus, centers, and other institutional units appointing the President and chancellors of each autonomous unit

- defining rights and duties of various constituents in the institutional community
- defining student financial aid standards
- preparing an annual report to the Governor and the Legislature on the state of the University of Puerto Rico

President

The President of the University, the chief executive officer of the University system, is appointed to an indefinite term by the Governing Board. Subject to the approval of the Board, he appoints chancellors to the various campuses and colleges. The President represents the University on corporate matters before courts and government agencies. He acts as an ex-officio member of all the UPR faculties, academic senates, and administrative boards.

The President is responsible for submitting an annual budget, an annual report, the institutional development plan and its revisions, regulations, contracts, and agreements which require university approval. He develops and maintains relationships with other cultural and educational institutions.

University Board

The University Board is constituted by:

- the President of the University
- eleven chancellors representing each autonomous institutional unit
- a financial director
- three additional members appointed by the President with the approval of the Governing Board
- one faculty representative from each Academic Senate
- one student representative from each institutional unit

The Board is responsible for the preparation of the following documents:

- general bylaws of the University
- general bylaws of the student body
- university's strategic plan with recommendations from the Academic Senates

These documents are submitted to the President and to the Governing Board for their consideration and approval. The Board also considers the integrated university budget, and it is the first avenue of appeals against any decision taken by the Administrative Board or the Academic Senate of an autonomous unit.

Organization of the Mayagüez Campus

The Mayagüez Campus serves a student population of 13,316 students. It was organized as a result of the University Act (PL1), which was approved on January 20, 1966 and amended by Law No. 16 in 1993.

Chancellor

The Chancellor of the Mayagüez Campus is the chief executive officer of the institutional unit. The Chancellor's main responsibilities include:

1. Presiding over the Administrative Board, the Academic Senate, and faculty meetings.
2. Appointing deans, departmental directors and university personnel.
3. Resolve controversial appeals against decisions made by deans.
4. Representing the campus at functions, ceremonies, and academic activities.
5. Preparing the campus' annual report and budget petition for submission to the President.
6. Considering and granting promotions and leaves of absence.

Administrative Board

The Administrative Board of the Mayagüez Campus consists of the Chancellor as presiding officer, the deans, two academic senators elected among those faculty members of the Senate who are not ex-officio, senators, and an elected student representative. The President of the University serves as an ex-officio member. The Board acts as an advisory body to the Chancellor, prepares the development plan of the Campus, approves the proposed budget prepared by the Chancellor, and grants tenure, promotions and leaves of absence.

Academic Senate

The Academic Senate at UPRM is composed by a member of the Administrative Board, the Director of the Library, the Director of the Counseling Office, representatives elected from the faculties whose total must not be less than twice the number of the elected ex-officio members, an elected member of the Library and Counseling Office, and ten student representatives. The Academic Senate is the official forum of the academic community. Its main task is to participate in the formulation of academic processes within the University's legal structure.

Faculty

The faculty is composed of the chancellor, the deans, department's directors and the teaching personnel. The General Regulations of the University of Puerto Rico define the faculty's functions, privileges, duties, and, rights.

Students

The rights and duties of students are set forth in the General Student Regulations. The General Student Council represents students before the university administration, and individual student councils represent them before each of their respective colleges and schools. The students are also represented on the Academic Senate, the Administrative Board, the University Board, and the Governing Board.

Student Ombudsman Office

The Students Ombudsman Office was created on November 10, 1999. It is a direct result of the interest and effort of both the Chancellor and the Students General Council. Its creation reinforces our University's belief in dialogue and communication as the best way to pursue truth and the integral development of its students. It also provides adequate and appropriate conditions which enhance their quality of life.

The mission of the Students Ombudsman Office (Oficina de Procuraduría Estudiantil) is to provide an independent, confidential, neutral, and accessible individual support for our students. The informal process facilitates fair solutions to the situations and problems of the parties involved.

The Students Ombudsman Office does not do formal investigations. Instead we listen to people, examine their options for dealing with a particular situation and help guide them toward making wise and healthy decisions. Moreover, the Office offers timely and relevant information concerning campus policies and procedures. The Office welcomes all community members, including professors and employees that wish to present any situation related to students.

Office: Students Center Building, 4th floor, 408
Phone: 787-265-5462; 787-832-4040 exts. 3588, 5462
Website: <http://www.uprm.edu/procuraduria>
Email: procuraduria@uprm.edu

UNIVERSITY REGULATIONS

Rights and Duties of Students of the University of Puerto Rico

Article 1

- A. The fundamental right of University students in the academic community is the right to an education. This right is not limited to the classroom but encompasses the aggregate of the students' possible relations and experiences with their fellow students, teachers, and administrators at the University and with their fellow citizens in the community at large. In like manner, the students' principal duty consists of fully exercising that right and conducting themselves in a manner that does not hinder other community members in the exercise of their rights or in the fulfillment of their duties.
- B. These regulations cover separately: (1) student rights and duties inherent in the sphere of the educational program; (2) those pertaining to extracurricular activities within the facilities of the University; (3) those related to student participation in the different aspects of institutional services; (4) those indicated by the standards and restrictions characteristic of academic life; and (5) the sanctions corresponding to violations of regulations and the procedure for the imposition of these sanctions.

Article 2

- A. The work involved in the subject under study constitutes the basis of teacher-student relationship. Maximum integrity and intellectual honesty should govern the drive to attain knowledge. The teacher shall foster creative dialogue and freedom of discussion and expression among students. The student shall have the opportunity to present reasonable objections to the facts and opinions stated by the teacher if in disagreement. Both may examine any aspect of the subject under discussion in accordance with the standards of intellectual responsibility vital to all academic endeavors. Neither one nor the other shall use the classroom as a forum to preach political, sectarian, religious, or other

doctrines alien to the subjects being taught. The right to dissent from the opinion of the teacher does not release the student from the responsibility of complying with the teacher's requirements for the course. The student's grade shall be based on considerations relative to academic achievements measured in the varying ways in which this is possible.

- B. The basis of the teacher-student relationship is trust and confidence which should be respected by both and by the administration. Opinions and beliefs expressed by students in the classroom are of a privileged nature, and students are entitled to have their teachers refrain from disclosing them to third parties. The preceding does not bar teachers from stating opinions about students' character and abilities or from discussing their progress with colleagues as part of the academic program and of the students' formative process.
- C. The relationship between students and teachers outside the classroom constitutes a part of the educational process. Students shall have the right to meet with teachers at specially designated times to request guidance on and clarification of aspects of their academic work.
- D. Academic and disciplinary files shall be kept separate. Any information relative to disciplinary files shall not be made available to unauthorized persons within or outside the University without the students' consent except by a court order. No record of the students' political beliefs shall be kept.

The legal and academic tradition recognizes the rights of students as members of the University community and also the obligation of moral and intellectual responsibility concomitant with these rights. The legal and academic tradition also recognizes the responsible participation of students in assuring and maintaining order, safety, and normalcy of academic life. These rights and responsibilities, the disciplinary procedures for dealing with their violation, and many other matters of interest are described in the UPRM Student Manual (Reglamento de Estudiantes del Recinto Universitario de Mayagüez) available in the Office of the Dean of Students.

UPRM STUDENT REGULATIONS

University law and tradition recognize the rights of students as members of the University community, and dictate the students' moral and intellectual responsibilities as members of that community. Also recognized is the responsible participation of students in insuring and preserving order, safety and normalcy of institutional tasks and procedures. The University graciously welcomes the democratic and responsible participation of its students in the institutional processes.

Rights and Duties

Article 1. To the extent that they are collaborators in the University's mission of education, culture, and service, students are members of the University community and, as such shall be entitled to participate effectively in the life of the community. They shall have all the moral and intellectual responsibilities of members of the community.

Article 2. Students have the duty and right to engage in the search for truth and strive for its expression, always respecting opinions. Academic discipline, behavior intrinsic to the academic community, and the dictates of conscience, itself, shall serve as guides.

Article 3. University students have the duty to seek the elements of intellectual and spiritual formation which can lead to their full development as persons. They also have the right to demand them in view of their responsibility as members of the Puerto Rican community.

Also incumbent upon them is the duty and the rights to preserve, enhance, and disseminate the values of learning and culture both universal and Puerto Rican.

Article 4. Students may hold, pursuant to established standards, any public function, meeting, or ceremony and invite any person they wish to hear speak on any subject of interest provided that the exercise of any of the aforementioned rights does not interrupt the educational, technical, or administrative work of the institution and that there is compliance with the provisions of the regulations in effect.

Article 5. Students may associate freely and may publish and circulate publications in accordance with the prevailing standards set forth by the office of the Dean of Students.

Article 6. No student may be deprived, by reason of sex, race, origin, social condition, or political or religious creed, of the right of association nor of the services and programs offered by the University.

Article 7. University students are entitled to have the University refrain from disclosing information or keeping records related to their political, religious, or philosophical beliefs.

Academic and disciplinary files shall be kept separate. The information contained in the academic and disciplinary files shall be confidential and shall not be made available for use by unauthorized persons within or outside the University without the written consent of the student or the student's parent or guardian, unless a court order to that effect has been obtained.

Article 8. Students shall have the right to meet with teachers at specially designated hours in order to receive guidance and clarification on matters related to their academic work.

Article 9. Students shall have the right and the duty to actively participate in classes and related activities, consult their teachers, express their doubts and differences on criteria, and be informed of their deficiencies and achievements in academic work.

Students shall be entitled to receive from their teachers at the beginning of each session proper guidance on oral or written contents of the course, which shall include: explanations of academic ends and objectives, teaching methods, topics of study, reading assignments, and other work requirements, grading criteria, and other pertinent data. All this must in no way affect the necessary flexibility of the courses.

Students shall have the right to discuss with their teachers the tests taken, the grades received, and the evaluation of the course as an essential part of the college learning process.

Article 10. Students have an obligation to exercise in a comprehensive and responsible manner all the rights and duties established in these Regulations so that the example they set inside and outside the classroom may serve as a bulwark for the continual enjoyment of such rights and duties by them and their fellow students.

(Copies of these Regulations including the remaining provisions are available from the Office of the Dean of Students.)

Privacy of Educational Records

The University of Puerto Rico intends to fully comply with the clauses of the Buckley Amendment of the United States Federal Government (Family Educational Rights and Privacy Act of 1974, as amended). This Act protects the private nature of students' educational files and establishes their right to inspect and examine them. It also provides guidelines to correct the accuracy of such information through informal and formal hearings. In relation to alleged violations of the Act by the institution, students have the right to file complaints written complaints to: The Family Educational Rights and Privacy Act Office, U. S. Department of Health and Human Services, 200 Independence Ave. S.W., Washington, D.C. 20201.

Copies of the institutional policy established by the University in compliance with the Act may be obtained in the Office of the Registrar, the General Library, the Office of the Dean of Students, the Financial Aid Office, and the Student Affairs Office. These offices maintain student lists and the location of students' educational records kept at the University. Questions related to this Act should be addressed to the Office of the Registrar.

Equal Opportunity

The Mayagüez Campus of the University of Puerto Rico guarantees applicants equal opportunities for employment and academic admission. It also guarantees student and employee equality in study and employment opportunities as well as in the benefits of the services and academic programs offered and the terms and conditions of employment. UPRM does not exclude from participation nor denies benefits to nor discriminates against any person by reason

of age, race, sex, color, place of birth, social origin or condition, physical or mental handicap, political or religious beliefs, ancestry, marital status, gender, sexual preference, ethnic origin, or status of veteran of the armed forces. Any applicant for academic admission or employment or any student or employee, who feels discriminated against for any of the reasons cited above may file a complaint in writing with the Dean of Academic Affairs. The establishment of this policy as well as its compliance and publication are pursuant to Federal regulations for the implementation of Title IX, Educational Amendments of 1972 and Section 504 of the 1973 Rehabilitation Act.

Disabilities

UPRM is committed to promote a safe atmosphere for disabled students where they will have access to all academic programs, support services, social events, and physical facilities.

Regulations specified in Section 504 of the Vocational Rehabilitation Act (1973) and the Americans with Disabilities Act (ADA) 1980, establish norms and procedures which guarantee handicapped persons' equal access to programs and services.

At present, responsibility for the effective means of providing these services lies in the Office of the Dean of Students through the Coordinator of Services to Handicapped Students (SEI).

Services for handicapped students stem from the following principles:

1. Request for accommodations must be initiated by the student.
2. Accommodations offered by the university have a shared responsibility among student, faculty, staff and Office of the Dean of Students.
3. Procedures and policies must be reasonable and easily understood by all parties involved.
4. The student's right to confidentiality will be protected at all times during the process of accommodation.
5. Appeal processes will take place in a fair manner and within a designated time frame.

Foreign Non-Immigrant Students

The Mayagüez Campus is authorized by law to admit foreign non-immigrant students. Refer to the sections on “Academic Regulations” and to the section on “Special Fees for Non-resident Students” for additional information.

Use of Vertebrate Animals in Research

This institution complies with all applicable provisions of the Animal Welfare Act and other Federal statutes and regulations concerning animals. It also complies with the U. S. Public Health Service policy on human care and use of laboratory animals. Its practices are guided by the U.S. government principles for the utilization and care of vertebrate animals used in testing, research, and training.

Protection of Human Subjects in Research

This institution complies with all Federal regulations regarding human subjects in research, including those stated in the Code of Federal Regulations, the Department of Health and Human Services, Title 45 (Public Welfare), Part 46: Protection of Human Subjects (Revised January 15, 2009; Effective July 14, 2009).

Intellectual and Scientific Misconduct

It is the institutional policy of the Mayagüez Campus to observe the highest standards of intellectual and scientific integrity, and to pursue the prosecution of all violations. The lack of integrity and the perpetration of academic and scientific fraud include plagiarism, fabrication, falsification, false attribution, and other violations of the cannons and practices of honesty generally accepted in the academic community, always excepting those which may result from involuntary errors or honest differences in the interpretation or handling of data or information.

Sexual Harassment

This institution adheres to the principles and statutes concerning sexual harassment and discrimination because of gender in the areas of employment, conduct in the workplace, and provision of services. Grievance procedures are stated in Circular Letter 88-07 (May 27, 1988) of the President of the University of Puerto Rico and the Administrative Board Certification #93-94-303 of April 7, 1994.

Smoking

Smoking is forbidden in all enclosed campus areas, including, but not limited to, classrooms, laboratories, lecture rooms, elevators, auditoriums, offices, museums, and all other places where people regularly meet. Smoking is permitted in public areas such as open hallways and other open spaces.

Drugs

The University of Puerto Rico pursues a vigorous policy in combating the manufacture, distribution, supply, possession, and illegal use of controlled substances within its grounds as defined by Puerto Rico Law No. 4 of June 23, 1971, and further treated in subsequent Federal and Commonwealth legislation. The policy, means and procedures for its enforcement are detailed in Circular Letter 89-01 (June 6, 1989) of the President of the University of Puerto Rico.

RESEARCH AND DEVELOPMENT ENDEAVORS

In addition to the numerous research laboratories under direct faculty supervision, Mayagüez Campus has several research and development institutes that provide valuable support for research activities.

The Agricultural Experiment Station

Established in 1910 by the Sugar Producers Association the Agricultural Experiment Station was ceded to the Government of Puerto Rico in 1913 and transferred to the University of Puerto Rico by legislative action in 1933. Its main objective is to conduct research, develop technology and improve agriculture and the quality of life in rural areas. The Station, a component of the College of Agricultural Sciences, has two main research centers, one at Mayagüez and the other at Río Piedras and six research substations located in Adjuntas, Corozal, Juana Díaz, Gurabo, Isabela, and Lajas. The Agricultural Experiment Station laboratories, research library, farms, and other facilities are available to graduate students for thesis research. The Station is an active member of the Southern Association of Experimental Stations. This Association serves as a regional link to the U.S. Department of Agriculture, U.S. Congress, National U.S. Association of State Universities and Land Grant Colleges (NASULGC).

Center for Excellence in Quarantine & Invasive Species

Invasive pest species are affecting world agriculture, forests and natural areas, causing billions of dollars of losses. With globalization and increases in trade and movement of people, the frequency of species invasions has substantially grown in the last decades. Puerto Rico is geopolitically located in a key strategic position and has the potential to host and play a crucial role in studies of *Prevention and Preparedness for Invasive Species*. Puerto Rico is located in a region where the probability of interception of new pests coming to the Americas and US mainland is high and where a proactive approach could be the front line for management of invasive species. In addition, Puerto Rico has its own agricultural interests and it, along with the rest of the Caribbean basin, directly benefits from an US offshore quarantine facility that provides research and appropriate training on target pests and potentially beneficial organisms. The 10,000 sq. ft. state of art laboratory and greenhouses facilities support the Center's mission that is to develop expertise, promote education and generate

tools to aid in the quarantine and mitigation of invasive species and help support sound decision-making. This Center is an initial effort between University of Puerto Rico (UPR) and US Department of Agriculture, and have collaborations with several national and international institutions.

Contacts:

José Carlos Verle Rodrigues, Ph.D.

<http://joselab.eea.uprm.edu>

jose_carlos@mac.com

Jose.rodrigues@upr.edu

Phone: 787-767-9705

Plant Diagnostic Clinic Agro-Environmental Sciences

The aim of the Plant Diagnostic Clinic (PDC) is to provide fast and accurate plant disease diagnosis and pest identification. The clientele of the PDC are commercial growers, researchers, extension specialists, seed companies and homeowners. The PDC is part of the Southern Plant Diagnostic Network (SPDN), a plant pest diagnostic and reporting system, which helps with diagnosis of plant disease and insect samples, using digital images, and detailed crop information diagnosis. Specific areas of diagnosis include vegetables, fruits, corn, soybeans and ornamentals, fungal, bacterial and viral diseases. The PDC is part of the Citrus Clean Plant Network (CCPN) that promotes the use of tested citrus propagative material to ameliorate citrus greening in the island.

Contacts:

Consuelo Estevez de Jensen, Ph.D

consuelo.estevez@upr.edu

Phone: 787-260-6037

Fax: 787-837-6823

Bio-Optical Oceanography Laboratory

BIOL is the site of an active teaching and research program in water optics and satellite remote sensing. Interdisciplinary studies of coastal and oceanic waters of the intra-Americas' sea include: variability of inherent and apparent water optical properties, effects of ultraviolet radiation on tropical marine organisms and on public health, satellite data validation and algorithm development and estimation of oceanic primary production.

Center for Applied Social Research

CISA, established in 1991, is an integral part of the Department of Social Sciences. CISA promotes and coordinates practical applications of faculty expertise to the analysis and mitigation of problems arising from or inextricably linked to social attitudes and behavior.

CISA's specific objectives aim to provide strong research training and mentoring to undergraduate students, to engage faculty and students in interdisciplinary research, to develop collaborative research projects with other research centers, programs and institutions, to enhance the professional development of researchers and students through participation in a diverse number of seminars, workshops, and conferences, and to increase the number of students pursuing a graduate degree in social sciences.

Since CISA's establishment, a diverse number of research projects has been generated by researchers affiliated to the Center such as: drug abuse, socioeconomic impact of resource management among fishermen, poverty and income inequality in the United States and Puerto Rico, public opinion and political participation, mitigation and preparedness regarding natural disasters, quantitative and qualitative aspects of urban rail transit systems, HIV/AIDS and mental health issues, female labor force participation in the tuna industry, comparative analysis of psychological depression in the Caribbean, and evaluation of the Minority Access to Research Careers (MARC) Program. A CISA research component that has been strongly developed focuses on outcome and process evaluation. Research projects in CISA have received funding from external (i.e., National Science Foundation, National Institute of Health, National Institute of Mental Health, National Fisheries Service, U.S. Army Corps of Engineers, Ford Foundation/American Sociological Association, National Forest Service), state, and local sources as well as from the University of Puerto Rico. All CISA projects involve direct student participation as research assistants, reflecting the center's commitment to undergraduate research training and mentoring.

Center for Hemispherical Cooperation in Research and Education in Engineering and Applied Science

CoHemis is part of the University of Puerto Rico. It is housed in and primarily serves the Mayagüez Campus.

CoHemis was founded in 1991 at a hemispheric conference-workshop sponsored by the National Science Foundation. It brought together national science and technology organization (ONCyT) delegates from 13 countries of the Americas to discuss ways to increase hemispheric collaborations in science and technology. CoHemis today is the hub of a network of 52 institutions from most countries of the Americas and Spain interested in collaborations by

such means as joint research faculty, student exchanges, short courses and workshops.

The Center promotes and facilitates the development of human resources, technology, and programs that help to organize research and educational initiatives in science and engineering for the benefit of the western hemisphere countries. The main objectives of CoHemis are: increase the industrial competitiveness of the Western Hemisphere, enhance the science and technology capabilities of the Americas and the Caribbean, stimulate the protection of the hemisphere's resources and environment, increase the knowledge of regional problems of high priority among researchers and educators in the Americas, increase the number and quality of Hispanic engineers and scientists in the global market.

For more information contact:

<http://cohemis.uprm.edu/>

Center Research Instrumentation Laboratory

CRIL was founded in 1982 by the Department of Chemistry it contains sophisticated instrumentation for inorganic, organic and environmental analysis. The staff includes a director and two instrumentation assistants. Available instrumentation include a 500 MHz Bruker and 300 MHz Varian NMR, a System 2000 FT-IR coupled to a Gas Chromatograph and equipped with near and mid IR detectors, a Hewlett Packard Gas Chromatography/Mass Spectrometry system, a Perkin Elmer and Varian Atomic Absorption Spectrophotometers equipped with flame, cold vapor and graphite furnaces; a Leeman Labs Inductive Coupled Plasma-Optical Emission Spectrometry system, a Dionex Ion Chromatograph equipped with conductivity detector; and a Finnigan GC/MS/MS equipped with direct insertion probe, electron impact and chemical ionization sources. The CRIL staff provides services to undergraduate and graduate courses, research groups of the Chemistry Department, as well as other academic departments, the community, government agencies, and local industry.

Laboratory for Applied Remote Sensing, Imaging and Photonics

LARSIP is a multidisciplinary laboratory dedicated to the research and implementation of Remote Sensing, Hyperspectral Image Processing, Optical Imaging, Signal and Image Processing, Geographical Information Systems (GIS), Emergency Response Systems, Global Positioning Systems (GPS) technologies, Applied Electromagnetics and Bio-Optics applications. LARSIP is a facility located

within the Department of Electrical and Computer Engineering at UPRM.

The objectives of LARSIP are to develop advanced data analytics and machine learning algorithms and technologies for information extraction and management (particularly from remote sensing sensors), and to educate and train students in the different technologies associated with remote sensing and signal processing. LARSIP provides a focus for multi-disciplinary research and education by promoting research and education projects that involve electrical and computer engineering researchers and students interacting with researchers and students in application areas such as marine sciences, geology, civil engineering, and chemistry, among others. LARSIP has extensive computing and image processing equipment as well as advanced hyperspectral optical imaging equipment (ranging from the visible and infrared spectrum) as well as portable spectrometers and underwater enclosures for fieldwork and collection of diverse imaging data.

The National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and the American Telephone and Telegraph Corporation (AT&T) provided initial funding for LARSIP and its research projects. Currently, LARSIP receives funding from NSF, NOAA, Lockheed Martin Corporation and the DoD. LARSIP function as a training center in a bilingual (Spanish and English) environment for current and future scientists and engineers of the Caribbean region and the South and Central Americas. The training centers are multidisciplinary in scope, serving Mayaguez and other UPR campuses. Universities and institutions in other countries are encouraged to form and establish liaisons with LARSIP through Memoranda of Understanding or other similar arrangements.

Contact:

Dr. Dr. Emmanuel Arzuaga

earzuaga@ece.uprm.edu

Department of Electrical and Computer Engineering

Phone: 787-832-4040 Ext 5854

<http://larsip.uprm.edu/>

Manufacturing Automation Room

Inaugurated in May 2004, **MAR** serves as a platform for hands-on experience on practical process control for undergraduate students. The room currently counts with two industrial control systems (Delta V, and PCS7) currently connected to six physical chemical processes. The students are required to configure control strategies for these 6 unit operations, validate the work done, and tune the control strategy.

MAR was developed with industrial funds from Merck, Pfizer, Abbott, Automation Technologies, OSI Safety, and Coneco and participation of UPRM-staff and undergraduate students. Engineers from system integration companies support the students working in their projects with seminars on validation, configuration, and data managing, and direct support during the programming. Students from other programs, such as electrical (currently participating) mechanical, and industrial engineering, could use and benefit from the facilities. It can also be used to offer training in control strategies.

Contact:

Dr. Carlos Velázquez

carlos.velazquez9@upr.edu

[Chemical Engineering Department](#)

Phone: 787-832-4040 Ext 5813, 2576

ERC for Structured Organic Particulate Systems (C-SOPS)

This engineering research center focuses on understanding the properties of organic particulate materials and the operations used in the pharmaceutical, food and agrochemical industries to process these materials. SOPS is led by Rutgers University with the participation of University of Puerto Rico at Mayagüez, (Chemical Engineering Department leaders), Purdue University, and New Jersey Institute of Technology. It started its operation on July 2006. Its vision is to transform the manufacturing of products of the aforementioned industries by enhancing the education experiences of undergraduate students, serving as platform for applied and basic research, offering training for professionals from the industry, and serving as technology transfer and demonstrations. The Center is backed up by most of the big pharmaceutical companies, such as Pfizer, Merck, Abbot, Lilly, Schering Plough, Bristol Myers Squibb, Glaxo Smith Kline and others.

Contact:

Dr. Rodolfo Romanach

rodolfoj.romanach@upr.edu

Chemistry Department

Phone: 787-832-4040 Ext 2604

<http://ercforsops.org/>

Center for Nanostructure Characterization (CeNaC)

The Center for Nanostructure Characterization is managed by the Department of Chemical Engineering and is located in an adjacent building in the UPRM Engineering Complex. It houses a high resolution JEOL 2100F Field Emission Transmission Electron

Microscope and other advanced nanomaterial characterization instruments, such as XRD, XPS and confocal microscope. Its purpose is to provide access to unique advanced instrumentation capabilities to academic researchers and industry, and to promote competitive research.

Contact:

Dra. María M. Martínez-Iñesta
mariam.martinez@upr.edu
Chemical Engineering Department
Phone: 787-832-4040 Ext 3605
<http://inqu.uprm.edu/research/centers/CeNaC>

UPRM Model Factory

The UPRM Model Factory integrates modern equipment, materials, and people into a manufacturing system. Its mode of operation is through interdisciplinary working teams from several engineering and business disciplines. This is a coordinated effort between Industrial, Electrical & Computer, and Mechanical Engineering. The goals of these laboratory facilities are to provide the following:

- Basic training to students through course labs and project initiatives
- Practice based experiences dealing with all aspects of an actual manufacturing system.
- A space where local manufacturing industry issues can be studied.
- A place where modern production technology and techniques can be studied as they are applied in an integrated manufacturing system.
- The opportunity to assist local manufacturers in the development of their production system.
- Incubator facilities where products and process can be developed or improved.
- Serve as a meeting place where people from several disciplines can meet and learn to work in teams, and get an appreciation for the technical aspects of the other's area of knowledge.

Currently, this laboratory houses a for-profit manufacturing activity and provides students with an exemplary manufacturing experience inside the university. The factory hosts a surface mount technology (SMT) printed circuit assembly (PCA) line and a three-axes CNC milling machine in which production and prototype runs are performed.

As for-profit initiatives are defined, students receive pay for their involvement, similar to a COOP experience. These students are then ideal candidates for course projects and summer and COOP internship in related endeavors. Such young but experienced

graduates are then positioned to initiate new business ventures or play lead roles in interested recruiters. Various companies (notably Hewlett Packard, Fuji America and FeatureCam) have contributed to this initiative, which has been active for over ten years.

Contact:

Dr. Pedro Resto
pedro.resto@upr.edu
Industrial Engineering Department
Phone: 787-832-4040 Ext. 3819 / 787-806-0170
<http://ininweb.uprm.edu/labs.asp?lab=ml>

Human Factors/Ergonomics and Work Measurement Laboratory

This laboratory has been designed to provide students with hands on experience in the analysis and evaluation of humans and their working environment. Tasks are simulated and evaluated based on anthropometrics, biomechanics, cardiovascular, and force requirements. The laboratory is equipped with modern equipment for the analysis of work systems and computers with software for the analysis of manual material handling activities. The following is a list of some of the equipment available in the laboratory: Computers with licenses of ErgoIntelligence for analysis and evaluation of workstation design as well as the analysis of lifting tasks with the NIOSH lifting guide; Chatillon digital force measurement gauges and equipment for the analysis of pushing and pulling tasks; hand dynamometers and pinch gauges to measure hand force; anthropometers and calipers for the collection of anthropometric data; heart rate meters and a treadmill for the evaluation of cardiovascular requirements of physical tasks; electromyography with data collection software for the analysis of muscular activity; goniometers and data collection software for the analysis of flexion, extension, and rotation of body members; heat stress monitors and Wet-bulb globe temperature meter for the analysis of environmental variables, among others.

Contact:

Dr. Cristina Pomales
cristina.pomales@upr.edu
Industrial Engineering Department
Phone: 787-832-4040 Ext 3819
<http://ininweb.uprm.edu/labs.asp?lab=hfl>

Manufacturing Automation Laboratory

This teaching-learning facility is the hands-on laboratory for the Real Time Process Control course where students design, build, and control scaled models, mainly emulating real manufacturing operations. The emphasis is in the use of

programmable logic controllers (PLC), industrial sensors and actuators, pneumatics, and computer-based human machine interfaces. The laboratory counts with 20 workstations equipped with all the necessary software and hardware. The facility is available for demonstration and custom trainings.

Contact:

Dr. Lourdes Medina

lourdes.medina@upr.edu

Industrial Engineering Department

Phone: 787-832-4040 Ext 3819

<http://ininweb.uprm.edu/labs.asp?lab=mal>

Statistical Quality Control Laboratory

The laboratory is equipped with Statistical software for data analysis, design of experiments, and validation procedures. It can also provide hands-on demonstrations for applied statistics courses and for simulation courses.

Contact:

Dr. David González

david.gonzalez6@upr.edu

Industrial Engineering Department

Phone: 787-832-4040 Ext 3819

International Service Systems Research Lab (ISSER)

ISSER is a research and consulting laboratory within the Industrial Engineering department at the University of Puerto Rico at Mayaguez. The Mission is to support ongoing research and professional services that advance the understanding, design and evaluation of complex service-delivery systems. A service system (or value co-creation system) is a configuration of technology and organizational networks designed to deliver services that satisfy the needs, wants, or aspirations of customers. Marketing, operations, and global environment considerations have significant implications for the design of a service system as well as human considerations, given that most services are co-created by human providers and customers. Research areas are grounded in service science theory, operations research tools and techniques and statistical analysis of customer data. One important and emerging area of research is how culture and other behavioral factors affect intercultural service systems and how one can design them to minimize negative effects while maximizing benefits. Research thrust areas include:

- Survey research and qualitative customer data analysis
- Systems Thinking and Systems Integration
- Operations Research

- Data Envelopment Analysis
- Facilities Design

In the consulting arena, ISSER faculty aims at working with the private sector and government with the goal of recommending a system design that is capable of delighting customers while achieving world-class efficiencies. This is done through the application of scientific design principles to real life problems affecting the service industry such as specific IE and OR tools for the improvement of systems in specific research areas.

Contact:

Dr. Alexandra Medina Borja

alexandra.medinaborja@upr.edu

Industrial Engineering Department

Phone: 787-832-4040 Ext 3819

<http://ininweb.uprm.edu/iSSER/>

Bio-Industrial Engineering Laboratory (Bio IE Lab)

The Bio IE Lab focuses on the use of engineering analysis methods to extract biological knowledge from scientific in-silico, in-vitro and in-vivo experiments. The laboratory integrates high computing capabilities and state-of-the-art algorithms to lead data-based biological discovery. The lab work relates statistical, soft-computing and optimization techniques to biological data analysis. In particular, the search and discovery of biomarkers of cancer is a central line of work of the Bio IE lab. Located in the Industrial Engineering Department, the laboratory is equipped with four MacPro workstations and one iMac capable of running UNIX, Mac and Windows software.

Contact:

Dr. Mauricio Cabrera

mauricio.cabrera1@upr.edu

Industrial Engineering Department

Phone: 787-832-4040 Ext 3819

Lean Logistics (LeLo) Lab

The Lean Logistics (LeLo) Lab is a student-centered lab seeking to provide hands-on experience while creating practical research-based solutions to contemporary logistics problems, particularly those of Latin American countries. Currently the lab has three main streams of research: facility logistics, humanitarian logistics, and supply chain networks security. Consulting and training at the supply chain, facility, or production line level are available through the lab. The LeLo lab is partly funded by the National Science Foundation and Department of Homeland Security.

Contact:

Dr. Héctor Carlo
 hector.carlo@upr.edu
 Industrial Engineering Department
 Phone: 787-832-4040 Ext 3819

Mechatronics Center

The Mechatronics Center at the Mechanical Engineering (ME) Department is dedicated to study electromechanical systems. The center offers training and support to industry and existing ME courses while providing facilities and resources for research in the control of mechanical and electromechanical systems. Training facilities are equipped with eight laboratory work stations with basic equipment to perform experiments and projects in mechatronics. The center also includes a prototyping laboratory with additional equipment to conduct independent research projects; a design center where students will be able to share ideas and make presentations; and a full-time technician to support the center's activities. The prototyping laboratory provides students with access to specialized mechanical, electrical, and software tools for the design and realization mechatronics systems. The center also utilizes the equipment available in the Manufacturing Processes Laboratory to handle a wide variety of complex projects involving the fusion of mechanics, electronics, and software technologies.

Contact:

Dr. Pedro J. Resto
pedroj.resto@upr.edu
 Mechanical Engineering Department
 Phone: 787-832-4040 Ext 3719

Mechanical Response Research Laboratory

The Mechanical Response Research Laboratory is located at the Mechanical Engineering Department and supports research efforts in areas that focus on mechanical/material component systems. Areas ranging from structural vibration control, material characterization, infrastructure health monitoring and diagnostics, and anomaly detection in turbine temperature measurement devices have been performed. Research that has been funded from various government agencies such as DoD, NSF-EPSCoR, NASA, and private industry has lead to peer review publications and patents.

Projects topics such as:

- Characterization of sandwich composite materials
- Vibration control using shape memory alloys
- Vibration shaker design
- Damage detection and health monitoring using neural networks

- Fluid structure interaction
- Novel dynamic material characterization techniques

The MSRRL laboratory is equipped for research in mechanical/material component systems. The laboratory has a laser vibrometer for structural vibration response, several dynamic signal analyzers, acoustic emission equipment, data acquisition equipment, transducers (acceleration, Laboratory facilities include a laser vibrometer, several electromagnetic shakers with corresponding amplifiers, data acquisition equipment, transducers (acceleration, force, and temperature), conditioning amplifiers, power supplies, oscilloscopes, and computer facilities.

Contacts:

Dr. David Serrano and Dr. Frederick Just
david.serrano@upr.edu
Frederick.just@upr.edu
 Mechanical Engineering Department
 Phone: 787-832-4040 Ext 3719

Micro and Nano Devices Research Laboratory

The Micro and Nano Devices Research Laboratory is a Class 100 (ISO Class 5) cleanroom for photolithography located at the UPRM Research and Development Center. The facility houses a SUSS MicroTec Mask Aligner (MA-6) with backside alignment, a Reactive Ion Etcher with CF₄ chemistry, a multiple target (AC/DC) Sputtering System (AJA Orion Thin Film Deposition System), a Stylus Profilometer (KLA Tencor P-6), a chemistry hood and photolithography peripherals.

Contact:

Dr. Rubén E. Díaz
rubene.diaz@upr.edu
 Mechanical Engineering Department
 Phone: 787-832-4040 Ext 3719
 Dr. Agnes Padovani
agnes.padovani@upr.edu
 Engineering Sciences and Materials Department
 Phone: 787-832-4040 Ext 6318

New Materials Development Laboratory (NMDL)

NMDL is responsible for matching many new differentiated materials and technologies with market needs in the areas of bioengineering, alternative energy and electronics. The NMDL include a materialographic laboratory, a mechanical testing facility (including a DMA), thermal chambers, tribometers Basic equipment for materialographic preparation, hardness testers, heat treatment furnaces and a sophisticated optical imaging system are

available. NMDL performs sponsored research from various government agencies such as: DoD, NSF, NIH, and various private industries for example Lockheed Martin.

Contact:

Dr. Paul Sundaram

paul.sundaram@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 3719

Vehicle Design and Research Laboratory

Vehicle Design and Research Laboratory is involved with research and development of high performance and alternate fueled vehicles for current and future transportation needs. It is equipped with a Design Center and a Machine Shop, two chassis dynamometers both and emissions measurement equipment. Data acquisition instrumentation is available for vehicle development and optimization. Current research includes: energy management for solar powered, electric and hybrid vehicles, motorsport vehicle optimization, high speed maglev transportation systems and remote control aircraft. Undergraduate student projects include Formula SAE, SUN, SAE Mini Baja and SAE Aerodesign.

Contact:

Dr. David Serrano

david.serrano@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 3719

Biosensing and Microfluidics Research Laboratory (BMRL)

The Biosensing and Microfluidics Research Laboratory (BMRL), led by Dr. Rubén Díaz-Rivera and Dr. Pedro Resto, is 900 sq. ft. facility located in the Department of Mechanical Engineering at UPRM. The purpose of this laboratory is to facilitate the design, construction and use of microfluidic systems for cell studies and biosensing applications. The laboratory houses a small cell culture facility, a faraday-caged microscopy setup for electrical/optical characterization of microfluidic devices, and tools for performing PDMS soft lithography. The laboratory has a LabSmith Synchronized Video Microscope workstation with black & white and EPI-fluorescent optic modules, controlled with a Dell Precision T1700 desktop computer, for microfluidic visualization and data acquisition. In addition, the laboratory houses a workstation for fluid mechanics and multiphysics simulations. The workstation was built in-house and is powered with the latest generation of Intel's Core i7 processor and 32 GB of RAM. Licensed software includes COMSOL Multiphysics 4.4 and CD-adapco

Star CCM+ Version 9 as well as the usual MS Office Suite. The laboratory has access to a rapid prototyping facility having a 3D printer, a small scale CNC and an electronics workstation. The laboratory also has access to a Dantec Dynamics Micro Particle Image Velocimetry System for the fluidic characterization of micro-scale devices, in collaboration with the Bubble Dynamics Laboratory.

Contacts:

Dr. Rubén E. Díaz Rivera

rubene.diaz@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 3719

Dr. Pedro J. Resto Irizarry

pedroj.resto@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 3719

Biomechanics and Biomaterials Laboratory (BBL)

The Biomechanics and Biomaterials Laboratory is dedicated to research and education principally in the area of characterization and testing of biomaterials. This Laboratory is equipped with a Tribometer, a DMA, Minimat tensile tester, Potentiostat/Galvanostat and an Analytical balance. Characterization of the wear resistance, tensile, compressive and fatigue properties are performed in this facility. Corrosion resistance and behavior through potentiodynamic polarization, cyclic voltammetry and electrochemical impedance spectroscopy are measured in this laboratory.

Contact:

Dr. Paul Sundaram

paul.sundaram@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 3719

High Performance Computing and Visualization Laboratory (HPCVL)

The HPCVLab is located in room L-127 of the Lucchetti building in the Mechanical Engineering Department. It performs investigation in computational fluid dynamics of turbulent flows with heat transfer, algorithm development, parallel programing, high performance computing, and scientific visualization; particularly, for fundamental thermal-fluid research with applications to aerospace. The facility is equipped with a powerful GPU cluster, two workstations (with 128 and 64 GB of RAM memory, respectively), a virtual reality kit, a high-resolution monitor, and several terminals for remote connection to supercomputers: Blue Waters, Stampede, and Comet in US as well as MareNostrum 4 in the Barcelona Supercomputing Center (Spain).

The Air Force Office of Scientific Research (AFOSR), National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and the Extreme Science and Engineering Discovery Environment (XSEDE) provided initial funding for HPCVLab and its research projects. The mission of the HPCVLab is to promote and facilitate thermal-fluid research by means of cutting edge computing and visualization technology for faculty, undergraduate and graduate students, and UPRM partners.

Contact:

Dr. Guillermo Araya

j.araya@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 5720

Human-Centered Design Research and Development Laboratory

The Human-Centered Design Research and Development Laboratory purpose is to enhance quality of life by understanding human behavior and cognition to connect Design and Engineering for the development of knowledge and products for social well-being. Currently, the laboratory focuses in three areas: the intersection between Design and entrepreneurship, Design for aesthetics, and Virtual Reality for Engineering applications. The laboratory is equipped with various high performance computers and head mounted displays (e.g. Oculus Rift) for the virtual reality experiments. In addition, a range of input output devices is available for inclusion in virtual reality experiments. The laboratory offers visualization of complex engineering analysis and product assemblies in support of ME courses and other partnerships.

Contact:

Dr. José E. Lugo Ortiz

jose.lugo2@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 3486

The Bubble Dynamics Laboratory (BDL)

At the bubble dynamics laboratory of the University of Puerto Rico – Mayaguez, cutting edge research is being conducted for understanding, producing and characterizing milli-micro- and nano-bubbles through the design of acoustic resonators. We develop experimental systems for validation and/or formulation of theoretical models involving the generation and collapse of bubbles with applications on the mechanical, naval, biomedical, agricultural and nuclear energy industry. The laboratory, located in the Mechanical Engineering Department at UPRM (Lucchetti Building), houses state of the art equipment

including: a 3D stereoscopic PIV (Particle Image Velocimetry) system with the capability to perform shadow-sizing micro-PIV and Laser Induced Fluorescence (LIF), a Dynamic Mechanical Analyzer (DMA), an Asymmetric Flow Field Flow Fractionator (AFFFF), a Nanoparticle Tracking Analyzer (NTA) and a Static and dynamic light scattering (SLS-DLS) equipment. The BDL laboratory is also equipped with modern data acquisition and measuring devices and it is supported through research funded by the National Science Foundation, Department of Defense, Department of Energy, the US Nuclear Regulatory Commission and the Puerto Rico Science Technology and Research Trust.

Contact:

Dr. Silvina Cancelos

silvina.cancelos@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext 5956 or 6382

The NANOmaterials Processing Laboratory

This multiple user laboratory, located at Stefani 313/314, comprises 900 sq ft of space intended for basic manufacturing and advanced synthesis of materials. Among the instrumentation relevant, there is a Cee 200 Spin-coater system from Brewer Science, Inc., a Mercury-Xenon 200W-UV lamp from Oriel Instruments, Inc., and a Thermo Fisher vacuum oven. Additional pieces of equipment available in this laboratory are: a Buehler Beta manual polishing unit, a Sartorius T212 balance with two density determination kits, a Struers Lectropol 5 electropolishing unit that permits final preparation of samples free of mechanical polishing hardening, a Buehler ISOMET 1000 high-precision diamond saw, and a fully automatic Leco LCR-500 Rockwell-type hardness testing system. Three dispersing tools available in the lab are: a high spindle speed homogenizer (KA T18 with S18N-19G dispersing tool), a low spindle speed Labmill – 8000, and a Cole Parmer ultrasonic processor. Additional equipment for materials synthesis and/or processing include: a 4575 model HP/HT Pressure Reactor from Parr Instruments Company, a 1100°C Vacuum Chamber Furnace (7.5"IDx 13"L, 7.6 Liter) with 30 Segments Programmable Temperature Controller - VBF-1200X-H8, and a model AUT-501 Automated Laboratory Titrator from DKK – TOA Corporation. The latest acquisition for materials synthesis is a Microwave Accelerator Reactor System, Model MARS 6 from CEM Corporation and a Siemens D500 X-ray diffractometer for structural analysis.

Contact:

Dr. Oscar Perales

oscarjuan.perales@upr.edu

Department of Engineering Sciences and Materials

Phone: 787-8324040 Ext 2398

The BioNANO Systems Laboratory

This Laboratory is located on the first floor of the Main Engineering Building (Stefani 106) and is devoted to do research on nanomaterials-based platforms for nanomedicine and biomedical applications. This 426 ft² layout facility hosts chemical-resistant bench tops, sinks, cabinets and Class 100 acoustic panels. The lab has a safety shower, eye irrigation station, flammables and acids storage cabinets, and a first aid kit. All equipment and facilities for cancer cell culture are available for research and training purposes at the graduate and undergraduate levels. Among the most important pieces of equipment, this laboratory hosts 2 Forma Scientific cell incubators, a laminar flow hood, a chemical hood, one Olympus phase-contrast microscope, one Olympus Eclipse 8000 fluorescence microscope, one BioRad cell counter, a ThermoFisher Scientific spectrophotometer, PCR equipment, a CO₂ chamber and one cell counter for cell viability measurements.

Contact:

Dr. Oscar Perales

oscarjuan.perales@upr.edu

Department of Engineering Sciences and Materials

Phone: 787-8324040 Ext 2398

Engineering Office of the Associate Dean for Research and Innovation (DR&I)

The DR&I proposes and implements the course of action of the College of Engineering (CoE) towards the strengthening of its leading position in Translational Research across UPRM, Puerto Rico and the Americas. The DR&I is in charge of overseeing of the research facilities within the CoE, recognizing emerging research areas, and promoting the development and implementation of strategic research clusters aligned to new graduate programs while updating of the current ones. The DR&I is also responsible for the guidance, evaluation, and verification of administration & compliance issues associated to research activities. Intellectual property (IP) matters are inherent to many of the activities within the CoE; therefore, a working understanding of IP becomes indispensable to manage related issues when interacting with academic peers, governmental offices or industrial partners. Accordingly, the Office of Intellectual Property and Technology Transfer (IP & TT), hosted by the DR&I, provides specialized

support to UPRM at large, starting from education and training, passing through invention disclosures, patent application and final patent assignment.

The above described activities are complemented with a dynamic and effective dissemination of the achievements and contributions of the CoE to the well-being of Puerto Rico in concordance with a healthy and robust partnership with Academia and Industry partners. On this basis, the DR&I office has been re-structured to provide qualified technical and administrative support in: (1) Research & Compliance; (2) Innovation & Intellectual Property; (3) Corporate Image & Partnerships; (4) Research Infrastructure & Facilities, and (5) Project Support.

Contact:

Dr. Oscar Perales-Perez

Associate Dean for Research & Innovation

decano.ingenieria@upr.edu

Phone: 787-832-4040 Ext 3822

<http://engineering.uprm.edu/research/>

JOUST: The Journal of Undergraduate Research Students

JOUST is an initiative of the College of Engineering at UPRM motivated by the need to disseminate the very energetic, but often overlooked, undergraduate efforts in research. JOUST is a two-component forum for undergraduate research: (1) an online technical journal with peer-reviewed short communications (5-pages maximum per article), and (2) a companion website to enrich the learning experience with pictures, interviews, videos and additional information especially prepared for the undergraduate audience. JOUST is issued online twice a year (once per academic semester) and accepts submissions from STEM fields and the Social Sciences both in English and Spanish. A submission entails a technical article as well as additional multimedia material geared to enrich the undergraduate learning experience. JOUST follows an Open Access format with articles distributed under the terms and conditions of the Creative Commons Attribution License. JOUST can be reached through Facebook: <https://www.facebook.com/JoustContact>

Puerto Rico and US Virgin Islands Climatology Center

Located at the Department of Marine Sciences, this center provides the latest climate data and weather information available for the Caribbean. It has access to a network of over 120 stations located throughout Puerto Rico and over 20 stations around the U. S. Virgin Islands. The Climate Center is also a repository

for a wealth of information on climate data obtained from many other organizations, such as the National Climate Center, Asheville, North Carolina, and the Climate Analysis Center, Washington, D. C. The Center receives journals on climate topics and holds a large collection of climate data on CD-ROMS.

Puerto Rico Water Resources and Environmental Research Institute

PRWRERI is one of 54 water research centers established throughout the United States and its territories by an act of Congress in 1964 which presently operates under Section 104 of the Water Research and Development Act of 1984 (P.L. 98-242). Since its foundation, the Puerto Rico Water Resources Research Institute has sponsored a substantial number of research projects supported jointly by federal and university funds.

The PRWRERI is a component of the Research and Development Center of the University of Puerto Rico at Mayagüez. As such, it acts as the official liaison of the University of Puerto Rico with industry and government agencies for all water resources research activities. The Institute also functions as an advisor to these two sectors on water resources issues. This role translates into multidisciplinary functions and activities which add relevance and impact to the Institute research efforts.

By virtue of the local relevance of its research and the prestige and leadership of its investigators, the Institute has become the focal point for water-related research in Puerto Rico. Meetings, seminars, technical reports, and a quarterly newsletter keep the water resources community and general public informed about advances in research. Approximately, once every two years, the Institute organizes major conferences on water-related research in Puerto Rico and the Caribbean in collaboration with other technical organizations in the region. All these activities facilitate the translation of Institute's sponsored research into practical applications of direct benefit to industry, government, and the general public.

Contact:

Jorge Rivera-Santos, Ph.D., P.E.
jorge.rivera40@upr.edu
Department of Civil Engineering and Surveying
Phone: (787) 833-0300

External Resources Research and Development Center

R&D Center was established in 1986 at UPRM to encourage and manage research and development activities in the areas of engineering, technology, and science, and to provide a technological basis to serve the Puerto Rican community. The R&D Center manages several research programs which include basic and applied research, research sub-stations for seismic investigation, industrial handling and disposal of hazardous chemical substances, natural resources renewal, and biotechnological research as well as technical support for the development of the Caribbean Basin. The R&D Center's mandate and principal functions are to promote, coordinate, and administer externally funded research projects conducted by faculty members of the Mayagüez Campus for clients from business and industrial segments, public and private organizations, and government agencies. The R&D Center's Advisory Board is comprised of fourteen members. It is chaired by the UPRM Chancellor, and includes the following members: the UPR President, the PR Industrial Development Company (PRIDCO) Executive Director, the Deans of Engineering, Arts & Sciences, Agricultural Sciences, Business Administration, and Academic Affairs, a UPRM researcher and five representatives of the industrial community, designated by the Chancellor.

All funding for the Center's research projects comes from grants provided by government agencies (Federal and insular), educational institutions, and private sponsors within the industrial community of Puerto Rico.

The R&D Center offers technical and administrative assistance to the UPRM research community through its Accounting and Finance, Budget, Purchasing, Receiving, and External Resources Offices (ORE). The Center has its own reference library within the General Library of the UPRM, which holds a specialized collection in the fields of scientific and technological research.

The R&D Center acts on behalf of researchers in conjunction with the university community and the general public. It is the instrument of promotion for the development of research on the Mayagüez Campus and serves as an intermediary between the University, the government, and the private sector. In this role, the R&D Center represents the interests of researchers on academic and administrative forums, plans and establishes UPRM's research policy regarding the island's economy and technology transfer to the

community, and administers research centers, institutes, and individual projects to encourage their development and to promote excellence.

Contact:

Dr. Marisol Vera
marisol.vera@upr.edu
R&D Director
Phone: 787-831-2065

NOAA Collaborative Science Center For Earth Systems Sciences and Remote Sensing Technologies (NOAA – CESSRST)

NOAA-CESSRST conducts research, educates, and trains a diverse group of students, early career scientists, and engineers, in NOAA-related science missions. The goal is to help create a diverse STEM workforce for NOAA and its contractors, Academia, Industries and the Private Sector. Established in 2016 through a national competition, and funded by the National Oceanic and Atmospheric Administration, CESSRST is led by The City University of New York (CUNY) and brings together Hampton University, University of Puerto Rico at Mayaguez; San Diego State University, University of Maryland Baltimore County, and University of Texas at El Paso. CREST also incorporates several industrial partners like STC, AER, Nobilis, SSAI, ERT, and IMMSG. The consortium brings together world class research capabilities for remote sensing technology consisting of exemplary faculty and research staff, advanced computational facilities, instrumentation for direct readout of satellite data and calibration/validation, experience in state-of-the-art remote sensing technology development for satellite and surface-based remote sensing, and in situ sensor systems. These capabilities drive an ambitious and research agenda for new applications of remote sensing and advancing the understanding of Earth System processes and improving predictions of weather and climate.

Faculty, scientists, and students from the Departments of Electrical and Computer Engineering, Computer Science and Engineering, Civil Engineering and Surveying, and Marine Science comprise the UPRM CESSRST team. The focus of the UPRM team research work is in remote sensing of land and coastal ecosystems, using satellite and UAV-mounted sensor data.

Contact:

Dr. Rafael A. Rodríguez Solís
rafael.rodriguez19@upr.edu
Department of Electrical and Computer Engineering
Phone: 787-832-4040 Ext. 2141
<https://inec.uprm.edu/uprm-essrst>

NSF-CREST: Nanotechnology Center for Biomedical, Environmental and Sustainability Applications

With National Science Foundation support, this Center for research and excellence in science and technology further develops the Nanotechnology Center for Biomedical, Environmental and Sustainability Applications at the University of Puerto Rico-Mayaguez (UPRM). The Center's mission is to combine transformational and interdisciplinary research and education efforts in the area of nanoscale materials by focusing on: biomedical, environmental remediation, and sustainability applications. Faculty members involved in the Center will investigate application-oriented processing of materials with properties and applications that depend on phenomena occurring at the nanometer scale: (1) Medical and Biological Applications; (2) Remediation of Recalcitrant and Emerging Contaminants from the Environment; and (3) Sustainability. This project will establish effective means to institutionalize research and education aimed at founding a sustainable platform at UPRM of international recognition. Through formative and summative assessments, a systematic project evaluation will provide information to ensure continuous improvement, focusing on achieving the proposed objectives.

This Center for Biomedical, Environmental and Sustainability Applications will develop technologies for cancer therapy, water disinfection and air cleaning, and sustainability. Despite dramatic improvements in cancer chemotherapeutics, there is still an unmet need to understand the underlying causes of treatment failures. The knowledge acquired through the proposed activities will become invaluable for the development of novel cancer therapies and materials with applications in medicine. Center goals will also address global environmental challenges associated with water and air. Sustainability-related research will also be impacted by the Center. At the undergraduate level, the Center will impact the Undergraduate Certificate in Materials Science and Engineering program, as well as undergraduate research courses in the various engineering departments.

Contact:

Dr. O. Marcelo Suarez
msuarez@ece.uprm.edu
Department of Engineering Sciences and Materials
Phone: 787-832-4040, ext. 2350, 2398
<http://crest.uprm.edu/>

Civil Infrastructure Research Center

Founded in 1991, **CIRC** began operating within the Civil Engineering Department in January 1992. For 10 years CIRC received funds from the National Science Foundation through the PR office of the Experimental Program to Stimulate Cooperative Research (PR-EPSCoR). At the present, the center receives funds from Federal Agencies (NSF, DOD, NASA, FEMA, US DOT, DOE, US FRGD), the University of Puerto Rico and the Department of Transportation and Public Works. CIRC also participates in the organization of international conferences and workshops. CIRC's mission is to help government and industry design, maintain, manage, and improve Puerto Rico's infrastructure while contributing to the expansion and improvement of the College of Engineering's undergraduate and graduate programs in infrastructure-related disciplines. CIRC developed a comprehensive strategic plan which can be accessed at <http://civil.uprm.edu/circ/>. The Civil Infrastructure Research Center has a computer center which is constantly updated with funding from projects and from the Department of Civil Engineering and Surveying.

Contact:

Dr. Ricardo López

ri.lopez@upr.edu

Civil and Surveying Engineering Department

Phone: 787-832-4040 Ext 3892, 2178, 3434

<http://circ.uprm.edu/>

Puerto Rico Seismic Network

PRSN is administered by the Department of Geology. The staff oversees a network of 25 broad and short period seismic stations and 6 tide gauges and weather stations installed in the Puerto Rico region. The main objective of PRSN is to process and analyze local, regional, teleseismic earthquakes. Data are made available to the general public and distributed among scientific and academic communities and emergency management organizations. The PRSN also operates a tsunami warning system monitoring seismic and tsunami events in Puerto Rico the Caribbean and adjoining regions.

Geological and Environmental Remote Sensing Laboratory (GERS Lab)

GERS Lab was founded in January 2002 as part of the Department of Geology in the University of Puerto Rico at Mayagüez. Our mission is to promote and facilitate the education and research of the Earth System Science using remote sensing. Current research is mainly focused on environmental

monitoring with bio-optical properties and digital images. We are also interested in developing Geographic Information Systems. Our vision is to become a prestigious laboratory in remote sensing of the Caribbean by generating innovative research and producing Earth System scientists well trained in the application of these tools. We conduct image processing and analyses of several sensors, including SeaWiFS, AVHRR, MODIS, ETM+, SAR, IKONOS, and Hyperion. Our research facilities include an image processing laboratory equipped with three Dell personal computers, two Silicon Graphics, scanners, a plotter, and color printers. We also have teaching facilities with twenty personal computers, scanners, and printers. ENVI and ArcGIS software are available in all our research and teaching computers.

Space Information Laboratory (SIL)

SIL was founded as part of the NASA Tropical Center for Earth and Science Studies (TCEESS) with the purpose of receiving and distributing satellite data from different sources. The facility is currently housing a NOAA Direct Broadcast Satellite Receiving Station, with capability of receiving data from the Suomi-NPP, JPSS-1, Aqua, Terra, NOAA-18, NOAA-19, METOP-A, METOP-B, and GCOM-W1 satellites, among others. Data is primarily used by the Space Science and Engineering Center from the University of Wisconsin, Madison, for ingestion into their forecast models, and for developing diverse imagery. Data is also used by UPRM NOAA CESSRST researchers for remote sensing of coastal environments and for calibration and validation of localized optical and microwave sensors, and other researchers at UPRM. This data is available for academic and academic research purposes. In addition, SIL houses a University of Colorado project for Multi-Constellation Multi-Frequency GNSS Data Collection Arrays for Low Latitude Atmospheric Effects Studies.

Contact:

Dr. Rafael A. Rodríguez Solís

rafael.rodriguez19@upr.edu

Department of Electrical and Computer Engineering

Phone: 787-832-4040 Ext. 2141

Weather Radar Network of Puerto Rico at UPRM

A weather research network comprised of two types of X-band weather radars was developed thanks to funding from two NSF programs; Engineering Research Centers (ERC) and Major Research Instrumentation (MRI). The first type of radars are the small Off-the-grid (OTG) radars which measure only rainfall rate and are capable of operating with renewable (wind and/or solar) power in case of

blackouts which are common during extreme weather events. The other type of radars are more sophisticated Doppler Polarimetric weather radars called Tropinet, which are capable of measuring rainfall, wind speed and other hydrometeors such as hail, among others. The network comprises 3 Tropinet and 5 OTG distributed mainly on the west side of the island of Puerto Rico and they could complement the data from the NWS radar located on the East of the island (in Cayey).

The new network uses a dense network of radars capable of very high spatial and temporal resolution, which is necessary for better prediction of landslides, flooding, tornado warnings and other meteorological phenomena. These systems operate collaboratively within a dynamic information technology infrastructure, adapting to changing conditions in a manner that meets competing needs of end users, the government, private industry, and the public.

Contacts:

Dr. Sandra Cruz Pol, Dr. José Colom Ustáriz

cruzpol@ece.uprm.edu

colom@ece.uprm.edu

Electrical and Computer Engineering Dept.

Phone: 787-832-4040 Ext 2448

<http://weather.uprm.edu>

Rapid System Prototyping Laboratory (RASP)

The Rapid System Prototyping Laboratory (TI-ICDL) is located in Room 208, Stefani Building in the UPRM campus. The facility provides 420sq. ft. of space devoted to the tasks of developing technologies and applications for prototyping algorithms, circuits and electronic systems on quick turn-around technologies like Field Programmable Gate Arrays (FPGA) and advanced hardware platforms. RASP was established in 2002 with the sponsorship of multiple entities, including Texas Instruments, The National Science Foundation, IBM, Xilinx, Harris, and Lockheed-Martin, among others. The main mission of the RASP Laboratory is to enable graduate students acquire the necessary training, skills, expertise, and capabilities to conduct academic and industrial research work in the field of rapid prototyping digital and mixed-signal electronic systems..

Contact:

Dr. Manuel Jiménez and Dr. Rogelio Palomera
manuel.jimenez1@upr.edu/palomera@ece.uprm.edu

Electrical and Computer Engineering Department

Phone: 787-832-4040 Ext 3780

http://ece.uprm.edu/index.php/About_RASP

The Power Electronics Laboratory

The main focus of this laboratory is for advance undergraduate education on power electronics and aerospace systems using graduate research techniques. Graduate students are welcome to do partially their related research work in the facility, and serve as mentors to the undergraduate research students. This facility is located in Stefani building (S101) and occupies about 100 sq ft. This laboratory has one Printed Circuit Board Rapid Prototyping System, 3D Printers, High temperature PCB Oven, Portable Drill/Saw Machinery, Network/Impedance/Spectrum Analyzer 10Hz-500 MHz, Milling/Drilling Machinery, and Lead-Free Soldering Station. This facility also includes the usual assortment of oscilloscopes, waveform generators, multi-meters, computers, etc. The laboratory has Software Licenses for SABER, P-spice, Matlab, and others useful for the design unmanned systems. This facility is useful for fabrication, characterization, and testing unmanned system prototypes and renewable energy systems. The UPRM's Power Electronics Laboratory is sponsored in part by the UPRM's ECE Industry Affiliates Program, Sandia National Laboratory, CIESESE Program and the US DoEnergy/NNSA.

Contact:

Dr. Eduardo I. Ortiz-Rivera

eduardo.ortiz7@upr.edu

Department of Electrical and Computer Engineering

Phone: 787-832-4040 Ext 6282

<http://minds2create.ece.uprm.edu/>

Texas Instruments Integrated Circuits Design Laboratory (TI-ICDL)

The Texas Instruments Integrated Circuits Design Laboratory (TI-ICDL) is located in Room 210B, Stefani Building in the UPRM campus. The facility provides 800 sq. ft. of space devoted to the tasks of designing and testing analog, digital, and mixed-signal integrated circuits and systems. The facility was established in 1999 with the sponsorship of Texas Instruments (TI) under the UPRM-TI Collaborative Program. It provides 16 design workstations running industry-grade software tools for the design entry and verification of integrated circuits developed in bipolar and MOS technologies. In addition, the lab provides four testing stations with state-of-the-art test and measurement tools used by senior and graduate students, in advanced and graduate course projects in electronics as well as graduate research students for their projects.

Contact:

Dr. Manuel Jiménez and Dr. Rogelio Palomera
manuel.jimenez1@upr.edu/palomera@ece.uprm.edu
 Electrical and Computer Engineering Department
 Phone: 787-832-4040 Ext 3821
<http://ece.uprm.edu/icdl/>

Parallel and Distributed Computing Laboratory

The PDC Group performs research in the design, implementation, and efficiency measurements of parallel algorithms. It also addresses research issues related to parallel and distributed computing systems with an emphasis in high-performance cluster computing and Grid computing. Our work includes a wide spectrum of experiences from computing systems to modeling and simulation of physical and biological phenomena.

The mission of the PDCLab is to stimulate and facilitate the growth necessary to extend the state of the art in parallel and distributed computing systems, while fostering a multidisciplinary research and educational environment for faculty, undergraduate and graduate students, and partners at UPRM.

Contact:

Dr. Wilson Rivera
wilson.riveragallego@upr.edu
 Electrical and Computer Engineering Dept.
 Phone: 787-832-4040 Ext 3821
<http://ece.uprm.edu/PDC/>

Microgrid Laboratory

The Microgrid Laboratory offers several experimental research, development, and education platforms, integrated in a single operational system. The facility is designed to run experiments at all levels of controls. It is composed of a DSPACE system and an inverter-based setup, two electronic DC power sources, loads, and two computers. The setup consists of four inverter-based generators, which can simulate different microgrid configurations. The microgrid setup includes the following equipment: 1×dSPACE system, which includes: 1 CPU board (ACE1006), an expansion box (PX10), a 16-channel A/D board (DS2004) and a connection (CP2004), 2 digital I/O boxes (DS4003), output board (DS5101) and connector (CP5101), the box of the whole system, and the digital bus cable, 1×10kVA transformer for grid connection; 4×2.2kW DANFOSS inverters; 1×Data logger; 2×screens; and 1× PC. In addition, to generate the DC link that supply each DC/AC inverter the facility has a 5kW AC/DC power electronics supply.

Also, an electric motors and drives setup is dedicated to component testing and prototyping, component modeling, and simulation. There is a test bench for implementation of control and identification algorithms for drives and power electronics applications. The test bench is based on the rapid prototyping system for control algorithms using the Dspace 1104 board. The laboratory also has the following equipment: UPRM built 3 phase rectifier/inverter for motor control, 1 HP; Controllable DC power supplies.

Contact:

Dr. Fabio Andrade and Dr. Marcel Castro Sitiriche
fabio.andrade@upr.edu, marcel.castro@upr.edu
 Department of Electrical and Computer Engineering
 Phone: 787-832-4040 Ext 5954, 6190

Microwave and Millimeter-wave Antennas and Remote Sensing Systems Laboratory (MAReS)

MAReS was created in 2000 through a Major Research Instrumentation grant from NSF. The laboratory instrumentation includes microwave and millimeter-wave instrumentation that allows us to perform circuits and antenna measurements up to 67 GHz, rapid prototyping equipment for printed circuit boards up to 10 GHz, and design workstations with commercial software for microwave circuits and electromagnetic simulations. The laboratory facilities have supported numerous research projects throughout the years, including projects under the NSF Engineering Research Center for Subsurface Sensing and Imaging Systems (CenSSIS), NSF Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA), and the NASA Tropical Center for Earth and Space Studies (TCESS). The laboratory has also supported projects from the Army Research Office, the Air Force Research Laboratory, the Department of Energy, and the Puerto Rico Science, Technology and Research Trust, in addition to NSF and NASA. The laboratory currently supports the NOAA Cooperative Science Center for Earth System Sciences and Remote Sensing Technologies (NOAA CESSRST), and the NSF project “*CRISP Type 2: Interdependent Electric and Cloud Services for Sustainable, Reliable, and Open Smart Grids*,” as well as other unfunded graduate and undergraduate projects. The laboratory has been a central component in obtaining more than \$7.35M in research funding since its creation in 2000, with an initial investment of \$677,000 by NSF.

Contact:

Dr. Rafael A. Rodríguez Solís
rafael.rodriguez19@upr.edu
 Department of Electrical and Computer Engineering
 Phone: 787-832-4040 Ext. 2141

SPECIAL PROGRAMS

Several comprehensive programs on campus have a special impact on research and education.

Puerto Rico Resource Center for Science and Engineering

RCSE is a consortium of the major institutions of higher education on the island, which includes the University of Puerto Rico System, Inter-American University System, and the Pontifical Catholic University of Puerto Rico. RCSE's mission is to achieve excellence in science technology, engineering, and mathematics (STEM) education in order to promote full participation of Puerto Rican students in these fields and to develop the human resources and research base needed to support the island's economic and technological development. Created in 1980 with joint funding from the National Science Foundation and the University of Puerto Rico, RCSE has been extremely successful in pursuing its goals and has experienced a sound and steadfast growth in the scope of its programs.

The high level of success at RCSE is in great part due to its development as a consortium based on a collaborative network among major institutions of higher education, while providing access to a broad pool of resources by promoting excellence. Its goals range from efforts to improve science and mathematics curricula from grades K-12 in the island's schools to the establishment of research and development capability on the island. Due to the multi-institutional nature of its structure and complexity of its goals, RCSE was established as an administrative unit of the University's Central Administration. As a special entity which is not identified with any particular academic program, level or unit, the RCSE has effectively promoted maximum collaboration among all institutions, facilitating a synergistic effect through the improvement of STEM education on the island. RCSE has acted as an intermediary among consortium institutions, bringing them together to identify major problems and needs in STEM education and to develop innovative programs to address these needs. Key academic and administrative officials from all member institutions participate actively in the planning and implementation of the RCSE programs. Offices for RCSE are located on Río Piedras and Mayagüez Campuses.

Puerto Rico Transportation Technology – T² Transfer Center – Local Technical Assistance Program: PR-LTAP, FHWA

The Puerto Rico Transportation Technology Transfer Center, also known as the T² Center was created on April 1, 1986 in the Civil Engineering and Surveying Department of the University of Puerto Rico, Mayagüez Campus. The Center is funded by the Puerto Rico Department of Transportation and Public Works (PRDTPW) and the Federal Highway Administration (FHWA). Currently the T² Center is part of a network of 52 Centers (one in each state, one national tribal center and Puerto Rico). All Centers are members of the National Local Technical Assistance Program Association (NLTA). At the national level, the LTAP Centers are under the Center for Local Aid Support (CLAS) of the FHWA.

Since 1996 the Puerto Rico T² Center is part of the reorganization of the FHWA the Center is part of the Southeastern region with the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. Each region has a member in the Executive Council of the NLTA. The Centers Directors of each region collaborate in organizing a regional meeting and conferences and sharing technology transfer materials and instructors. At the local level, the Puerto Rico T² Center receives assistance and guidance from an Advisory Committee consisting of members from the state Department of Transportation and Public Works and the Puerto Rico Highway and Transportation Authority, Metropolitan Bus Authority and Municipalities.

The T² Center Director and Administrative Staff are very active as spokesperson for the Decade of Action for Road Safety in Puerto Rico, the Dwight David Eisenhower Transportation Fellowship Program for Hispanic Serving Institutions (DDETFP-HSI) and the State Transportation Innovation Council (STIC).

Seminar Program

The seminar program of the T² Center is geared to local transportation officials from the 78 municipalities in Puerto Rico and the Puerto Rico Department of Transportation and Public Works. The annual program includes at least 50 seminar days. The level of training and the selection of the instructors depend upon the topic and the audience to be addressed. Three major categories of seminars are offered: technical seminars, hands-on demonstration seminars and webinars. Technical seminars correspond to topics of technical nature related to

transportation, such as pavement design, pavement rehabilitation and management, materials, drainage, highway safety, traffic engineering, geographic information systems, surveying, geotechnical and environmental. In addition, seminars that complement routine transportation related activities of administrative nature, including motivational aspects, supervisory and management skills, tort liability, and ethics are also offered.

All seminars are accredited by the International Association for Continuing Education and Training (IACET), through the College of Engineers and Surveyors of Puerto Rico. Engineers and Surveyors that are in good standing can register on our seminar program for contact hours applicable to the renewal of their professional license.

Technical Library & Audiovisual Material

The T² Center provides technology transfer materials in the form of technical publications and audiovisual materials to municipalities and transportation officials upon request. The T² Center also maintains a library of technical reports associated with the field of transportation. The library includes over 3,000 research reports, technical magazines, transportation and highway engineering textbooks, proceedings of transportation related conferences, and catalogues of information services that assist in the acquisition of technical information not available at the Center. This library is complemented with newsletters received from the other LTAP Centers as well as CD's from the Transportation Research Board (TRB), the Institute of Transportation Engineers (ITE) among others.

The T² Center has audiovisual material from recognized profit and non-profit organizations associated with transportation such as International Road Federation (IRF), Federal Highway Administration (FHWA), American Road and Transportation Builders Association (ARTBA), American Public Works Association (APWA) and Transportation Research Board (TRB).

T² Information Service / Technical Assistance

The T² Center provides technical assistance and information services to municipalities as requested using university staff, Center Director and through its web page, www.uprm.edu/prt2. The information provided is in terms of advice, guidance, or referral to published materials, new video and CDs associated with highway safety, drainage, pavement maintenance, traffic congestion, roundabouts, environmental issues associated with surface

transportation and other pertinent areas associated with the built transportation infrastructure in Puerto Rico. Letters, electronic mails and personal contact are also used to handle individual request. Many of these requests have been used to develop a seminar topic of interest to transportation officials from the municipalities and DTPW.

Every Day Counts (EDC)

The T² Center also performs training and research activities through the Every Day Counts (EDC) initiative, sponsored by the Federal Highway Administration (FHWA) of the US Department of Transportation (USDOT). This federal program includes innovation, ingenuity, invention and imagination as pillars in the selection of emerging technologies associated with highway transportation. The program is designed to identify and deploy innovation in strategic areas aimed at shortening project delivery, enhancing the safety of our roadways, and protecting the environment. Examples of the EDC initiatives implemented in Puerto Rico with the assistance of the T² Center includes safety edge, warm mix asphalt, pre-fabricated bridge elements, pavement preservation, high friction surface treatment, programmatic agreements, intersection and interchange geometrics, implementing quality environmental documentation, intelligent compaction, accelerated bridge construction, traffic incident management, road diet, data driven safety analysis.

Special Projects

The T² Center participates in short-term projects to complement its technology transfer activities. These projects are of interest to the municipalities and to the Puerto Rico DTPW. A sample list of special projects that the T² Center has participated are listed below:

- Development of microcomputer software associated with transportation.
- Identification of municipalities needs related to transportation.
- Development of guidelines for the municipalities on how to prepare Request for Proposal (RFP) related to public transportation projects.
- Translation and adaptation of Federal guidelines related to different aspects of the mass transportation program.
- Development of technical videos regarding the proper use of asphalt, concrete and soils, in road and bridge construction.

- Spanish translation of Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects (FP-85).
- Development of technical guidelines for traffic control in construction zones.
- Participation in the Strategic Highway Research Program (SHRP) Assessment Project regarding the documentation of successful stories associated to the implementation of safety products in highway construction zones, and the inventory of existing pavement distresses.
- Surveys to determine the need of municipalities with a population less than 50,000.
- American with Disabilities Act (ADA) and its legal implications.
- Evaluation of existent transportation facilities in municipalities with a population less than 50,000.
- Evaluation of marketing methods to promote public transportation in municipalities with a population less than 50,000.

Contact:

Benjamín Colucci, PhD, PE, PTOE, FITE, JD, API
Director

benjamin.colucci1@upr.edu

Civil Engineering and Surveying Department

Phone: 787-832-4040 Ext 3393

<http://prltap.org/eng/>

Puerto Rico Strong Motion Program

The Puerto Rico Strong Motion Program (PRSMP) has the mission to minimize the fatalities and the economic losses during moderate and high intensity earthquakes through the seismic instrumentation and supporting related research. The PRSMP has two main divisions: the free field stations, and the seismic instrumentation of structures. Regarding the free field stations there are 110 strong motion stations in the main island, surrounding islands (Mona, Caja de Muerto, Culebra and Vieques) and countries US Virgin Islands, British Virgin Islands (BVI), and Dominican Republic. Fifteen stations are continuous recording and sending the data through Internet while other 46 are modem connected. In addition, there are twelve continuous recording joint seismic stations where accelerograph and broad band seismograph are one beside the other. The program uses both the Antelope and Earthworm Network Administrator.

Regarding the instrumentation of structures there are five buildings, nine dams, two bridges, and the Control Tower of the BVI main airport instrumented. Strong Motion records are available upon request. The program is housed in the Civil Engineering and

Surveying Department. It is funded from a grant assign by the PR Legislature.

Contact:

Dr. José a. Martínez Cruzado

jose.martinez44@upr.edu

Civil and Surveying Engineering Dept.

Phone: 787-832-4040 Ext 3406

<http://prsmpr.uprm.edu/prsmpr2/>

Education and Research Internship Program (ERIP)

ERIP is a model Summer Education and Research Internship Program sponsored by the US ARMY Corps of Engineers and coordinated at the Department of Civil Engineering and Surveying at the University of Puerto Rico at Mayagüez for near three decades. Near 600 interns have participated in the program which serves as a pipeline to graduate programs, terminal degrees and competitive research and development jobs. It begins orientations every January. Students express this has been a life changing experience in their academic and professional careers. For 10 weeks the students will receive technical and scientific training in the different national laboratories of the Engineer Research and Development Center (ERDC). ERDC has seven research labs where our students may participate.

Contact:

Prof. Ismael Pagán Trinidad, PI and Program Manager

ismael.pagan@upr.edu

Civil and Surveying Engineering Dept.

Phone: 787-832-4040 Ext 3393

<http://www.uprm.edu/inci/erdc-erip>

UPR Sea Grant College Program

Since 1980, the University of Puerto Rico Sea Grant College Program has been working to promote the conservation, sustainability and wise use of the coastal and marine resources of Puerto Rico and the U.S. Virgin Islands. This is one of 31 programs which conform the National Sea Grant Program created in 1966 with the signing of Public Law 89-688, the National Sea Grant and College Program Act. The aim of UPR Sea Grant is to better inform public policy makers, change resource user attitudes and practices, develop educational curricula and promote conservation and sustainable economic development. The UPR Sea Grant program achieves its mission through a multifaceted approach which includes research, outreach and formal(K-12) education programs.

UPR Sea Grant links the university setting, which focuses on the development of theoretical and applied

research, with regional and national agencies, and stakeholders producing a better understanding of marine technologies, seafood production (including marine aquaculture), coastal ecosystem health, and coastal economic development (including human environmental impact, and public safety). Sea Grant provides research and educational opportunities to graduate and undergraduate students of all fields related to conservation of marine resources. The information produced by research activities is organized and disseminated through workshops and activities developed by the Marine Outreach Program and the education component of our program.

Center for Pharmaceutical Engineering Development and Learning

CPEDaL is a center focused on providing services of process and product development, troubleshooting, training, materials characterization and related tasks to the pharmaceutical industry, contractors, and R&D groups among others. Companies such as Janssen, Lilly del Caribe, Neolpharma, BMS, Pfizer have used CPEDaL for specific needs in the last three years.

The center also supports the learning of undergraduate students through formal courses, for example InQu 4029 Pharmaceutical Operations, and undergraduate research.

In addition, CPEDaL receives students from junior and high schools to spend a day at the laboratory performing experiments and learning about pharmaceutical engineering. Every summer the Pharmaceutical Engineering Summer Camp is held at the laboratory where 24 students from 10th and 11th grades spend a whole week performing experimental work.

This Spring 2016, a pharmaceutical engineering minor was approved to strengthen the academic offering in pharmaceutical engineering. For more details, please visit cpedal.uprm.edu.

Contact:

Prof. Carlos Velazquez

Director

carlos.velazquez9@upr.edu

Phone: 787-832-4040 Ext. 5813

Mrs. Carmen V. Santiago

carmenv.santiago@upr.edu

Phone: 787-832-4040 Ext. 5816

Center for Aerospace and Unmanned Systems Engineering (CAUSE)

Center for Aerospace and Unmanned Systems Engineering (CAUSE) is the First Center of Excellence in the Caribbean to provide a framework for broad-based, competitive, multi-institutional, multidisciplinary science and engineering research that will advance the aims of space, aeronautic, and astronautic Mission Directorates across the nation and world at large. The center will foster synergy between the following science and engineering directorates: (i) unmanned systems, (ii) aeronautic, and (iii) space. The center provides an interdisciplinary environment that enables and facilitates participants to carry out collaborative educational and research of a scope and complexity that is not possible through traditional funding models. The Center's overall mission is to leverage our strong theoretical, computational, and experimental programs to advance the frontiers of fundamental and applied research while educating a new cadre of STEM students. We intend to create strong collaborative relationships with the current aerospace industries, centers, institutes, schools and universities.

CAUSE allows students and faculty to learn and apply concepts about flight and unmanned systems, whether in the atmosphere or space.

Contact:

Dr. Sheilla Torres Nieves

sheilla.torres@upr.edu

Mechanical Engineering Department

Phone: 787-832-4040 Ext.6379

<https://engineering.uprm.edu/cause/>

OASIS Project

Electric energy networks are the cornerstone of the civil infrastructure of our society. These networks provide the energy essential to carrying out daily operations in education, health care, commerce, entertainment, defense, and government. However, electric energy markets, due to their vertical integration, often exclude customers from the processes associated with energy production, pricing, transmission and distribution. Smart grids and distributed generation schemes have been proposed as mechanisms to modernize energy grids and balance the current power structures in electric markets. In a smart grid, computers and communications networks are attached to the power generation, transmission, distribution and load elements, establishing a mechanism to gather information, control generation, control demand, diagnose problems, bid for prices in energy markets, and forecast energy consumption.

However, a smart grid creates interdependencies between the energy network and the computer network since the energy network powers the computers that in turn control the operation of the energy grid. In this project, a team from the University of Puerto Rico, Mayaguez (UPRM) will study smart grids and the interdependency between the energy grid and the IT infrastructure that is setup to manage it. This project champions a transformation of the electric grid, moving it away from being centered on centralized utilities that supply most, if not all, power services. Instead, the grid becomes a marketplace of third-party power-service suppliers, who compete to sell their electric services over the Internet. These services include energy block purchases, storage, billing, weather forecasting, energy demand forecasting, and other ancillary services. This brings in an important societal element – it empowers common citizens, whose homes are now renewable energy generation systems, to become suppliers and key actors in the energy market. This project is thus aimed at designing and developing the basic science and technology for an Open Access Smart Grid in order to create truly sustainable energy markets.

In this project, the smart grid is modelled as a collection of interdependent electric and cloud services, whose collaborative interactions help manage the smart grid. All the electric services (e.g., energy, storage, billing) are exposed to users as REST-based cloud services, enabling the development of algorithms and applications for customers, power producers, and other users to consume or subscribe to these electric services, collect operational data and customer feedback, and support analytics to predict electric energy demands. Microgrids and renewable energy systems will be important components in this framework, as they enable modularization of the grid into autonomous or semi-autonomous subsystems. The research team will develop methods to map reliable power microgrids into electric services that can be rapidly brought online to compensate for lost generation capacity or to obtain more affordable energy. A major challenge with microgrid systems is activating them without introduction major power disturbances in the system. Another challenge is forecasting the availability of renewable energy, which will be addressed this by developing rain-cell tracking frameworks for solar and wind output estimation services, and the determination of local sensors requirements to improve short-term forecasts services. Finally, the team will apply the social acceptance model to the development, implementation, management and assessment of the Open Access Smart Grid with the purpose of identifying the institutional change necessary for the

integration of all stakeholders and the effective democratization of electric services.

Contact:

Dr. Manuel Rodríguez Martínez
manuel.rodriguez7@upr.edu
 Electrical and Computer Engineering Dept.
 Phone: 787-832-4040 Ext. 3630
<http://oasis.uprm.edu/>

Pre-Engineering Program

This is a two-week summer-residential program designed to introduce talented high school students to the engineering profession. The program's main objective is to motivate participants to select and pursue careers in engineering. Upon completion of the program, participants are able to make informed career decisions. The program has served a total of 890+ students. Ninety-four percent of the students served by this program pursued careers in engineering. Funding for the program comes from corporate institutions.

Contact:

Dr. Manuel Jimenez
 Associate Dean for Academic Affairs
decano.ingenieria@upr.edu
 Phone: 787-832-4040 Ext 2038
<http://engineering.uprm.edu/academic-affairs/pre-ingenieria>

PUBLICATIONS

Atenea:

An academic journal published twice a year by the College of Arts and Sciences containing literary articles in Spanish and English.

Boletín de Avances Técnicos:

A free monthly publication by the Technical Information Center comprising titles and abstracts of recently published articles and documents which informing of new advances and developments in the areas of engineering, technology, and related fields.

Boletín Informativo de la Facultad de Artes y Ciencias:

The College of Arts and Sciences bulletin with information related to faculty members, departmental activities and achievements, serving as a link between faculty and students.

Boletín Marino:

A monthly publication of the Sea Grant Program containing information about the program's activities.

Bulletins:

A series of technical and informative bulletins about research in agriculture and related areas published by the Agricultural Experiment Station.

The Caribbean Journal of Science:

A scientific journal published twice a year by the College of Arts and Sciences highlighting research work related to the Caribbean area.

Ceteris Paribus:

The Puerto Rico Economic Review

An academic journal of socioeconomic research published online twice a year by the Department of Economics of the College of Arts and Sciences focusing on the most recent research on the socioeconomic aspects of Puerto Rico and the Caribbean.

Journal of Agriculture of the University of Puerto Rico:

A scientific periodical published twice a year by the Agricultural Experiment Station including technical and scientific articles related to the agriculture of Puerto Rico and the Caribbean.

Miscellaneous Publications: The Cooperative Extension Service publishes a series of bulletins and leaflets of interest to farmers and housekeepers about livestock, agriculture, agricultural engineering, health

and hygiene, nutrition, child care, home economics, clothing and textiles, 4-H Clubs, and other subjects.

Newsletter El Puente

A bilingual newsletter (English/ Spanish) of the Transportation Technology Transfer Center published three times a year, serving as a bridge of information with local transportation officials in Puerto Rico and the US Virgin Islands and as a vehicle for reader response consisting of brief articles about the latest transportation-related technology. Keeping abreast on the latest technical publications and audiovisual materials available, it provides a schedule of seminars and workshops sponsored by the center as well as web sites related to training in transportation. An electronic version is available at www.prt2.org.

Revista Internacional de Desastres Naturales, Accidentes e Infraestructura Civil

An international Spanish Portuguese journal published twice a year by the Department of Civil Engineering and Surveying discussing areas of natural hazards, accidents and civil infrastructure problems, as well as fundamental and applied research case studies. Papers submitted to the journal are considered through a peer-review process. Its editorial board is formed by researchers from Puerto Rico, U.S., Latin America, and Spain. An electronic version is available at <http://academic.uprm.edu/laccei/>. It has been continuously published since 2001.

COLLECTIONS

The Art Gallery located in the Carlos Chardón Building of UPRM was inaugurated in 1959. Works by both local and foreign artists are frequently exhibited. The Department of Humanities holds a permanent collection of copies of some of the great paintings and sculptures of the past.

A **Natural History Collection** located in Celis Hall and collections in the Departments of Geology and Marine Sciences serve as a nucleus for an expanding museum in the near future.

The **Geology Museum** displays a collection of fossils, minerals, and rocks, representative of the Geology of Puerto Rico. **The Planetarium** and the **Astronomical Observatory**, located in the Physics building, offer monthly evening shows.

The **MAPR** herbarium, founded in 1958, includes about 30,000 specimens of vascular plants, bryophytes, and fungi. Most of the collections are from Puerto Rico, Cuba, and the Dominican Republic; the herbarium is especially rich in collections from western Puerto Rico and the islands of the Mona Passage (Desecheo, Mona and Monito). The herbarium is located in the Biology building and is open to the university community and the general public.

A center of cultural and intellectual life on campus, the **Museo de Arte (MUSA)**, serves as a recreational space that promotes creativity through formal and informal learning. The museum hosts the legacy of the late local artist Marcos Irizarry as well as watercolors by botanical Dr. Agustín Stahl and a collection of contemporary works by Puerto Rican and Latin American artists.

OFFICE OF THE DEAN OF ACADEMIC AFFAIRS

The Office of the Dean of Academic Affairs coordinates and supervises all academic activities of the four academic colleges and the Division of Continuing Education and Professional Studies at UPRM. These include graduate programs, academic institutional research, continuing education programs, and the professional development of academic personnel. The Office is responsible for the assessment, analysis, and implementation of new curricular proposals and of revisions to existing curricular offerings in order to ensure their academic excellence and promote scholarly research activities across campus.

The Office also oversees the enforcement of existing academic procedures and regulations in order to ensure teaching, research, and service excellence. Moreover, it serves as a liaison with other higher education institutions in Puerto Rico, the United States, and around the globe in order to promote intellectual collaborations with a global vision.

The Office of the Dean of Academic Affairs supervises the following units and programs:

- Admissions Office
- Center for Resources in General Education (*CIVIS*)
- Department of Aerospace Studies and Department of Military Sciences
- Division of Continuing Education and Professional Studies
- Graduate Studies Office
- General Library
- Professional Enrichment Center
- Registrar's Office
- Teacher Preparation Program
- Office of Immigration Affairs

Graduate Interdisciplinary Courses

INTD 5001. MULTIDISCIPLINARY ARCHAEOLOGY I. Three credit hours. Two hours of lecture and two hours of laboratory per week.

Introduction to the systematic description of archaeological data, their recording procedures, analysis, and methodical synthesis of the information obtained. Includes the analysis of material remains using approaches and techniques from diverse disciplines of the natural sciences and engineering. Organized in modules of archaeometry, analysis of

archaeological materials, and synthesis of archaeological data.

INTD 5002. MULTIDISCIPLINARY ARCHAEOLOGY II. Three credit hours. Two hours of lecture and two hours of laboratory per week. Prerequisite: INTD 5001 or authorization of the Director of the Department.

Introduction to archaeological research in Puerto Rico and the Caribbean from a multidisciplinary perspective. Includes the study of archaeological sites and regions using approaches and techniques from diverse disciplines of the natural sciences and engineering. Organized in modules of introduction to archaeological theory; survey and remote sensing; excavation and geoarchaeology.

INTD 5095. APPROPRIATE TECHNOLOGY. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

General overview of technology from historical and philosophical viewpoints. Critical examination of choice inherent in technology. Traditional and new definitions of appropriate technology. Challenges and best practices to apply engineering and technology to underserved, under-funded, or wrong-development communities.

INTD 6005. THE PRACTICE OF TEACHING IN HIGHER EDUCATION. Three credit hours. Three hours of lecture per week.

Theoretical and practical issues regarding the teaching process at the university level. Study of the fundamentals of the teaching-learning process which includes: teaching and learning theories, instructional objectives, teaching planning, preparation, adaptation and use of educational materials, strategies, methods and techniques for effective teaching; and fundamentals in testing, evaluation, and assessment. All students are required to demonstrate proficiency in the areas studied by making a formal presentation.

INTD 6006. PROPOSAL AND THESIS WRITING. One credit hour. One hour of lecture per week.

Application of the principles of precise, clear, concise, formal writing in the preparation of research proposals, masters theses and doctoral dissertations.

INTD 6015. COMPREHENSIVE EXAMINATION PREPARATION. Zero credit hours. Prerequisite: to be an Option III graduate student and have completed all the courses in his program.

Study period to prepare for the comprehensive examination, which allows students to maintain their regular-student status.

INTD 6017. PHILOSOPHIC ASPECTS OF TECHNOLOGICAL CHANGE. Three credit hours. Three hours of lecture per week.

Study of non-technical aspects of the design and use of technologies with emphasis on the critical analysis of the idea of progress. Consideration of the political, cultural, and quality of life implications of current technological tendencies.

INTD 6995. INSTITUTIONAL COOP PLAN. Zero to three credit hours. Six to ten weeks during the summer or twelve to fifteen during the semester, depending on the required duration of the internship. Requisites: be a regular graduate student. To have applied to the government agency, private enterprise or foundation of his (her) choice, and to have complied with the requisites established by it. To have been selected by the host government agency, private enterprise or foundation.

Work experience supervised and evaluated by a faculty member in coordination with a government agency, private enterprise or foundation, according to the student's academic background and work requirements.

ADMISSIONS OFFICE

The Admissions Office fulfills these tasks:

1. Receives and processes all applications according to eligibility criteria.
2. Provides orientation regarding eligibility criteria.
3. Compiles, maintains, and updates statistical data regarding admissions and serves as a facilitator to the academic community that utilizes this information for tuition evaluation and other procedures.
4. Enforces University admission regulations.
5. Serves as consultant to the Administrative Board regarding admission indexes.

Office: Celis Building, 1st floor, 101

Phone: 787-265-3811; 787-832-4040 exts. 2400, 2412, 2404, 2420

Website: <http://www.uprm.edu/admisiones>

Email: admisiones@uprm.edu

PROFESSIONAL ENRICHMENT CENTER

Professional Enrichment Center (Centro de Enriquecimiento Profesional - CEP) was established in July 1996 with matching non-recurrent funds from the Central Administration. The concept for the Center originated in the Division of Continuing Education and Professional Studies under the Dean of Academic Affairs in coordination with the Project Pro-Excellence in Teaching and Learning (PEEA). The PEEA initiative arose mainly from a resolution from the Parents' Association presented to UPRM's Chancellor in 1990.

CEP was created in 96-97 by the Administrative Board, through Certification number 596, which mandates professional development activities for all faculty personnel hired since August 1997. Faculty must comply with 29 contact hours during the first year of service. The professor's participation is kept on record and it is taken into consideration for the various personnel actions at the institutional level. Additionally, certifications number 11-12-105 (2011) and 14-15-247 requires all graduate students receiving assistantships to complete 21 hours of professional development during their first year to maintain eligibility. Furthermore, in response to faculty and administrative professional development interests, CEP formed an alliance with the Research and Development Center (R&DC) to create the Research Academy for Faculty & Postdoctoral Fellows in 2012. The Research Academy's primary goal is to foster,

energize, and promote research at UPRM. The Academy offers mentorship, professional development, and social activities for researchers.

Consequently, CEP's mission is **to expose faculty members to diverse educational strategies in order to promote academic excellence and ensure high-caliber student performance.** New faculty, permanent faculty, librarians, counselors, graduate students, and academic management personnel are all considered part of the Center's mission. The Center covers all aspects of professional development including teaching, learning, assessment, evaluation, technology, and research strategies. Its goal is to create a community of well-prepared and motivated individuals who will contribute to the academic excellence of our institution.

Services include annual orientations for new faculty and all graduate students, trainings for graduate lab assistants, retreats to recruit and develop interdisciplinary teams of resource professors, and seminars for faculty and graduate students during the academic year. Activities are tailored to fit the audience's needs, involve theory along with hands-on activities. Services also include workshops for academic management, educational research activities, and individual assistance for departments and faculty. In accordance with Certification 96-76-596, CEP keeps track of faculty and graduate student participation in professional development activities. Stakeholders can access this information via CEP web site and generate reports and certificates as needed.

To fulfil its mission, the CEP coordinates with various stakeholders in order to provide offer a wide range of activities. Partners includes the Graduate Studies Office, Center for the Development of Information Literacy and Bibliographic Research (CEDIBI), Graduate Research and Innovation Center (GRIC), Research and Development Center (R&DC), Information Technology Center (CTI), and the Center for Distance Education Resources (CREAD).

For more information call (787) 832-4040, extensions 3829 or 3674, (787) 265-3829, Fax (787) 831-5249. E-mail: cep@uprm.edu. URL: <http://cep.uprm.edu>.

DEPARTMENT OF AEROSPACE STUDIES

AIR FORCE RESERVE OFFICER TRAINING CORPS (ROTC)

Air Force ROTC is designed to recruit, educate and commission officer candidates through college campus programs based on Air Force requirements.

Mission

Our mission is to develop quality leaders for the Air Force, Puerto Rico, and America.

Vision

The AFROTC vision is to be a highly successful organization, respected throughout the Air Force, the educational community and the nation.

Program Overview

The Air Force ROTC program offered at the University of Puerto Rico-Mayaguez is a 3 or 4 year undergraduate-level program by which young men and women are educated, motivated, and trained for Air Force commissioned service.

The program consists of the General Military Course (GMC) and the Professional Officer Course (POC).

General Military Course (GMC)

The GMC is a 1 or 2-year course, consisting of the following four courses: Aerospace Studies (ESAE) 3001, 3002, 3011, and 3012. These courses are designed to motivate and prepare cadets for entry into the POC. Each course meets once weekly and is two-academic hours course.

Professional Officer Course (POC).

The POC is a 2-years course, consisting of ESAE 4001, 4002, 4011, and 4012. These courses are designed to prepare cadets for active duty as Air Force officers. Each course meets twice a week and is a four academic-hours course.

Leadership Laboratory (LLAB)

LLAB is a dynamic and integrated grouping of leadership developmental activities designed to meet the needs and expectations of prospective Air Force second lieutenants and complement the Air Force ROTC academic program. It is a student planned, organized, and executed practicum conducted under

the supervision of the Professor of Aerospace Studies and Assistant Professor of Aerospace Studies.

Field Training

Students who are selected for the POC will attend a 13 days Field Training program that takes place in Maxwell AFB, AL. The primary objective of Field Training is to evaluate leadership potential to enter the POC through a transformational training environment.

Membership Eligibility

Each individual must:

1. Be a full-time undergraduate student enrolled at any of the following universities:

University of Puerto Rico:

Aguadilla
Arecibo
Mayaguez
Ponce

Inter-American Universities:

Aguadilla
Arecibo
Ponce
San German

Pontifical Catholic University of Puerto Rico

2. Participate in both AS classes and LLAB while enrolled in school to be considered a GMC or POC member.
3. Be age 14 or older.
4. Have an AFROTC calculated GPA of 2.5 or greater for all previous college-level coursework.
5. Pass the American Language Course Placement Test with at least an 80%.

Program Goals

Each student must demonstrate:

1. An understanding of the fundamental concepts and principles of military, naval, and aerospace sciences.
2. A basic understanding of associated professional knowledge.
3. A strong sense of personal integrity, honor, and individual responsibility.
4. An appreciation of the requirements for national security.

Air Force ROTC Scholarships

Air Force ROTC offers three different type of scholarships (up to \$18,000) for outstanding students. Scholarships include tuition, most fees and books. Upon activation, all scholarship cadets receive a monthly living expenses stipend during the academic year. Currently, the monthly stipend is \$300 for first year cadets, \$350 for second year cadets, \$450 for third year cadets and \$500 for fourth year cadets.

FACULTY

LIEUTENANT COLONEL ERIC E. HAMILTON, *Professor Aerospace Studies*. M.S. Mechanical Engineering, North Carolina University. B.S. Mechanical Engineering, North Carolina University.

CAPTAIN RAFAEL E. BELTRAN, *Assistant Professor of Aerospace Studies*, M.A. Global Security/Intelligence Studies, American Military University.

CAPTAIN MICHAEL W. HERBERT, *Assistant Professor of Aerospace Studies*, MBA Business Administration, Webster University. B.S. Electrical Engineering, Southern Illinois University-Edwardsville.

DEPARTMENT OF MILITARY SCIENCE

US ARMY ROTC

Mission

Military Science at the University of Puerto Rico is presented under the provisions of the National Act of June 3, 1916, as amended, which established the Reserve Officers' Training Corps (ROTC) Program at colleges and universities throughout the United States.

The mission of the US Army ROTC Program is to obtain well-educated, commissioned officers in sufficient numbers to meet Army requirements. The objectives of the ROTC Program are to attract, motivate, and prepare selected students to serve as commissioned officers in the regular Army, Army National Guard, or the Army Reserve; to provide an understanding of the fundamentals, concepts, and principles of military science; to develop leadership, managerial skills, basic professional knowledge, and a strong sense of personal integrity, honor, and individual responsibility among students in the Program; and to develop an appreciation of the requirements for national security. The Army ROTC Program draws upon the many educational disciplines required for the modern Army. It ensures that men and women educated at a broad spectrum of institutions of higher learning are commissioned annually in the Army Officer Corps.

Vision

In the future, the Army ROTC Program will continue to be the major source of newly commissioned officers for the active Army and reserve components.

GENERAL EDUCATION

The Army ROTC offers college students a four-year program composed of two separate two year programs; the two-year basic course (CIMI 3011-3012, CIMI 3021-3022) and a two-year advanced course (CIMI 4011-4012, CIMI 4021-4022). Credits obtained in these courses will be included in the student's general grade point average. Deans may consider these courses as general electives for academic credit by granting up to a maximum of 12 credit-hours.

The basic course is conducted on a voluntary basis as an elective. Students may drop the course at any time as they would any other elective. Students must satisfactorily complete both years of studies in order to be eligible for the advanced course. The advanced course is optional and selective. The ROTC furnishes all required uniforms and equipment for both basic and advanced courses. All students that contract with the ROTC with the intent of receiving a commission as an officer will receive from \$300-\$500 per month, depending on what year they are in.

Students may qualify to enter the advanced course without completing the basic course if they have attended Basic Training in the past as active duty soldiers or members of the National Guard or Reserves. Students may also qualify to enter the Advanced Course by attending a summer camp offered by the ROTC called the Basic Camp (BC). Basic Camp is a paid summer camp that trains the students in basic military skills and incurs no obligation for service or commitment. Students may attend the camp, and decide not to pursue ROTC if they choose.

Students in the Advanced Course are required to attend a paid summer camp known as the Advanced Camp (AC) between their third and fourth years.

Students requesting admission to the advanced course, senior division, are screened and tested by the Professor of Military Science (PMS). These students must satisfy requirements established by the Department of the Army before they are formally enrolled.

A. Basic Course Requirements:

1. Enrollment in a baccalaureate or graduate degree program full time (12 credits or more).
2. 2.00 GPA or better to enter second year of basic course.
3. Enrollment in the ROTC English program or satisfy the English requirement by approving an examination.

Note: Cadets will not fail the basic courses for lack of English skills. ROTC will prepare cadets in this area.

B. Advanced Course Requirements:

1. 2.00 GPA or better.
2. Be medically qualified (Medical exam is free of charge).

3. Be a full-time student (12 credits or more).
4. Score 80 or more on Comprehension Level Test (ECLT).*
5. Having four semesters left including the ROTC classes according to the CC Form 104-R Academic Program Worksheet.

Program Outcomes:

The goals, objectives and assessment plans for the Military Science Department are outlined below. The ROTC Program objective and assessment strategies are consistent with the goals of the U. S. Army in preparing students to become commissioned officers. We are responsible for providing men and women valuable skills such as self-discipline, personal development, problem solving and knowledge to complete demanding missions entrusted to them.

A program for tomorrow's leaders. Army ROTC enrolls well-rounded students with the proven ability to set goals and achieve high standards of excellence in academics, fitness and leadership in their schools and communities.

Critical Success Factors

- Meet or exceed enrollment goals.
- Increase program retention rates.
- Pursue strategies to maintain a Corps demographic profile that promotes and reflects diversity.
- 100% graduation of Cadets from the Advanced Camp (AC)
- 100% graduation of Cadets from the Basic Camp (BC)

ROTC Scholarship Program

The Department of the Army grants scholarships to selected outstanding students enrolled in the ROTC Program. The scholarships, ranging from two to five years, include full tuition and laboratory fees, approximately \$1,200 a year for textbooks, and a living allowance of up to \$5,000 per semester or \$10,000 for tuition each academic year that the scholarship is in effect. In addition, ROTC scholarship students receive approximately \$800 for attending Leadership Development and Assessment Course.

FACULTY

LIEUTENANT COLONEL ANGEL R. ORTIZ, *Professor of Military Science*, M.B.A. in Logistics, 2016, Trident University International.

MAJOR EMANUEL VELEZ, *Assistant Professor of Military Science*, M.A. in Managerial Logistics, 2012, North Dakota State University.

MAJOR CESAR SALICRUP, *Assistant Professor of Military Science*, M.A. in Human Resources, 2012, Inter American University of Puerto Rico.

CAPTAIN BRAULIO DE JESUS, *Assistant Professor of Military Science*, M.A. in Business Administration, 2013, Phoenix University.

MR. PEDRO J. ROSARIO, *GS Recruiting and Operations Officer*, M.B.A., 2005 University of Phoenix.

MR. FELIX CHICO, *Chief English Language Program*, M.A., 1992, University of Puerto Rico, Río Piedras.

MRS. MARIA DE LOURDES PEREZ, *English Instructor*, M.A. ED, 2009, University of Puerto Rico, Mayaguez.

DIVISION OF CONTINUING EDUCATION AND PROFESSIONAL STUDIES

History

The Division of Continuing Education and Professional Studies was created during the 1958-59 academic year. It was established in order to integrate within a unit several UPRM programs which were not administered jointly: the summer program, the evening program and the Saturday course program. The inclusion of these three programs as a new academic unit has served as basis for innovative and extended services in non-traditional fields.

Goals and Objectives

The goals of the Division of Continuing Education and Professional Studies are to attend the special educational needs at the university level or those related to university work that are not presently addressed by traditional offerings in order to foster a closer collaboration between the university's physical and human resources and the community's problems and needs.

Objectives

1. To provide educational opportunities for the adult working population and for adults who have interrupted their schooling.
2. To provide educational opportunities to disadvantaged groups, minorities, and other sectors of the community not benefiting from traditional offerings.
3. To initiate educational programs and credit courses in response to educational needs that have not been fulfilled by traditional offerings.
4. To create continuing education offerings for professional groups.
5. To identify continuing education needs of the community at large and provide courses and educational experiences to meet these needs.
6. To provide the community with information and orientation services.
7. To develop awareness and sensitivity to the needs of the community and undertake initiatives to meet those needs.

The Division of Continuing Education and Professional Studies addresses its goals and

objectives through various initiatives such as the creation of projects, educational offerings, and programs which are transitory in nature and short in duration.

At present, the work of the Division consists of the following programs:

1. Continuing Education Program
2. Special Training Programs
4. Community Services
5. Education Program
6. Online Education Resource Center

Continuing Education Program

Continuing Education is recognized as a growing need for all adults. The Division offers educational options on weekdays, evenings, and Saturdays in order to enable working adults to further their education. It also fulfills different needs for children, adolescents, adults and elderly interested in developing their knowledge, talents, or abilities.

This non-traditional service offers continuing education hours/credits required to renew licenses and/or certifications pertaining to a variety of professions and provides educational alternatives in special areas such as business administration, microcomputer applications, technical skills, arts, language, handicrafts, and sports where professional and cultural growth might occur independently of traditional degree programs. Continuing Education embraces a wide field of strategies to fulfill the teaching-learning process at different stages in formal or informal settings. It is offered through non-credit courses, seminars, workshops, or special projects.

Special Training Programs

The Division of Continuing Education and Professional Studies collaborates with community institutions, other departments and campuses of the University of Puerto Rico in the creation of these special training programs which blend the traditional offerings at the University, such as language, mathematics, and science courses, with special instruction emphasizing immediately marketable skills. Courses in these programs do not carry college credits and cannot be used to fulfill degree requirements. At the completion of a program, however, a certificate will be issued which might serve as credential for the job market.

Community Services

The Division of Continuing Education and Professional Studies in association with civic and professional groups offers educational services to the community.

Community activities include conferences, seminars, workshops, group meetings, continuing education courses, and short-term special training sessions.

Online Education Resource Center

Mission

Support and guide the faculty in the development of digital educational materials and multimedia technology based processes, ensuring compliance with the highest quality standards.

View

Position the UPR-RUM at the forefront of the development of distance education modalities. In addition, study and develop educational methodological procedures supported by digital and multimedia resources.

TEACHER PREPARATION PROGRAM (TPP)

Mission of the TPP

The unit's mission is to serve society by preparing professional educators who are subject matter specialists with dispositions of social, cultural, humanistic sensibilities and ethical values, who also possess competence, skills and general knowledge, all of which will allow them to be highly effective teachers.

Vision of the TPP

The Teacher Preparation Program aspires to develop new educational certifications and graduate programs according with the Department of Education of Puerto Rico needs. Also aspire to maintain the recognition of the teacher's accreditation institutions and specialized professional associations.

Goal of the Education Unit

The DECEP Teacher Preparation Program principal goal, as stated in Certifications No. 27 2003-04 and No. 47 2004-05 of the Board of Trustees of the University of Puerto Rico, is to offer the curricular sequence for teacher certification in secondary education in accordance with the norms and regulations of the Department of Education of Puerto Rico. Consistent with the University's vision and mission, the program offers a sequence designed to update and strengthen knowledge and skills of professional educators, Certification No. 190 2000-01 of the Board of Trustees of the University of Puerto Rico. To expand our academics offerings and not limit them to the secondary level, the teacher preparation program decides to change its official name to "Curricular Sequence for Teacher Certification", change approved March 2, 2016 by the Academic Senate of the University of Puerto Rico at Mayaguez, Certification Num. 16-14

The goal of the Teacher Preparation Program of the Mayagüez Campus of the University of Puerto Rico is to prepare professional educators committed to 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 seeks to foster that the candidate develop cognitive, affective, psychomotor, research, technological and communication skills. The intention is that the candidate becomes a lifelong learner in order to be a competent, effective teacher.

Teacher-Preparation Program

This intensive training program is designed for students pursuing a bachelor's degree in the College of Arts and Sciences, College of Business Administration, and College of Engineering. In addition to education courses, the program includes observations and practice in the classroom under the direct supervision of experienced teachers, and university faculty.

The Education Program offers the sequence of courses required by the Department of Education of Puerto Rico to obtain Certification as Secondary and Elementary Level Teacher. In order to receive a teaching license, students must present evidence to the Department of Education at the conclusion of the Education Program. In addition, students must approve the required State

Teaching Certification Test (PCMAS), offered by the College Board.

Teacher Preparation Program

Transition Point #1:

Prospective candidates may enroll in the Teacher Preparation Program after completing a bachelor's program or while pursuing a bachelor's degree at UPR-Mayagüez.

To be admitted to the program applicants must have an overall grade point average of 3.0, a grade point average of 3.0 in the major, according to regulations of the Department of Education of Puerto Rico. They have to fill an admission document to the sequence at the Register Office and then make an interview at TPP with regards to their disposition towards teaching. The candidate could have credits on fundamental education before formal admission to the TPP. All the credits of Foundations courses must have a grading pass of B or more.

Transition Point #2: Enrollment in Theory and Methodology Course

To enroll in the Theory and Methodology Course candidates must have completed five foundations of education courses EDFU 3001 (Human Growth and Development I), EDFU 3002 (Human Growth and Development II), EDFU 3017 (Evaluation of Students Learning), EDFU 3007 (Social Foundations of Education), and EDFU 4019 (Philosophical Foundations of Education) and also EDPE 3129 (Use of microcomputer in the classroom) with a grade point average of 3.0 or better. They also must have completed at least 18 credits in their major with grade point averages of 3.0 or better overall and in their major.

In some education courses including Methodology and Student's Teacher Courses the candidate have to satisfactorily develop an electronic portfolio with Teacher Candidate Work Sample (TCWS) that demonstrates the candidate's content knowledge, applied knowledge of human development and learning, sensibility to diversity, pedagogical content knowledge skills and reflective habits on the effectiveness of their practice. In the TCWS the candidate has to include artifacts such as lesson or unit plans, samples of assessment techniques including pre and post text, and classroom management techniques. They also have to prepare a reflection diary about the observation they do in schools.

Transition Point #3: Entrance to Practicum

To enroll in the Teaching Practice Course candidates must have completed the Theory and Methodology course with a grade of B or better. They have to score 80% or higher on the Educational Philosophy Essay Rubric and on the evaluation of the Electronic Portfolio with the Teacher Candidate Work Sample. They should also have at least 21 credits in their major with grade point averages of 3.0 or better overall and in their major.

Transition Point #4: Program Completion

Candidates fulfill the requirements for the Teacher Preparation Program when they complete 21 credits in core courses in the teaching specialty and the 36 credits. The 36 credits include: 15 credits in foundation of education courses; 3 credits in The Use of Microcomputers in the Classroom; 3 credits in Nature and Needs of Exceptional Learners; 3 credits in the history of Puerto Rico; 3 credits in the history of the United States; 3 credits in theory and methodology; and 6 credits in student teaching. Candidates are advised to take the PCMAS after completing their methodology course.

In the Student Teaching Course the candidate have to satisfactorily develop an electronic portfolio with Teacher Candidate Work Sample (TCWS) that demonstrates the candidate's content knowledge, applied knowledge of human development and learning, sensibility to diversity, pedagogical content knowledge skills and reflective habits on the effectiveness of their practice. In the TCWS the candidate has to include artifacts such as lesson or unit plans, exams with their analysis, and classroom management techniques. A systemic assessment process database that addresses the candidate's proficiencies is being designed by the unit.

FACULTY

CARMEN BELLIDO-RODRÍGUEZ, *Professor*, Ph.D., 1997, University of Puerto Rico.

HERBERT BRAVO-GARCÍA, *Associate Professor*, M.S. Health Education, 1986, Penn State University.

MOISÉS CAMACHO-GALVÁN, *Professor*, Ph.D., 1986, Florida State University.

JOSE R. FERRER LOPEZ, *Assistant Professor*, Ed.D., 2010, *Universidad del Turabo*.

JANNETTE FERRER MONTES, *Assistant Professor*, Ph.D., 2013, University of Wisconsin, Madison Campus.

EFRAÍN GRACIA-PÉREZ, *Professor*, M.A., 1972, Interamerican University of Puerto Rico; Juris Doctor, 1981, Catholic University of Puerto Rico.

ANA M. LEBRÓN-TIRADO, *Professor*, Ed.D., 1998, Interamerican University of Puerto Rico.

REBECA ORAMA-MELÉNDEZ, *Professor*, Ed.D., 2005, University of Puerto Rico, Río Piedras.

GRISEL RIVERA-VILLAFÑE, *Associate Professor*, Ed.D., 2006, Interamerican University of Puerto Rico.

ANTONIO SANTOS-CABRERA, *Professor*, M.A.Ed., 1976, Interamerican University of Puerto Rico.

OFFICE OF GRADUATE STUDIES

Graduate offerings at the University of Puerto Rico, Mayagüez Campus began in 1957, prompted by the establishment of the Nuclear Center and postgraduate programs in Mathematics, Physics, and Nuclear Technology. The graduate program in Chemistry was established in 1960, followed by the Biology and Physics programs in 1962. Our first doctoral program, in Marine Sciences, was established in 1972. Doctoral programs in the fields of Civil Engineering, Chemical Engineering, Applied Chemistry, and Computing and Information Sciences and Engineering have also been established. In the past year, doctoral programs in Mechanical and Electrical Engineering have been established as well as M.S, ME and PH.D degrees in Bioengineering and M.S. and M.E. degrees in Materials Science and Engineering. The Mayagüez Campus also offers M.A. degrees in Kinesiology, Hispanics Studies, and English Education. Furthermore, offers Masters of Arts in Business Administration (MBA) and Masters of Sciences in Agricultural Sciences including Soils, Animal Sciences, Agricultural Economics, Agricultural Education, Horticulture, Food and Science Technology and Crop Protection.

According to Certification 09-09 of the Mayagüez Campus Academic Senate, this Office supervises and enforces the rules and regulations related to graduate studies. The Office deals with three

main areas: graduate admissions, assistantships, and active students. The Office is directed by an Associate Dean of Academic Affairs and Director of Graduate Studies, and an Associate Director of Graduate Studies. The Office is located at **111 Celis Building**, and can be reached by phone **787-832-4040** at extensions **3442** or **3598**. They can also be reached at their direct number **787-265-3809**, via Internet at <http://grad.uprm.edu>, or by email at egraduados.uprm@upr.edu.

OFFICE OF IMMIGRATION AFFAIRS

The *Office of Immigration Affairs* is currently under the Deanship of Academic Affairs, it's principal mission is to provide assistance and guidance to all international students and scholars who study and work at the UPRM. Since 2013 the office is focused solely on matters related to our international students and scholars. The Principal Designated School Official (PDSO) or Designated School Official (DSO) prepares Form I-20 for students who are admitted to the UPRM. We work closely with the Admissions Office, the Graduate School and the Registrar's Office, making sure that all requirements for the preparation of Form I-20 are met. This office issues Form I-20 to students admitted to the UPRM, in order for them to be able to get the entry visa into United States territory at the US Embassy in their country of origin. We also prepare and submit H1B visa petitions on behalf of scholars that are being hired by academic departments, in coordination with such departments.

Our office also plays an important role in guidance and advising not only for our international students and scholars, but also for all administrators and faculty working with them. Our vision is to facilitate study and work at the UPRM for foreign nationals following all federal regulations and requirements established by *Student and Exchange Visitor's Program (SEVP)* and *United States Citizenship and Immigration Services (USCIS)*, as well as other federal agencies under the *Department of Homeland Security (DHS)*.

Every fall and spring session starts off with an orientation for all newly admitted undergraduate and graduate students. During this orientation we emphasize the importance of maintaining status while in F1 visa classification, and we go over regulations regarding international students as

contemplated in the *Code of Federal Regulations*: 8 *CFR* 214.2(f).

The *Office of Immigration Affairs* is continually collaborating with all academic departments and UPRM dependencies (Human Resources Office and others) giving guidance and advice on all matters relating to international students and scholars. Our PDSO is continuously keeping up to date as an active member of NAFSA (The Association of International Educators).

Contacts:

Dr. Frances J. Santiago Torres, Ph.D., PDSO, ARO

Email: francesj.santiago@upr.edu

Ms. Janet Estrada Vargas, DSO

Email: janet.estrada@upr.edu

Office: Celis Building 207

Phone: (787) 832-4040 Ext. 2415 / 5757

Fax: (787) 265-5418

GENERAL LIBRARY

Vision

To distinguish itself as a facilitator of teaching, learning, and research. To promote lifelong learning and ethical values in the academic community. To be recognized as a leader in service, resources, information literacy skills, innovative technology, and access to the Campus intellectual output.

Mission

The General Library supports the institutional mission of excellence. The library guarantees access to information and resources needed for teaching, research, and creative endeavors. It is a pioneer in offering formal courses, incorporating information literacy skills in the curriculum, and establishing the liaison program with the university faculty.

LIBRARY SYSTEM

The General Library serves the local campus community as well as the residents of Mayagüez and nearby towns. It fully supports UPRM's educational and research mission and objectives by providing adequate library and information resources, facilities and services. It consists of a

main library and a special departmental collection.

The main library has an area of approximately 124,335 square feet, with a seating capacity of 1,031, nine individual study rooms, eight study rooms for group discussions and collaborative work, a computer lab with 75 workstations, and two library instruction classrooms. There is also a large conference room as well as smaller meeting rooms.

In order to fulfill its mission, the Library is divided into key areas: Collections and Departments

- Álvarez Nazario Collection
- Audiovisual Collection
- Center for Technological Assistance (CAT)
- Circulation/Reserve Collection
- Graduate Research and Innovation Center (GRIC)
- Electronic Resources Center
- Interlibrary Loan Department
- Marine Sciences Collection
- Patent and Trademark Resources Center
- Puerto Rican Collection (Manuel María Sama y Auger)
- Reference/Documents Collection
- Research and Information Literacy Center (CEDIBI)
- Technical Process Department
- Systems Department

The library provides a wide range of services directly to the public. Among these are assisting users in finding information, facilitating access to information and teaching skills necessary for their academic research and life-long learning. This all Collections and Departments manages the circulation of materials, course reserves, user accounts, reference and audiovisual services, information literacy program, the promotion of library services and outreach efforts to campus community. Other services include library instruction modules, faculty liaison and collaboration program and orientations of the library. In September 1, 2016 the Graduate Research and Innovation Center (GRIC) was inaugurated in the General Library. GRIC is a creative space for collaboration and innovation, where UPRM's graduate students, faculty and researchers can gather together to develop projects and receive specialized research services

in scholarly communication, research methodology and data management.

The Library holdings include: 733,412 volumes; 275,235 book volumes; 117,893 journals; 147,435 electronics journals; 8,874 electronic books; 69,704 microfiches; 386 microcards; 2,466 microfilms; 171,809 government documents; 3,545 films; 4,563 maps; 10,300 sound recordings; 442 musical scores; 508 sound magnetic tapes; 2,852 videocassettes; 3,467 CD/DVD; 4,881 theses; and access to millions of U.S. patents and trademarks.

The Library is a selective depository for the publications of the U.S. Government and one of the coordinating agencies of the Puerto Rico Census Data Center under the State Planning Board. It serves as depository for the publications of the U.S. Bureau of the Census, and holds membership in the Patent and Trademark Resource Centers Program of the U.S. Patent and Trademark Office since 1995. It's one of the centers serving Puerto Rico, the Caribbean Basing and Latin America.

Other library services include books, documents and journal loans, interlibrary loans, traditional reference, and photocopying. Additionally, virtual reference, digital reserve, electronic resources, online databases and catalog are accessed through our webpage.

The Library offers tours of its facilities, and provides information literacy workshops, library instruction sessions and credit courses. Faculty librarians teach the following credit courses: AGRO 4019—Seminar in Agronomy and Soils (Agronomy and Soils Department), BIOL 3055—Bibliography and Library Research in the Biological Sciences (Biology Department), CISO 3145—Bibliography and Library Research in the Social Sciences (Social Sciences Department), CIAG 3025—Library Resources in Agricultural Science. An interdisciplinary three-credit course is offered for those students wanting to learn about Research Methods in Libraries: INTD 3355.

The Library keeps its academic community informed through various social media platforms, media display within the library and institutional email. Further information about library services, facilities, resources and collections is available at: <http://www.uprm.edu/library>. You can also

find us in Facebook (Biblioteca UPR-Mayagüez) and in Twitter (Biblioteca UPRM).

Phone: 787-265-3810; 787-832-4040 exts. 3810, 2151, 2155

Website: <http://www.uprm.edu/library>

Email: library@uprm.edu

GENERAL LIBRARY FACULTY

JACQUELINA E. ÁLVAREZ, *Librarian III*, M.L.I.S., 1997, University of Wisconsin, Madison.

MARÍA DEL C. AQUINO-RUIZ, *Librarian IV*, M.L.S., 1991, University of Puerto Rico, Río Piedras Campus.

MARÍA VIRGEN BERRÍOS-ALEJANDRO, *Librarian IV*, M.L.S., 1989, University of Puerto Rico, Río Piedras Campus.

HILDA TERESA AYALA-GONZÁLEZ, *Librarian I*, M.A.S., 2016, University of British Columbia, Vancouver, Canadá, M.I.S., 2011, University of Puerto Rico, Río Piedras Campus.

CYNDIA CARABALLO-RIVERA, *Librarian III* M.L.S., 1997, Interamerican University, San Germán, Puerto Rico.

LUIS O. CASIANO-TORRES, *Librarian IV*, M.L.S., 1989, University of Puerto Rico, Río Piedras Campus.

ARELYS FERNÁNDEZ-TROCHE, *Librarian II*, M.I.S., 2008, University of Puerto Rico, Río Piedras Campus.

JORGE L. FRONTERA-RODRÍGUEZ, *Librarian IV*, M.S.L.S., 1988, Catholic University of America at Washington, D.C.

ILEANA GUILFUCCI-GONZÁLEZ, *Librarian IV*, M.L.I.S., 1992, Interamerican University, San Germán, Puerto Rico.

GLADYS E. LÓPEZ-SOTO, *Librarian III*, M.L.S., 2002, University of Puerto Rico, Río Piedras Campus.

LOURDES RIVERA-CRUZ, *Librarian IV*, M.L.S., 1990, University of Puerto Rico, Río Piedras Campus.

GRISELL RODRÍGUEZ-VELÁZQUEZ,
Librarian IV, M.L.I.S., 1996, University of
Wisconsin at Milwaukee.

EDITH M. TORRES-GRACIA, *Librarian IV*,
M.B.A., 1988, Interamerican University, San
Germán; M.L.I.S., 1992, Long Island University,
CW, Post Campus, Brookville, New York.

ELSIE TORRES-NEGRÓN, *Librarian IV*,
M.L.S., 1986, University of Puerto Rico, Río
Piedras Campus.

ANIDZA VALENTÍN-RODRÍGUEZ,
Librarian I, D.B.A., 2013, Turabo University,
M.I.S., 2014, University of Puerto Rico, Río
Piedras Campus, M.B.A. Management
Information Systems, 2007, Interamerican
University, San Germán, Puerto Rico.

REGISTRAR'S OFFICE

The Office of the Registrar provides information
in an accurate manner with consistent quality
service that is responsive to the needs of the
university community.

The office has the responsibility of maintaining
academic records of students, current and former,
graduate and undergraduate, while ensuring the
privacy and security of those records.

The office also provides registration services to
departments and students; records and reports
grades; certifies attendance, grade point averages
and degrees; issues transcripts, and schedules
final exams.

The Office of the Registrar seeks to provide the
highest quality services using innovative
procedures and advanced technology.

Confidentiality of Academic Records

The University of Puerto Rico, Mayagüez
Campus, fully complies with the provisions of the
Buckley Amendment (Family Educational Rights
and Privacy Act of 1974, as amended). This Act
protects the privacy of students' educational
records and establishes the students' right to
examine their own files. It also provides
guidelines for correcting the accuracy of the
information contained in those files through

informal and formal hearings. Students wishing
to do so may file complaints with the Family
Policy Compliance Office U.S. Department of
Education 600 Independence Avenue, S.W.
Washington DC 20202-4605. Copies of the
institutional policy established by the University
of Puerto Rico in compliance with this Act may
be obtained from the Office of the Registrar.

Veteran Services Office

The Veteran Services Office serves veterans,
dependents of veterans, servicemen, and
servicewomen in matters pertaining to the
Veterans Administration such as: educational
benefits, registration, and studies at the university.
All beneficiaries must comply with the norms
established by this office. ([Veteran addendum](#))

Academic Progress (applicable to veterans and/or beneficiaries)

Veterans and/or beneficiaries should complete
their studies during the regular time allotted
(100%) as stated in the program curricula. If they
exceed the time allotted they lose eligibility for
the benefits of Veterans Programs. This norm is
not applicable to federal aids such as Pell Grant or
others where eligibility is established by the
institution and/or the entity/agency granting the
scholarship if the recipients maintain the
correspondent requisites. Also students must
maintain the minimum average required (general
and major average) as established for each
program in order to graduate.

Repetition of courses (applicable to veterans and/or beneficiaries)

The Veterans Administration (VA) only approves
payment for the repetition of a failing grade such
as "F". The VA does not approve payment for
repeated courses with passing grades, unless they
are repeated in order to comply with the
requirements of the program of study.

Office: Celis Building, 2nd floor, 203
Phone: 787-265-3813; 787-832-4040, ext. 3424,
3343, 3813
Website: www.uprm.edu/registrar
Email: registro@uprm.edu

OFFICE OF THE DEAN OF STUDENTS

The Office of the Dean of Students assures and maintains an optimal learning environment by providing a variety of services and activities as support systems for academic programs. Students are urged to take full advantage of these services and are encouraged to participate in extra-curricular activities which are designed to enrich their personal development and academic growth. The office is located in the Dean of Students building in room DE-1. For more information contact Dr. Francisco Maldonado at decanodeestudiante@upr.edu, 787-265-3862.

DEPARTMENT OF ATHLETIC ACTIVITIES

Athletics

UPRM is a member of the Puerto Rico Inter-University Athletic League (LAIPR) and fully participates in a variety of intercollegiate sports. It is also an active member of the National Collegiate Athletic Association (NCAA) Division II. The program offers 15 men's and 14 women's sports for students who demonstrate superior athletic abilities. Men's sports include baseball, basketball, beach volleyball, cross country, judo, soccer, swimming, table tennis, taekwondo, tennis, track and field, volleyball, weightlifting, wrestling and cheerleading. Women's sports include weightlifting, basketball, beach volleyball, soccer, cross country, judo, softball, swimming, taekwondo, table tennis, tennis, track and field, volleyball and cheerleading. The NCAA sponsors six men's and six women's sports (volleyball, basketball, track and field, cross country, swimming and tennis). Exhibition sports include a co-ed dance team.

The Intramural Program provides activities and competitions that take place mostly on campus grounds. Students, faculty and staff participate in a wide variety of competitions including 3 on 3 basketball, indoor soccer, softball, 5 on 5 basketball, volleyball, employee softball tournament and other recreational activities sponsored by students in their free time.

Athletics facilities include and old gymnasium, a coliseum, a world class natatorium with an Olympic size swimming pool, a diving pool and a 25 meter

warm up pool, a tennis complex with 8 lighted courts that includes a grand stand court, 3 indoor racket ball courts, synthetic 400 meters running track, weightlifting gymnasium, training and conditioning exercise room, old athletic field for soccer practice and recreational activities, lighted softball field, and fitness trail.

The mascot is an English male bulldog name Tarzan and the female, Jane. The athletic nickname is Colegio and the moto is: Antes, Ahora y Siempre COLEGIO.

Office: Rafael A. Mangual Coliseum, 2nd floor, #209

Phone: 787-265-3866; 787-832-4040, ext. 2565, 3866, 3679, 3540, 3534, 3527, 3549

Website: www.uprm.edu/actividadesatleticas

Email: ray.quinones@upr.edu

BAND AND ORCHESTRA

Vision

To become a service unit that supports the transformation of society by strengthening the institutional environment.

Mission

To train students in the pro-active participation in the fine arts through musical performance, so as to contribute to the emotional, cultural and educational development to complement their comprehensive training, educational and ethical.

Students with musical talent may join different music groups such as the marching band, chorum, chamber choir "Coral Universitaria", strings orchestra, and Latin music groups. Students interested in participating in any of these groups are required to perform in an audition.

Groups are required to rehearse twice or more weekly to develop interpretive skills and maintain an ample musical and artistic program. The ensembles present a variety of concerts and performances as representatives of the university also international performances, festivals and competitions. For more information contact: BAND AND ORCHESTRA DEPARTMENT at (787) 265-3895; 787-832-4040 exts. 3415, 3895.

Website:

<http://www.uprm.edu/cms/index.php/page/380>

DEPARTMENT OF COUNSELING AND PSYCHOLOGICAL SERVICES

The Department is fully accredited by the International Association of Counseling Services (IACS). Counseling and Psychological Services are offered to the students so that they may achieve better self-understanding and make adequate adjustment to the university environment. Programs and services are offered to diminish the negative impact of everyday stress and to help students cope with academic and environmental demands.

The Department of Counseling and Psychological Services provide personal counseling, career and life planning, testing, and psychological services.

Psychologists provide individual therapy, crisis intervention, workshops and lectures on personal, emotional, and social growth topics. Also, some of these areas are supported with a Clinical Social Worker.

Professional Counselors assist students with personal, educational, and career development issues and concerns. They also teach a freshman orientation course, known as:

UNIV 3005. INTRODUCTION TO THE UNIVERSITY WAY OF LIFE. Zero credit hour. One hour of lecture per week.

Course directed towards a better understanding of the fundamental aspects that affect student life and adequate adjustments to the campus environment. Designed to enhance the academic and social integration in order to help students during their college years. Includes topics such as: study and communication skills, career planning, personal development, computer literacy, academic regulations and institutional resources.

Freshman Orientation Days are offered a week prior to the registration period for the first semester. It is a campus wide activity in which new students receive information about facilities, academic programs, services, and student organizations. It offers freshmen the opportunity to meet faculty, staff, and other students. Members of the **Peer Counseling Program** work intensely during this week and throughout the year in coordination with the Department of Counseling and Psychological Services assisting Professional Counselors with campus tours, group guidance, open house, and career days.

COUNSELING AND PSYCHOLOGICAL FACULTY

PROFESSIONAL COUNSELORS:

MARÍA E. ALMODÓVAR-ALMODÓVAR, *Associate Professor*, (Counselor III), Ed.D. 2010, Interamerican University of Puerto Rico-Metropolitan Campus.

LISANDRA COLÓN-RIVERA, *Professor*, (Counselor IV), M.A.M.C.R., 1994, University of Puerto Rico at Río Piedras.

MAYRA L. GONZÁLEZ-ORNES, *Assistant Professor*, (Counselor II), Ed.D. 2016, Interamerican University of Puerto Rico-Arecibo Campus.

AGNES D. IRIZARRY-IRIZARRY, *Professor* (Counselor IV), M.A.E., 1978, Interamerican University of Puerto Rico at San Germán Campus.

MAGALY MERCADO-NAZARIO, *Assistant Professor*, (Counselor II), Ed.D. 2012, Interamerican University of Puerto Rico-Metropolitan Campus.

EDWIN MORALES-TORO, *Professor* (Counselor IV and Acting Director), M.A.E., 1977, Interamerican University of Puerto Rico at San Germán Campus.

GLORIA MUÑIZ-CRUZ, *Professor* (Counselor IV), M.S., 1979, University of Bridgeport.

NELSON PAGÁN-SUÁREZ, *Associate Professor* (Counselor III), Ed.D. 2014, Interamerican University of Puerto Rico – Metropolitan Campus.

MADELINE J. RODRÍGUEZ-VARGAS, *Associate Professor* (Counselor III), Ed.D. 2013, Interamerican University of Puerto Rico - Metropolitan Campus.

PURA B. VICENTY-PAGÁN, *Professor* (Counselor IV), M.A.M.C.R., 1987, University of Puerto Rico at Río Piedras.

PSYCHOLOGISTS:

ZAIDA M. CALDERÓN-FONTANES, *Professor* (Psychologist IV), M.S., 1988, Louisiana State University at Natchitoches.

SHEILA Y. MAESTRE-BONET, *Professor* (Psychologist IV), PSY.D. 2005, Ponce School of Medicine.

SCOTT TSAI-ROQUE, *Professor*, (Psychologist IV), Ph.D., 2006, University of Puerto Rico, Río Piedras.

EMIR S. RIVERA-CATILLO, *Associate Professor*, (Psychologist III and Associate Director), PSY.D. 2008, Ponce School of Medicine.

Office: Students Center 501, Stéfani 225, ADMI 120

Phone: 787-832-4040 exts. 3526, 3374, 3060, 3619

Website: <http://www.uprm.edu/orientacion>

FINANCIAL AID DEPARTMENT

The Department of Financial Aid administers financial aid programs to assist students with educational expenses. Even though costs at the University are considered low, each year approximately 70% of the student body qualifies for financial assistance. This assistance is provided through Federal, state, institutional, and private sources. These programs include grants and scholarships which do not have to be repaid, part-time employment for students who wish to work, and loans that require repayment.

The philosophy followed in rendering financial assistance is based on the principle that parents are the ones who are primarily responsible for providing financial means to educate their children. Students are also considered responsible in helping finance their college education through self-help which includes resources from assets, earnings from work, and loans to be repaid from future earnings.

The established requirements for financial assistance are:

- US citizenship or eligible non-citizen.
- Enrollment in a degree or certificate program.
- Not in default status in Title IV Program.
- Justified financial need.

Financial need is determined by the difference between the cost of education and the amount of aid that parents and student can contribute and the economical resources and aids that the students receives from the institution. The amount which a student may receive is determined according to student's financial need and fund availability. In order to be considered for all financial aid programs, students must complete and submit once every academic year the Application for Federal Student Aid and all other required documents.

Financial Aid Programs

Grants and Scholarships

The ***Legislative Scholarship Program*** receives funds assigned by the Puerto Rico Legislature to assist students with need and who also meet specific academic criteria.

Private scholarships and grants are received by the University for student assistance which are administered according to criteria and guidelines specified by each donor.

Federal Work-Study Program

The ***Federal Work-Study Program*** provides on campus employment opportunities for graduate students with financial need. To be considered to apply for work and study you must complete the FAFSA form.

Loans

Based on their determined financial need, the ***Direct Loan Program*** allows graduate students to borrow low-interest federally unsubsidized funds based on need. Repayment begins six month after the student graduates or ceases to be enrolled.

The ***Geer Loan Program*** is funded through a private trust donation to the Mayagüez Campus. It provides 5 percent interest loans for up to a maximum yearly amount of \$ 1,000 based on financial need. Repayment begins 46 days after the loan proceeds are disbursed.

Office: Deans Students Building

Phone: 787-265-3863; 787-4040 ext. 3440, 3863

Fax: 787-265-1920

Website: <http://www.uprm.edu/financialaid>

Email: aeconomica@uprm.edu

HEALTH SERVICES DEPARTMENT

The Health Services Department offers primary health care, and emergency aid services free of charge, for all students. Among the services provided are medical consultation, dental care, emergency and short-stay recuperation care, ambulance services, clinical laboratory tests, psychology service, addiction counseling, health education, and promotion program, stress management and a family planning program. The University of Puerto Rico also offers a university health insurance plan throughout a private provider for students who are not covered by a private or government health insurance.

These services are classified in two areas: preventive medicine with emphasis on primary and secondary prevention and therapeutic medicine. Preventive medicine pursues the prevention, detection, and screening. The therapeutic medicine covers control of medical conditions for students that may need immediate attention, observation or special and emergency care. Services are offered during regular working hour, except ambulance transportation service, which is coordinated on a twenty-four hour daily by police university thru the municipal or state emergency services.

All students entering the University for the first time are required to complete and submit a medical history exam that includes and required complete physical examination and laboratory tests. Evidence of immunizations is also required. Failure to comply will result in a medical hold on registration.

Medical consultation and emergency services are offered by general physicians and professional nurses. These services are offered from 7:30am to 5:00pm, Monday to Thursday and from 7:30am to 4:30pm on Friday. A clinical laboratory complements these services during regular working hours.

Dental services are offered to students by appointments. Services include oral examinations, X-rays, prophylactic treatment, control of infections and cavities, and orientation on dental hygiene. Senior year students of the School of Dentistry of the University of Puerto Rico Health Science Campus provide primary dental care under the supervision of the Health Service Department dentists.

Psychological services are also part of the services offered. This includes psychotherapy, crisis intervention, group therapy and consultation to other health departmental professionals. Workshops on various mental health topics are also available.

The Stress Management Center offers services to all the university community by previous appointment. This center specialized in teaching techniques for stress management which are music therapy, visualization and direct relaxation. The psychologist coordinates this service. The Center is a practice center for psychology students from the Social Science Department.

Through a Health Promotion and Prevention Program, individual and group orientations are offered covering various health topics. Some of the areas covered are: nutrition, sexual health, eating disorders, sexually transmitted diseases including AIDS, alcohol and other drug abuse prevention, counseling on addiction and referral. Secondary prevention for chronic illness such as heart diseases, diabetes, and asthma, as well as other health related areas with emphasis in the promotion of healthy lifestyles and health maintenance are also part of the program. A resource library with books and printed educational and informational material is available to the community.

The University, through a private health insurance company, offers the students an insurance health plan in order to provide more comprehensive health services. The plan is required, unless the student provides evidence of other health insurance coverage. The university plan offers medical specialists services, X-rays and laboratory tests, emergency room care, hospitalization, surgical procedures, maternity services including prenatal and postnatal care within others. There are options on pharmacy, dental and major medical services.

A Title X Family Planning Program offers comprehensive sexual and reproductive health to all members of the university community. This program offers evaluation and medical consultation by a gynecologist specialist physician, as well as sexual health education, guidance in reference to abstinence, natural family planning, referrals, PAP smears tests and others tests for sexually transmitted diseases such as Chlamydia and HIV, as well as education and availability of contraceptive methods supply.

A Traffic Safety Project sponsored by the Puerto Rico Traffic Safety Commission offers educational and promotional activities establishing traffic safety as part of a healthy way of life among all members of the community.

The Health Services Department considers social health as a very important component of the integral university health services. Some of the actual health issues such as alcohol and other substance abuse are related to social health. This motivated the development of the project “Café Colegial La Cueva del Tarzan”; a pro-active socialization prevention project that offer social alternatives. This environmental project is developed and run by students where a positive, creative and entertain environment free of alcohol is present.

A Smoke Cessation Program is available to student and university staff.

The department also sponsors three student organizations that advocate healthy lifestyles among the student community.

Phone: (787) 832-4040 Exts. 3405, 3408, 3416

Website: <http://www.uprm.edu/medical>

Email: servmed@uprm.edu

PLACEMENT DEPARTMENT

Vision

Serve as liaison among students and businesses, providing both with valuable service.

Mission

Provide students, graduating seniors, and alumni the necessary tools to execute an effective job search, with positive results.

The Placement Department’s main objective is to assist students in obtaining permanent, summer, or temporary employment. Services provided include arrangement of on-campus interviews with prospective employers, coordination of employer presentations, and job referrals. The Department offers seminars and workshops to facilitate job search, résumé preparation, and interviewing skills.

Twice a year, the Placement Department organizes and hosts a **Job Fair** with the participation of private and government agencies from Puerto Rico and the United States.

Annually, the department prepares a study with each graduating class that reflects the number of students that find job placement in and outside of the island, continue their graduate studies in Puerto Rico or the United States or continue to seek employment. Students are advised to initiate their job search as early as their freshmen year, since this will increase their chances of obtaining summer or co-op experience.

Office: Student Center Bldg., 5th Floor Room 508

Phone: (787) 265-3898; (787) 832-4040 Exts. 2070, 2074, 3691 Fax: (787) 834-5115

Website: <http://www.uprm.edu/placement>

Email: placement@uprm.edu

QUALITY OF LIFE OFFICE

The Quality of Life Office offers a wide variety of services in order to promote a safe campus environment and achieve the educational objectives of this institution. This office encourages a safe and secure environment through various activities each semester. It sponsors peer education and support student groups.

Proactive prevention programs are offered in order to prevent campus crime, violence, sexual assault, and the use and abuse of alcohol and other drugs, which may affect the quality of life on campus. Further information about the office, its services, and activities may be obtained by calling 787-832-4040, Extensions 3894, 3107, 5467 or at calidaddevida@uprm.edu, <http://www.uprm.edu/cvida>.

Mission

Our mission is to raise community awareness about total welfare, alcohol abuse and prevention, drugs, smoking, crime alert, prevention of sexual harassment and sexual assault, violence, aggression and safety and adjacent areas. We seek to contribute to the integral development of our students by offering alternatives to develop healthy lifestyles in the university community. Coordinate activities directed to meet, the regulations established by the Department of Education and the University of Puerto Rico.

Vision

To be the leading office in prevention and safety and to promote healthy lifestyles, responding to the needs of the university community. To promote a culture of tolerance and diversity, with the determination of improving the Institutional Climate of our campus.

CAMPUS SAFETY AND SECURITY

Emergency Numbers: Security Office (787) 265-1782, Office of the Dean of Students (787) 265-3862, Quality of Life Office (787) 265-5467, Health Services (787) 265-3865, Counseling and Guidance (787) 265-3864.

At UPRM, the safety and well being of our students, faculty, and staff is an important priority.

UPRM's urban campus and its environs are safe and have a relatively low crime rate.

The University is required by federal law to publish an annual security report containing information with respect to campus security policies and statistics on the incidence of certain crimes on and around our campus.

FEDERAL CAMPUS SEX PREVENTION LAW

The Department of Superior Education of the United States of America established an order that any educational institution that receives federal funds must have open access to the university community of the sex offender's register.

That database contains public record information of offenders classified as sexual predators and sex aggressors under the law of Puerto Rico known as Registration of Convicted Persons of Sexual Crimes and Abuses Against Children Law (Law No. 266 of September 9, 2004).

This information would be available on the website Quality of Life Office, <http://www.uprm.edu/cvida/ofensores.php>, and on the website of the Information System of Criminal Justice, <http://prcjisweb.gobierno.pr/CjisServices/Forms/Registries/Registry266TermsConditions.aspx>.

Statistics of Campus Crime Report:

ON-CAMPUS CRIME REPORT-2013-2015 REQUIRED BY THE PUBLIC LAW 101-542 (STUDENT RIGHT TO KNOW AND CAMPUS SECURITY ACT)

CATEGORIES*	In Campus			Students Residence		
	2015	2016	2017	2015	2016	2017
Murder/Negligent Manslaughter	0	0	0	0	0	0
Non-Negligent Manslaughter	0	0	0	0	0	0
Forcible Sex Offenses (Including forcible rape)	0	0	0	0	0	0
Non-forcible Sex Offenses	0	0	0	0	0	0
Robbery	1	0	0	0	0	0
Aggravated Assault	1	0	0	0	0	0
Burglary	0	0	0	0	0	0
Motor Vehicle Theft	1	0	0	0	0	0
Arson	0	0	0	0	0	0
Property Damage	31	0	6	0	0	0
Illegally Appropriated by Force	18	21	13	0	0	0
*Hate Crimes	0	0	0	0	0	0
Disciplinary Actions/Judicial Referrals and/or Arrests for:						
Liquor Law Violations	0	0	0	0	0	0
Drug Law Violations	1	0	0	0	0	0
Illegal Weapon Possession	0	0	0	0	0	0

**ON-CAMPUS CRIME REPORT-2013-2015
REQUIRED BY THE PUBLIC LAW 101-542
(STUDENT RIGHT TO KNOW AND
CAMPUS SECURITY ACT)**

CATEGORIES*	On Campus Residence			Public Properties		
	2015	2016	2017	2015	2016	2017
Murder/ Negligent Manslaughter	0	0	0	0	0	0
Non-Negligent Manslaughter	0	0	0	0	0	0
Forcible Sex Offenses (Including forcible rape)	0	0	0	0	0	0
Non-forcible Sex Offenses	0	0	0	0	0	0
Robbery	1	2	0	0	2	0
Aggravated Assault	1	2	0	0	2	3
Burglary	0	0	0	0	0	0
Motor Vehicle Theft	1	2	0	0	2	0
Arson	0	0	0	0	0	0
Property Damage	31	0	0	17	0	11
Illegally Appropriated by Force	18	4	6	16	4	20
*Hate Crimes	0	0	0	0	0	0
Disciplinary Actions/ Judicial Referrals and/or Arrests for:						
Liquor Law Violations	0	0	0	0	0	0
Drug Law Violations	1	0	0	0	0	0
Illegal Weapon Possession	0	0	0	0	0	0

**ON-CAMPUS CRIME REPORT-2013-2015
REQUIRED BY THE PUBLIC LAW 101-542
(STUDENT RIGHT TO KNOW AND
CAMPUS SECURITY ACT)**

CATEGORIES*	Total		
	2015	2016	2017
Murder/Negligent Manslaughter	0	0	0
Non-Negligent Manslaughter	0	0	0
Forcible Sex Offenses (Including forcible rape)	0	0	0
Non-forcible Sex Offenses	0	0	0
Robbery	1	2	0
Aggravated Assault	1	0	3
Burglary	1	0	0
Motor Vehicle Theft	1	0	0
Arson	0	0	0
Property Damage	51	1	17
Illegally Appropriated by Force	37	36	39
*Hate Crimes	0	0	0
Disciplinary Actions/Judicial Referrals and/or Arrests for:			
Liquor Law Violations	0	0	0
Drug Law Violations	1	0	0
Illegal Weapon Possession	0	0	0

**STATE POLICE CRIME REPORT OF
CAMPUS ADJACENT AREAS
REQUIRED BY THE PUBLIC LAW 101-542
(STUDENT RIGHT TO KNOW AND
CAMPUS SECURITY ACT)**

CATEGORIES*	In Campus			Students Residence		
	2015	2016	2017	2015	2016	2017
Murder/ Negligent Manslaughter	0			0		
Non-Negligent Manslaughter	0			0		
Forcible Sex Offenses (Including forcible rape)	0			0		
Non-forcible Sex Offenses	0			0		
Robbery	0	1		10	7	
Aggravated Assault	0			3		
Burglary	0	2		0		
Motor Vehicle Theft	0	1		0		
Arson	0			0		
Property Damage	0	10	6	0	11	
Illegally Appropriated by Force	27	12	14	32	10	
*Hate Crimes	0			0		
Disciplinary Actions/Judicial Referrals and/or Arrests for:	0	1		0		
Liquor Law Violations	0	0		0		
Drug Law Violations	0	0		0		
Illegal Weapon Possession	0	0		0		

**STATE POLICE CRIME REPORT OF
CAMPUS ADJACENT AREAS
REQUIRED BY THE PUBLIC LAW 101-542
(STUDENT RIGHT TO KNOW AND
CAMPUS SECURITY ACT)**

CATEGORIES	Outside Campus Residence			Public Properties		
	2015	2016	2017	2015	2016	2017
Murder/ Negligent Manslaughter	0			0		
Non- Negligent Manslaughter	0			0		
Forcible Sex Offenses (Including forcible rape)	0		1	0		
Non-forcible Sex Offenses	0			0		
Robbery	2		8	1		
Aggravated Assault	1	1	5	1		
Burglary	32	3		3		
Motor Vehicle Theft	0		11	0		
Arson	0			0		
Property Damage	0		44	0		
Illegally Appropriated by Force	1	5	63	0	4	
*Hate Crimes	0		1	0		
Disciplinary Actions/ Judicial Referrals and/or Arrests for:	0			0		
Liquor Law Violations	0			0		
Drug Law Violations	0		1	0		
Illegal Weapon Possession	0			0		

**STATE POLICE CRIME REPORT OF
CAMPUS ADJACENT AREAS
REQUIRED BY THE PUBLIC LAW 101-542
(STUDENT RIGHT TO KNOW AND CAMPUS
SECURITY ACT)**

CATEGORIES*	Total		
	2015	2016	2017
Murder/Negligent Manslaughter	0		
Non-Negligent Manslaughter	0		
Forcible Sex Offenses (Including forcible rape)	0		1
Non-forcible Sex Offenses	0		
Robbery	13	8	8
Aggravated Assault	5	1	5
Burglary	35	5	
Motor Vehicle Theft	0	1	11
Arson	0		
Property Damage	0	21	50
Illegally Appropriated by Force	60	31	77
*Hate Crimes	0		1
Disciplinary Actions/Judicial Referrals and/or Arrests for:	0	1	
Liquor Law Violations	0		
Drug Law Violations	0		1
Illegal Weapon Possession	0		

*Subcategories under hate crimes:

Theft

Aggression

Intimidation

Vandalism, property damage

Domestic violence

Gender violence

Stalking

ADYACENT AREAS:

Parking Satellites Area

(Palacio de Recreación y Deportes and Juan Rivero Zoo)

Pedro Albizu Campos Avenue

Barrio Dulces Labios

Barrio Paris

Bosque Street, West Side

Dr. Basora Street, West Side

Martínez Nadal Street

Mayagüez Town Center

Méndez Vigo Street (Darlington Building)

Morell Campos Street, West Side

Los Próceres Park

Urb. Ensanche Ramírez

Urb. La Riviera

Urb. Mayagüez Terrace

Road 108, 2 km.

SOCIAL AND CULTURAL ACTIVITIES

The Social and Cultural Department offers diverse social and cultural activities such as theatrical and musical plays, concerts, sport events, and art exhibitions. The department is responsible for all UPRM student organizations accreditation and work with the approval of all their campus events and fundraising initiatives. Although most activities are on campus, university-sponsored activities are also offered at municipal government facilities such as the Yagüez Theater, the Cultural Center, and the Municipal Coliseum.

Vision

To complement the formal education through social and cultural activities that give students the interpersonal, leadership, communication and social skills needed to give society active, creative, social and self-confident individuals.

Mission

To present and promote an agenda of extracurricular activities for the UPRM community through artistic, social and cultural events that contributes to an integral student education, promoting also arts and culture development.

STUDENT ORGANIZATIONS AND CLUBS

The UPRM has over 300 recognized student organizations and clubs which respond to student's social needs and interests. These organizations include chapters of national organizations, local clubs and groups of interest which give them an opportunity to enrich their cultural wealth and educative experiences. They also help their professional network to grow, and to develop leadership, interpersonal skills and sensibility through community service events.

Office: Students Center Building, 3rd floor, 306

Phone: 787-832-4040 exts. 3366, 3370

Website: <http://www.uprm.edu/actividadessociales>

Email: actividadessociales@uprm.edu

STUDENT GOVERNANCE

The General Student Council, is composed of representatives from each academic faculty elected by the student body. Additional information regarding the student council and its functions may be obtained at the General Student Council Office located on the 1st floor of the Student Center or at (787) 832-4040 ext. 3409.

STUDENT CENTER

The Student Center is the university's community center and it is open to all students, faculty, staff, alumni, and visitors every day.

Mission

To provide students with a comfortable facility that meets recreational, entertaining, dining, and social needs in a safe environment.

There is always something going on in the UPRM Student Center. It is a focal point for cultural, social, and recreational activities while providing study areas for students.

Departments from the Dean of Students are located in the Center like Placement, Social and Cultural Activities, and the Student Exchange Program-International Services. It also houses a Computer Center with free printing services for students, a relaxation room and a breastfeeding room. Other offices located in Center include the Students Affairs Council Office, Book Store, and the "Café Colegial", an alcohol free club and cafeteria managed by UPRM students. A food court, a game room, a branch of a local bank Banco Popular de Puerto Rico and a branch of the First Credit and Savings Coop of Puerto Rico, are also in the building and free wireless connection to UPRM network and the WWW is available.

Students, faculty and administrators also hold meetings, conferences and special events at the Student Center. The facility has the *Tarzan Room* to accommodate 125 sitting people with audio/visual equipment. Also the 3rd floor is available with a stage and audio for events like these.

Services are available from:

Monday to Thursday: 7:00 am to 12:00 midnight

Friday: 7:00 am to 6:00pm

Sunday and holidays: Available by reservation

*Check dates for availability

Administrator's Office: Students Center Building,
4th floor, 411

Phone: 787-832-4040 exts. 2711, 3366, 3370

STUDENT EXCHANGE PROGRAMS AND INTERNATIONAL STUDENT SERVICES

Mission

Our mission is to offer our students the opportunity to expand their educational and cultural horizons through their participation in the student exchange programs. To provide information to international students who visit our campus, and familiarize them with our college community and with the Puerto Rican culture.

The Mayagüez Campus is an active member of the National Student Exchange Consortium and the International Student Exchange Program. Also, we have Agreements with universities in: Europe, Latin America, Dominican Republic and U.S.A.

Exchange programs offer excellent opportunities to explore academic, social, and cultural settings.

The National Student Exchange offers students the opportunity to attend and study at another college or university in the United States and its territories.

www.nse.org

The International Student Exchange Program offers students the opportunity to study, experience and learn from exposure to different regional, cultural, and ethnic perspectives and to broaden their educational background. A qualified, full-time undergraduate student may participate in the exchange program for an entire academic year and live in one of 50 countries.

www.isep.org

The Exchange Program office provides orientation services to students from other countries as they become acquainted with registration procedures, educational facilities, and student services. Information is offered in areas of immigration, financial assistance, foreign embassies located in Puerto Rico, programs sponsored by international agencies, and housing. The office works closely with the academic community, the administration, and the local community.

Office: Students Center Building, 5th floor, 510

Phone: 787-832-4040 exts. 3896, 2270

Website: <http://uprm.edu/intercambio>

OTHER SERVICES

Alumni

The UPRM Alumni Office is engaged in activities designed to strengthen relationships between UPRM and its graduates.

Vision

Be a life liaison between the University of Puerto Rico at Mayagüez (UPRM), it's current and future alumni, encouraging their collaboration and support to achieve institutional goals for the benefit of future generations.

Mission

To establish, strengthen and maintain the relationship between the University of Puerto Rico at Mayagüez and it's alumni so they can contribute to institutional goals and support the University. This is addressed by:

- Promoting communication and active alumni participation in campus events
- Recognizing and reporting alumni contributions to our society
- Promoting UPRM love and pride

This office tracks UPRM alumni, run fundraising campaigns, and organize events for the UPRM alumni community.

Office: Students Center Building, 3rd floor 306

Phone: 787-832-4040 ext. 3366, 3370, 5062

Website: <http://www.uprm.edu/egresados/>

Email: egresados@uprm.edu

Bookstore

UPRM Bookstore is located at the Campus Student Center on the first floor and provides ongoing service Mondays through Fridays from 7:00 AM to 4:00 PM. Recent restructuring of services that were traditionally offered, allow us to provide our campus community bookstore supplies, textbooks, office and school supplies, university logo souvenirs and personal care supplies. Additional information available at <http://www.uprm.edu/decadmi/libreria/librecolegial.php>. Please contact us at edgardo.perez8@upr.edu, or call 787-265-3885, 787-832-4040 Exts. 2294 or 3885, 787-834-8290 (fax).

Campus Dorms

An in-Campus accommodation for our athletes is provided through the University Enterprises Department. UPRM Athletes residence is located at Building A and provides our students with the following services and amenities: laundromat, vending machines, common-use kitchen and study area.

Phone: 787-265-3891

Website: <http://hotelcolegial.com/>

Email: margarita.quintana@upr.edu

Dining

Food service is provided in our Cafeteria which is conveniently located in the Student Center. Ongoing service is provided in specific time slots separately at our main dining room and snack bar. Mondays through Thursdays from 6:30 AM to 8:00 PM, our main dining room will serve breakfast, lunch and dinner. Food service on Fridays will run up to 3:00 PM. Snack bar service will be available Mondays through Fridays from 7:00 AM until 3:00 PM.

Phone: 787-832-4040 ext. 2991

Information Technology Center

As one of the units of the Chancellor's Office, the Information Technology Center, also known as the Campus Computer Center, serve the academic and administrative community by providing support to their technological needs. The CTI facilities are located on the ground floor of the Luis de Celis Building. Our servers are located in an adequate space and we are continually working to provide the best infrastructure to maintain our computer services running in a 7/24 basis.

The institutional network **RUMNET** (Recinto Universitario de Mayagüez Network) is the most valuable resource supported by the Center. With a strong fiber optic infrastructure interconnecting over 40 buildings throughout the campus, it is part of the Internet 2 project with two Giga-Ethernet connections to connect UPRM to the outside world. The Center also supports the most widely deployed wireless network for academic purposes in Puerto Rico, covering the most part of the campus. The university community can access information resources, including Internet access wirelessly from almost anywhere, anytime.

Computing services for the academic users, are offered through the User Support Unit. Consulting and training services in academic and administrative tools like WordPress, CMS and the Portal, preparation of online user guides and manuals, academic support to the learning management system (LMS) Moodle and administration of institutional software licensing agreements, are some of the services provided.

The Analyst/Programming and Systems Units, ensure the flow of information needed for the day to day tasks of the academic and administrative community. Also, the Technical Services Unit provide network infrastructure, computer equipment maintenance and repair services, in coordination with other technical personnel around the campus.

The University covers the operational expenses of the computer network to provide Internet access through the wireless system inside the campus.

Additionally to the services provided from the CTI, several academic departments operate their own computer laboratories, some with specialized hardware or software, so their use is restricted to students who are enroll in certain courses or engaged in research. Most departmental laboratories are open to the general campus population.

Phone: 787-834-3718; 787-832-4040 ext. 2009, 2051, 2059, 2132, 3331,

Website: <http://www.uprm.edu/cti>

Press and Publications

The Press Office is the link between the university community as well as local and international media. Press releases and articles regularly published in daily and weekly newspapers and internal publications such as *Cartelera Semanal*, *La Gaceta Colegial*, and the UPRM web page (www.uprm.edu), keep the general public informed of UPRM's main events. The Press Office produces two television programs, *Prensa RUM TV*, a news magazine format program reviewing the latest UPRM's events and *Foro Colegial TV*, an interview format program with hosts from the Mayagüez Campus. Both programs are broadcasted on the local television channel WORA TV 5.2. They also produce *Foro Colegial*, with the same television format but in its version for radio, which is broadcasted weekly on Radio Universidad WRTU FM. The Press Office also manages the content of the institution official social networks pages. Radio and TV announcements are also prepared by the Press Office.

TUITION, FEES AND EXPENSES

The following fees, prescribed by the university are tentative for new students and transfers for 2018-2019 and are subject to change at the discretion of trustees. University charges such as tuition and fees are due and payable in full by the date announced before the beginning of each term.

Tuition Fees

Cost per credit Masters and Doctoral

For U.S.A. citizen's residents of Puerto Rico:

\$175.00 per credit for students enrolled in **masters** programs plus applicable regular or special fees.

\$200.00 per credit for students enrolled in **doctoral** programs plus applicable regular or special fees.

\$50.00 for students enrolled in thesis only.

For U.S.A. citizen's non residents of Puerto Rico:

\$350.00 per credit for students enrolled in **masters** programs plus applicable regular or special fees.

\$400.00 per credit for students enrolled in **doctoral** programs plus applicable regular or special fees.

For foreign students:

\$525.00 per credit for students enrolled in **masters** programs plus applicable regular or special fees.

\$600.00 per credit for students enrolled in **doctoral** programs plus applicable regular or special fees.

Visiting students:

\$67 per graduate course plus \$13 maintenance fee and \$25 technology for each academic session.

Regular Fees

Application for admission	\$30.00
Maintenance fee (per registration period)	\$47.00
Technology Fee	\$25.00
Graduation fee	\$80.00
Application for transfer to a different program	\$20.00
Application for readmission	\$35.00
Late registration fee	\$20.00
Academic transcript of credits (per copy)	\$ 5.00
Duplicate of admission letter, class ticket or schedule card (per copy)	\$ 5.00
Identification card	\$10.00
Letter of recommendation of the Dean of Students	\$ 5.00
Repetition courses	\$10.00
Partial withdrawal	\$15.00
Total withdrawal	\$20.00

Students applying for admission, readmission, or transfer after the corresponding due date will pay one-and-a-half times the regular fee. Late applications are accepted only after complete justification is presented.

Special Fees

Laboratories fees (per laboratory course)	\$100.00
Maintenance fee (per registration period)	\$47.00
Technology Fee	\$25.00

Annual Medical Insurance

Basic \$1,112.00

Basic including pharmacy and dental charges \$1,430.00

Basic including pharmacy, dental and mayor medical charges \$1,486.00

Basic including pharmacy and major medical charges \$1,168

REGULATIONS

Date for Payment of Fees: All general student fees for each semester are paid in advance on the corresponding registration day.

Deferred Payment of Fees: As a general rule, no deferred payment of fees is granted. However, in very exceptional cases, the Dean of Students is authorized to grant an extension of time which cannot exceed 10 days before the end of the course. In those exceptional cases, a student must apply for deferred payment of fees in ample time prior to the registration date so that the merits of the application may be evaluated. On registration day, those students to whom deferred payment of fees is granted, must pay 100% of Special Fees plus the corresponding percent of Tuition Fees. The balance must be paid at least 10 days before the last day of classes of the semester. Students who fail to pay accordingly must pay a late fee of \$3.00 per credit.

Students who fail to settle their accounts with the university 30 days before the last day of classes every semester or the specified date for each Summer Session will receive no credit for their work, nor will the Registrar release any transcript of record or other official documents until all outstanding fees and charges have been paid. All fees must be paid in United States currency, certified check, or postal money orders made out for the exact amount to the University of Puerto Rico.

REIMBURSEMENTS

Fees: Students who drop out of the University of Puerto Rico, Mayagüez Campus within the first two weeks of any semester or the first week of the Summer Session, are entitled to a 50 percent refund of tuition fees excluding special fees. The application for reimbursement must be approved by the corresponding Dean and the Registrar, and filed in the Treasurer's Office within five days following the date of approval. No refunds are allowed thereafter.

Visitors and students forced to withdraw for disciplinary reasons are not entitled to a refund of fees.

The Medical Services fee, the transfer and readmission fees, the construction fee, laboratory fee and late registration fees are not refundable.

RETURN OF UNIVERSITY PROPERTY

Before leaving the university, the student must return, in good condition, all ROTC and AFROTC property and any other university properties that he or she may have used during the year. The ROTC and AFROTC property custodians will send a written notice to all students who do not return property. If the property is not returned within 30 days of notification, the individual's name will be forwarded to the Registrar. The value of any property that has been lost, damaged or not returned will be deducted from the total of his or her deposits.

The University will retain all fees and deposits not claimed by the end of the second semester of the academic year following payment. All books and/or library materials should be returned to the Library. If any of these materials are overdue, fines should also be paid. Failure to comply with these regulations will cause the student to be included in the Finance Department Debtor's List.

ACADEMIC INFORMATION

GRADUATE STUDIES PROGRAMS AT UPRM

UPRM offers graduate programs which lead to the degrees of Master of Arts, Master of Business Administration, Master of Engineering, Master of Science, and Doctor of Philosophy. The departments and programs of study are as follows:

Master of Arts in:

Hispanic Studies, English Education, and Kinesiology.

Master of Business Administration in:

Human Resources, Industrial Management, Finance, and General Business Administration.

Master of Engineering in:

Bioengineering, Chemical, Civil, Computer, Electrical, Industrial, Materials Science and Engineering and Mechanical Engineering.

Master of Science in:

Agricultural Economics, Agricultural Education, Agricultural Extension, Agronomy, Animal Science, Horticulture, Crop Protection, Food Science and Technology, and Soils;

Biology, Chemistry, Geology, Computer Sciences, Marine Sciences, Mathematics (Applied, Pure, and Statistics), Teaching Mathematics at Secondary Level, Physics, and Scientific Computing;

Bioengineering, Chemical, Civil, Computer, Electrical, Industrial, Materials Science and Engineering and Mechanical Engineering.

Doctor of Philosophy in:

Marine Sciences, Applied Chemistry, Bioengineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Computing and Information Sciences and Engineering.

PHILOSOPHY AND OBJECTIVES

Graduate programs at UPRM seek to develop graduate students' expertise in their particular field of studies as well their ability to conduct original research and/or creative, professional and community education projects in the fields of arts, sciences, engineering, agriculture and business. All graduate programs encourage and support students to attain a high level of scholarship and/or professional development in their fields.

Additional objectives of the graduate programs are:

1. To extend the boundaries of knowledge through original research committed to developing students' academic formation as well as their ability to contribute to the development of their surrounding communities.
2. To preserve, acquire, and transmit knowledge to successive generations.
3. To serve as a focus for research and teaching in the Caribbean, with the recognition of Puerto Rico's unique position as a crossroad of the Americas.

Graduate Studies Organization

Graduate studies at UPRM are overseen by four basic units:

- Office of Graduate Studies
- Graduate Council
- Departmental Graduate Committee
- Student's Graduate Committee

The functions and responsibilities of these units are described below.

Office of Graduate Studies

The Office of Graduate Studies (OGS) is an academic and administrative unit within the Office of Academic Affairs. The OGS oversees all academic and administrative regulations at the graduate level, manages graduate admissions, coordinates graduate student professional development activities, and serves as a liaison between graduate students, graduate programs and other units that pertain to graduate students' admissions, enrollment, employment and support at UPRM.

The Director of Graduate Studies, who is also an Associate Dean of Academic Affairs, chairs this office. An Associate Director collaborates in all duties assigned by the Director.

In addition to the usual administrative duties, the Director presides over the Graduate Council, schedules final dissertation, thesis or project examinations, and participates in such exams personally or through the designation of a representative.

The Graduate Council

The Graduate Council is composed of representatives from all academic units which offer graduate programs. The Council consists of the Director and Associate Director of Graduate Studies, the Dean (or representative) of each college sponsoring graduate programs, a representative of each Departmental Graduate Committee, and a representative of the graduate students of each college.

The Council acts as an advisory board to the Office of Graduate Studies. Its main duties include:

- Serve as forum for the discussion of all matters pertaining to graduate studies.
- Make recommendations on the administration and regulations involving graduate studies.
- Evaluate and decide on regulations which a department submits for its own program.
- Evaluate and decide on those administrative and academic decisions of its jurisdiction.

The Departmental Graduate Committee

The Departmental Graduate Committee consists at least of three elected members, including the Director of the Department. In multidisciplinary programs, it includes representation from each department involved.

The functions and responsibilities of the committee include:

- Formulation of complementary regulations.
- Evaluation of applications for admission, readmission, and transfer.
- Accreditation of courses taken in other institutions or prior to admission to UPRM.
- Preparation of qualifying and comprehensive examinations with the assistance of qualified faculty.
- Promotion and periodic evaluation of graduate programs.

The Student's Graduate Committee

The committee consists of three to five members in Master's programs and four to six members in Doctoral programs. The student chooses the committee members and chair based on his/her research interests.

This committee is responsible for:

- Overseeing the preparation of the student's plan of study and, if applicable, its amendments.
- Revising and approving the student's dissertation, thesis, or project proposal.
- Directing studies and research until the student completes the degree.
- Revising and approving the dissertation, thesis, or project report and its oral defense (if included in the student's plan of study).

The Graduate Advisor

The student's graduate advisor must hold an academic degree equal to or higher than the degree sought by the student. The graduate advisor's responsibilities include:

- Informing the student of regulations and procedures related to graduate studies.
- Overseeing, in consultation with the student and the student's committee, the preparation of the student's plan of study.
- Revising and approving the dissertation, thesis, or project proposal, and recommending changes.
- Meeting regularly with the student to evaluate academic progress, research and/or project development.
- Providing adequate resources to carry out research.
- Verifying that other members of the graduate committee collaborate efficiently.

The Representative of Graduate Studies

The representative of graduate studies is a professor or professional who is appointed by, and represents, the Director of Graduate Studies in the oral examination of the dissertation, thesis, or project report. The representative of the OGS cannot belong to the same department or the same program of study of the student who is under examination. The representative oversees the examination of the dissertation, thesis, or project report and ensures that it takes place according to regulations. The representative participates in the administration, evaluation and decisions concerning the exam, and makes corrections and changes to improve the final document.

Application Procedure

A candidate for admission to graduate studies at UPRM must file an online application with the Office of Graduate Studies at <https://app.applyyourself.com/AYApplicantLogin/flApplicantLogin.asp?id=UPR-GMAYA>. Additional supporting documents are required. Information about these requirements is available at <http://grad.uprm.edu/oeg/>.

Admission

Admission to graduate studies requires the favorable recommendation of the Departmental Graduate Committee. The department forwards its recommendation to the Director of the Office of Graduate Studies for final action.

Academic Requirements

General requirements for admission to graduate studies include:

1. Holding a bachelor's degree from the University of Puerto Rico or an equivalent degree from an accredited institution.
2. Have a working knowledge of Spanish and English, as determined by the corresponding academic program.
3. Satisfying one of the following academic index requirements:
 - (a) a minimum graduation 2.50 GPA;
 - (b) a minimum 3.00 GPA in the area of specialization;
 - (c) successfully completed a minimum of 60 credit hours during the last five semesters of the bachelor's program with a 3.00 GPA or better.

4. Satisfying all departmental requirements, which may include, but are not limited to, holding a bachelor's degree in an area of specialization, having a grade point average higher than 3.00, and having successfully completed courses in specific subjects, along with the required exams such as GRE, TOEFL, EXADEP, etc..

Detailed regulations are available in the departmental sections of this catalogue.

Applicants who do not meet the academic index requirements listed under (3) above, but who have practiced their profession for a minimum of three years, may be considered for regular admission if they obtain admission as a professional improvement student and successfully complete, with at least a 3.00 G.P.A., a minimum of nine credits in advanced undergraduate and/or graduate courses during the first three semesters following admission. Up to twelve credits successfully completed under this provision may be credited towards a degree if the applicant is admitted as a graduate student.

Meeting the above requirements does not automatically grant admission. Candidates are elected on a competitive basis from among those who apply and satisfy the requirements.

Readmission and Transfer

Students who have voluntarily interrupted their studies and desire to continue at a later date must apply for readmission. The student will pay a non-refundable fee of US \$35.70 (late: US \$52.20).

Students in good standing (with a GPA of at least 3.00) are eligible to apply for transfer to another department or program within the Mayagüez Campus. The student will pay a non-refundable fee of US \$22.70 (late: US \$32.70).

In both cases, the application must be filed at the Registrar's Office before the deadline established in the official academic calendar. The department director will send his/her recommendation to the director of graduate studies for final action. The allowable time periods for completing the studies are stipulated in the Academic Senate's Certification 09-09.

STUDENT CLASSIFICATION

Graduate students at UPRM are classified according to

- **admission status**
- **academic load**
- **academic status**

Admission Status

A student in **Full Admission** is one who at the time of admission satisfies all requirements and is admitted unconditionally.

A student in **Conditional Admission** is one who at the time of admission satisfies all requirements except for some deficiencies in undergraduate courses (up to four maximum). Full-standing status can be granted once the student successfully removes the deficiencies within the first two years of study. Courses with deficiencies must be passed with a grade of C or better maintaining a grade point average of 3.00 or better.

A **Professional Development** student is one who does not seek a graduate degree, but desires to take advanced undergraduate or graduate courses for academic or professional benefit. Up to 12 credits of advanced undergraduate or graduate courses successfully completed under this classification may be used to satisfy degree requirements if the student is conditionally or fully admitted.

A **Visiting Student** is one registered in another university and who registers in a course at the Mayagüez Campus. Up to 12 credits of advanced undergraduate or graduate courses successfully completed under this classification may be used to satisfy degree requirements if the student is conditionally or fully admitted.

Academic Load

A **Regular** or **Full-time** student is one who takes at least nine advanced undergraduate or graduate credits per semester, including deficiency courses, and/or who is registered for dissertation, thesis, or project, or who participates in the COOP Plan.

An **Irregular** or **Part-time** student is one who does not meet the academic load requirements of a regular student.

Academic Status

A student on **Probation** is one whose grade point average drops below 3.00 or receives a non-satisfactory (NS) grade for dissertation, thesis research, or project. Increasing the grade point average to 3.00 or above, or receiving a satisfactory (S) grade in research or project, removes the probation status. Probation for a third time will lead to academic suspension from graduate studies. Suspended students may apply for a second and final admission to graduate studies after one year of suspension.

A student in **Good Standing** is one who is not on probation.

GRADES

The Grading System is as follows: A, excellent; B, satisfactory; C, approved; D or F, failed; W, authorized withdrawal; I, incomplete (does not carry a provisional grade); S, satisfactory; NS, not satisfactory. Incompletes must be removed during the term following the one in which the course was registered; otherwise an F will be posted. The Academic Index or grade point average is computed as a weighted average (by credit) using these point equivalencies A=4, B=3, C=2, D=0, F=0. Courses with an incomplete grade are not included. Credit for thesis research or project is not given until the oral examination of the thesis, dissertation or project is successfully passed and the final report is completed and submitted. A graduate grade point index of 3.00 is considered satisfactory and it is the minimum required for graduation.

GRADUATE COURSE NUMBERING SYSTEM

Advanced undergraduate courses are codified in the 5000's. Graduate courses are codified with numbers between 6000 and 8999. Courses codified between 8000 and 8999 are intended for the doctoral level.

ALPHABETICAL DISCIPLINE CODES

ADMI	BUSINESS ADMINISTRATION
AGRO	AGRONOMY
ASTR	ASTRONOMY
BING	BIOENGINEERING
BIOL	BIOLOGY
BOTA	BOTANY
CIAN	ANIMAL SCIENCE
CIIC	COMPUTER AND INFORMATION SCIENCES AND ENGINEERING
CIIM	MATERIAL SCIENCE AND ENGINEERING
CIMA	MARINE SCIENCES
CITA	FOOD SCIENCE AND TECHNOLOGY
CMOB	MARINE SCIENCES BIOLOGICAL OCEANOGRAPHY
CMOF	MARINE SCIENCES PHYSICAL OCEANOGRAPHY
CMOG	MARINE SCIENCES GEOLOGICAL OCEANOGRAPHY
CMOQ	MARINE SCIENCES CHEMICAL OCEANOGRAPHY
COMP	COMPUTER SCIENCE
CONT	ACCOUNTING
ECAG	AGRICULTURAL ECONOMICS
ECON	ECONOMICS
EDAG	AGRICULTURAL EDUCATION
EDFI	PHYSICAL EDUCATION
EDMA	TEACHING MATHEMATICS
EING	ENGLISH EDUCATION
ESHI	HISPANIC STUDIES
ESMA	MATHEMATICAL STATISTICS
ESTA	STATISTICS
EXAG	AGRICULTURAL EXTENSION
FINA	FINANCE
FISI	PHYSICS
GEIN	INDUSTRIAL MANAGEMENT
GEOL	GEOLOGY
GERE	MANAGEMENT
GERH	HUMAN RESOURCES MANAGEMENT
HORT	HORTICULTURE
ICOM	COMPUTER ENGINEERING
INCI	CIVIL ENGINEERING

INEL	ELECTRICAL ENGINEERING
INGL	ENGLISH
ININ	INDUSTRIAL ENGINEERING
INME	MECHANICAL ENGINEERING
INQU	CHEMICAL ENGINEERING
INTD	INTERDISCIPLINARY
KINE	KINESIOLOGY
LING	LINGUISTIC
MATE	MATHEMATICS
MECU	QUANTITATIVE METHODS
MERC	MARKETING
PROC	CROP PROTECTION
QUIM	CHEMISTRY
SICI	COMPUTERIZED INFORMATION SYSTEMS
UNIV	UNIVERSITY COURSES
ZOOL	ZOOLOGY

Course Offerings

I=course usually offered during the first semester

II=course usually offered during the second semester

S=course usually offered during a summer session

PLAN OF GRADUATE STUDY

The student's Plan of Graduate Study should be submitted to the Registrar's Office (original) and the Office of Graduate Studies (copy) by the beginning of the second semester of the student's enrollment as a graduate student at UPRM. This plan must be approved by the student's committee members, the Graduate Program Coordinator and the Department Chair.

PROPOSAL

Graduate students pursuing a degree in which a dissertation, thesis, or project is required must submit a proposal describing goals, objectives, previous work, justification, and proposed work. This document must be completed before the student is registered for master's thesis, or project credit for a third time or doctoral dissertation for a fourth time.

GENERAL ACADEMIC REGULATIONS

Academic Load

The maximum academic load is eighteen credits during the academic semester and six credits during the summer. Class attendance is compulsory.

Academic Residence

Studying two academic semesters and successfully completing 60 percent of the courses at the Mayagüez campus satisfies residence requirements for the master's degree. Studying four academic semesters and successfully completing 60 percent of the courses at the Mayagüez campus satisfies residence requirements for the doctoral degree.

Validations

Graduate courses taken at other universities or validated by the Departmental Graduate Committee can be part of the graduate student's plan of studies if the courses were not used as requirements for the student's bachelor's degree. The number of validated courses cannot be in conflict with the academic requirements established by the UPRM.

Repetition of Courses

Courses not completed successfully may be repeated once up to a maximum of three advanced undergraduate or graduate courses, including courses with a grade of C.

Withdrawal from Courses

Graduate students should avoid withdrawing from courses, but can do so during the period prescribed in the official academic calendar.

Withdrawal from the University

A student may withdraw completely from the Mayagüez campus at any time until the last day of classes. The Registrar will post a "W" in every course for the applicable semester. Any student intending to continue graduate work who has withdrawn from Graduate Studies is eligible for readmission within the stipulations of Certification 09-09 (Academic Senate).

Academic Dismissal

A graduate student may be dismissed from the graduate school if any of the following conditions occur:

1. During the first two years of study, deficiency courses indicated in the conditional admission are not successfully completed with a 3.0 GPA or higher.
2. Placed on probation three times.
3. Fails for the second time any of the required degree examinations.
4. Fails to satisfy all requirements for a master's degree within six academic years after being admitted.
5. Fails to satisfy all requirements for a doctoral degree within ten academic years if admitted with a bachelor's degree, or within eight academic years if admitted with a master's degree.

REQUIREMENTS FOR THE MASTER'S DEGREE

At UPRM, there are three options in programs leading to a master's degree. Applicants should seek information on the program of interest in order to best determine available options.

In all cases, the student needs to complete all courses in the Plan of Graduate Study with a GPA of at least 3.00. Graduate courses taken by the student as a senior in the Mayagüez Campus may be accepted as long as these were not utilized to satisfy bachelor's degree requirements.

Students must inform the Registrar in writing of their intention to use a course as part of their Plan of Graduate Study. The last day to notify the Registrar is the last day to submit the application for graduation from the bachelor's degree. The student must also comply with the established academic residence requirements.

PLAN I. With Thesis Requirement

In addition to the common requirements stated above, the student shall:

1. Pass all the courses in the Plan of Graduate Study with a 3.0 minimum graduate point average and complete:
 - (a) A minimum of 30 credits in advanced undergraduate courses and graduate courses.

- (b) Up to nine credits in advanced undergraduate courses.
 - (c) Up to six credits in thesis research.
 - (d) A minimum of six credits in courses related to, but outside the area of interest.
2. Carry out a research project, as specified in the Plan of Graduate Study and prepare a thesis.
 3. Pass an oral exam on the thesis subject. If the student fails the exam, the student will have the opportunity to take a second exam during the same semester or in the following semester within the stipulations of Academic Senate's Certification 09-09. The result of the second exam shall be final.

PLAN II. With Project Requirement

In addition to the common requirements stated above, the student shall complete specific requirements in PLAN I's description, except that all work completed will lead to a project report instead of a thesis. An oral exam on the project will also be required. If the student fails the exam, a second exam can be taken in the same or following semester. The result of the second exam shall be final.

PLAN III. Without Thesis or Project Requirements

In addition to the common requirements stated above, the student shall:

1. Complete all courses in the Plan of Graduate Study as follows:
 - (a) A minimum of thirty-six credits in advanced undergraduate and graduate courses.
 - (b) A minimum of twenty-seven credits at the graduate level.
 - (c) A minimum of twenty-one credits in the major field of study.
 - (d) A minimum of six credits in courses related to, but outside the area of specialization. Courses within the area of specialization will be used to satisfy this requirement only when there are two or more distinct and well-defined areas.
2. Pass a written examination on the material covered in courses taken within the area of specialization. In the event of failure, the student may take a second exam during the same semester or in the following semester within the stipulations of Certification 09-09. The result of the second exam shall be final.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE

The Doctor of Philosophy degree is conferred for distinguished scholarly attainment and original contribution to knowledge.

To qualify for the degree, the student should:

1. Pass a qualifying examination.
2. Complete all the courses in the Plan of Graduate Study with an academic index of at least 3.00, including other requirements.
3. Comply with the academic residence requirements.
4. Pass a comprehensive examination on the courses included in the academic program. The exam may be written, or written and oral. If the student fails, a second exam may be taken later that semester or in the following semester within the stipulations of Certification 09-09. The result of the second exam is final.
5. Carry out an independent research project which will produce a significant contribution to the advancement of knowledge, and write a dissertation. The dissertation should be a scholarly presentation suitable for publication.
6. Pass a final oral exam on the research and dissertation. If the student fails, a second exam may be taken later during the same semester or in the following semester within the stipulations of Certification 09-09. The result of the second exam is final.
7. Complete all courses in the Plan of Graduate Study as follows:
 - (a) Up to nine advanced undergraduate courses.
 - (b) Up to eighteen credits in thesis research.
 - (c) A minimum of nine credits outside the field of specialization but in related areas.
8. Courses completed before admission to the doctoral program may be accepted upon recommendation of the departmental graduate committee, as long as the student meets residence requirements. Master's thesis, or Master's project research will not be awarded credit.

FINAL EXAMINATION

The final thesis exam takes place after the student has satisfied all other requirements for the degree, except for any courses in which the student is registered at the time. No exam will take place after the last day of classes. The exam should last at least two hours but no more than four.

The examining committee consists of the student's committee and a representative of the Director of Graduate Studies. The examining committee will be presided by the student's advisor. All corrections to the thesis or report should be completed within the time period specified by the committee. Such period shall not extend beyond the last day of school of the semester immediately following the day the exam was taken.

Additional Graduation Requirements

In addition to the requirements specified in the section on general academic regulations, the student must:

1. Satisfy all financial obligations to the University of Puerto Rico, Mayagüez Campus.
2. File an application for the degree at the Registrar's Office before the deadline established in the official academic calendar.
3. Receive recommendation for the degree by the Faculty.
4. Attend Commencement Exercises, unless excused by the Registrar's Office.

GUIDE FOR THE PREPARATION OF PROPOSALS, DISSERTATIONS, THESES, AND PROJECT REPORTS

Please refer to the Office of Graduate Studies website <http://grad.uprm.edu>.

COLLEGE OF AGRICULTURAL SCIENCES

The College of Agricultural Sciences is the unit within the Mayagüez Campus where formal teaching, research, and extension in agricultural sciences are integrated. The three functions are mutually complementary and are under a central scheme of a three-dimensional organization that includes the Faculty of Agricultural Sciences, the Agricultural Experiment Station, and the Agricultural Extension Service.

University teaching in the field of agriculture began formally in Puerto Rico in 1911 with the establishment of the College of Agriculture at Mayagüez. Graduate instruction in agricultural sciences began in 1963-64 with the approval of the Master of Science degrees in Agricultural Economics, Agricultural Education, Agricultural Extension, Horticulture, Animal Science, Agronomy, and Soils. A program leading to the M. S. in Crop Protection was approved in 1981-82, and in Food Science and Technology in 1990-91.

The Agricultural Experiment Station of the University of Puerto Rico was originally established in 1910 as a private entity of the Sugar Producers' Association of Puerto Rico. In 1914 it was transferred to the Government of Puerto Rico. With the Jones Act of 1917, the Agency became part of the Department of Agriculture and Labor and it was given the name "Insular Experiment Station". In 1933 the Experiment Station was transferred to the University of Puerto Rico.

The Smith-Lever Act of 1914 created the Cooperative Extension Service. In Puerto Rico, the establishment of the Agricultural Extension Service in 1934, was made possible by an understanding between the United States Department of Agriculture and the University of Puerto Rico.

The College of Agricultural Sciences was created in accordance with Public Law No. 1, approved on January 20, 1966, known as the University Law, and Certification No. 13 of the Council of Higher Education, dated September 11, 1968, integrating within the Mayagüez Campus the formal teaching, research, and extension in agricultural sciences. A management team, composed of the Dean and Director of the College of Agricultural Sciences, the Associate Dean of

the Faculty of Agricultural Sciences, the Associate Dean and Deputy Director of the Agricultural Experiment Station, and the Associate Dean and Deputy Director of the Agricultural Extension Service, provides direction for the plans and programs of the College.

The Office of International Programs adds a dimension of hemispheric cooperation to the College of Agricultural Sciences. Through this office, the College coordinates short course offerings to international participants and trainees; facilitates short term technical assistance to institutions in developing nations; sponsors international graduate student programs; and provides logistic support for faculty exchange and internship programs in tropical agriculture.

The Mayagüez Campus is one of two Land-Grant universities in the tropics and the only one where Spanish is the native language (although the English language is also used extensively). The Campus provides a unique setting and, to some extent, is in a privileged position to serve as an international center for studies, training, and research in the fields of agricultural sciences. At the Graduate level, the Faculty of Agriculture offers study programs leading to the Master of Science degree in Animal Science, Agricultural Economics, Agricultural Education, Agricultural Extension, Agronomy, Soils, Crop Protection, Food Science and Technology, and Horticulture.

Besides the library, laboratories, and farm facilities for research at the Mayagüez Campus, facilities are also available at the Río Piedras Research Center (AES) and at the six research substations located at different geographic regions of Puerto Rico. The Substations at Adjuntas and Corozal are located in the central, humid mountain region. Those at Lajas and Juana Díaz are in the dry, flat coastal southern region. The Substation at Isabela is in the sub-humid northern region and the Gurabo Substation is in the east central region. This wide distribution allows for the evaluation of different crops and animal production systems in the ecological zones where they best adapt.

Also the USDA Tropical Agriculture Research Station (TARS), adjacent to the Mayagüez Campus, offers technical assistance and makes available to the graduate students its Library and other physical facilities for research.

AGRICULTURAL ECONOMICS

The Department of Agricultural Economics and Rural Sociology offers a program leading to the degree of Master of Science in Agricultural Economics.

In addition to the admission requirements of the Office of Graduate Studies, a Bachelor's degree in Agricultural Economics or its equivalent is required. There are no specific program requirements above those of the Office of Graduate Studies. All students are required to conduct an original research and to write a thesis. A strong knowledge of macroeconomics, microeconomics, and quantitative methods is needed for every candidate willing to pursue the degree.

It is possible for students to focus their thesis research on the department's research projects. Research facilities of the Agricultural Experiment Station are available to students.

The program includes course offerings and research opportunities in the following areas: Agricultural Production Economics, Farm Management, Marketing, Natural Resource Economics, Global Marketing and others.

AGRICULTURAL ECONOMICS (ECAG)

Advanced Undergraduate Courses

ECAG 5006. FEASIBILITY STUDIES AGRICULTURAL ENTERPRISES. Three credit hours. Three hours of lecture per week. Prerequisites: ECAG 4019 or authorization of the Director of the Department.

Use and application of feasibility studies for the establishment and development of agricultural enterprises, considering sustainability of the resources.

Graduate Courses

ECAG 6006. CONSUMER ECONOMICS. Three credit hours. Three hours of lecture per week.

Study of the role of consumers in the economy of a nation and decision making in the market place. Analysis of economic principles of consumer behavior that affect consumer and producers decisions in the market of goods and services.

ECAG 6601. RESOURCE ECONOMICS. Three credit hours. Three hours of lecture per week.

Analysis of problems in the development and management of natural resources. Emphasis on natural resources in agriculture and their impact in economic development. Economic principles involved in efficient utilization of natural resources, such as water, land, sea and forest.

ECAG 6604. ADVANCED FARM MANAGEMENT (On demand). Three credit hours. Three hours of lecture per week.

Analysis of situations and problems related with management of farm businesses. Includes study and analysis of methods of collecting and analyzing farm data; marginal analysis and budgeting techniques; and managerial concepts as they apply to all levels of decision-making.

ECAG 6605. COMPUTER PROGRAMS FOR ECONOMETRICS. Two credit hours. Two hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Use of computer programs for data analysis and estimation of econometric models.

ECAG 6611. ECONOMICS OF AGRICULTURAL PRODUCTION (On demand). Three credit hours. Three hours of lecture per week.

Economic analysis of agricultural production. Includes the study of production and cost functions; input-output analysis; and the decision-making process necessary for a proper utilization of resources.

ECAG 6631. ADVANCED AGRICULTURAL MARKETING (I) (Even numbered years). Three credit hours. Three hours of lecture per week.

A comprehensive advanced study of the field of agricultural marketing.

ECAG 6635. GLOBAL AGRIBUSINESS MARKETING. Three credit hours. Three hours of lecture per week.

Analysis of the different marketing strategies used by agribusiness organizations in the global market.

ECAG 6641. AGRICULTURAL DEVELOPMENT (On demand). Three credit hours. Three hours of lecture per week.

Study and analysis of the factors that influence the process of transformation and development of the

agricultural sector of the economy, emphasizing those of an economic nature. Emphasis is given to the situation presented by an economy in full process of development. The interrelationships of the agricultural sector with other sectors of the economy are examined and analyzed.

ECAG 6650. ECONOMICS OF AGRICULTURAL POLICY. Three credit hours. Three lectures per week.

General comprehensive study of the formulation and implementation of policy for the agricultural sector of the economy, with major emphasis on the economic aspects. Reference is made to specific aspects of policy, especially in Puerto Rico and the United States.

ECAG 6654. RURAL SOCIOLOGY PROBLEMS. Three credit hours. Three lectures per week.

The application of sociological theories to the analysis of rural social problems; investigation of factors detrimental to community development and human welfare.

ECAG 6660. AGRICULTURAL PRICES. Three credit hours. Three hours of lecture per week.

A cross-sectional analysis of the factors affecting demand and product prices, study of empirical techniques of economic model building and interpretation and of forecasting.

ECAG 6665. APPLIED ECONOMETRICS I. Three credit hours. Three hours of lecture per week.

Use of econometrics in the agricultural economics problems and its application in production, price and consumption models.

ECAG 6666. APPLIED ECONOMETRICS II. Three credit hours. Three hours of lecture per week. Prerequisite: ECAG 6665 or authorization of the Director of the Department.

Study, application, and evaluation of econometric models with limited dependent variables, panel and time series data. Analysis and interpretation of results based on regression models.

ECAG 6990. SUPERVISED PROFESSIONAL OCCUPATIONAL EXPERIENCE FOR COOP STUDENTS. Three to six credit hours. Prerequisite: Authorization of the Director of the Department.

Practical experience in Agricultural Economics and Agribusiness Management in cooperation with the private sector or government. To be jointly supervised by the academic department, the Coop program coordinator, and an official from the cooperating entity. A written report will be required upon completion of each work period.

ECAG 6995. SPECIAL PROBLEMS IN AGRICULTURAL ECONOMICS. Two to six credit hours. One to three research periods per week.

This course provides for study in any phase of Agricultural Economics in which the student is especially interested. Individual problem method.

ECAG 6997. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in agricultural economics such as economic evaluation of agricultural projects, agricultural law, environmental economics, agricultural finance and others.

ECAG 6998. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in agricultural economics such as economic evaluation of agricultural projects, agricultural law, environmental economics, agricultural finance and others.

ECAG 6999. RESEARCH IN AGRICULTURAL ECONOMICS (I, II, S). One to six credit hours. One to six research periods per week.

Organized research in Agricultural Economics on a Master's thesis level, including thesis presentation and discussion as part of the requirements for a Master of Science degree with a major in Agricultural Economics.

AGRICULTURAL ECONOMICS FACULTY

A list of professors who engage in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

CARMEN I. ÁLAMO-GONZÁLEZ, *Professor* (Agricultural and Applied Economics), Ph.D., 2012, Texas Tech University, Lubbock, TX. Research and Teaching interest: Agricultural Economics.

MARIO J. BARRAGAN-ARCE, *Associate Professor*, (Finance and Quantitative Methods), Ph.D., 2007, University of Minnesota.

VIVIAN CARRO-FIGUEROA, *Professor*, M.A., 1976, University of London. Research and Teaching interest: Rural Sociology.

MYRNA COMAS-PAGÁN, *Professor*, (International Business), Ph.D., 2009, University of Puerto Rico. Research and Teaching interests: Farm Management, Agricultural Marketing, and Food Supply.

MILDRED CORTÉS-PÉREZ, *Professor* (Economics), M.A., 1995, University of Puerto Rico, Río Piedras Campus. Research and Teaching interest: General Economics.

FLOR M. DELGADO-PHILIPPI, *Associate Professor*, M.B.A., 1983, Louisiana State University.

GLADYS M. GONZÁLEZ-MARTÍNEZ, *Professor* (Natural Resources Economics), Ph.D., 1984, University of Missouri. Research and Teaching interests: Natural Resources Economics, Land Use, Production Economics.

JULIO C. HERNÁNDEZ-CORREA, *Assistant Professor*, (Applied Economics), Ph.D., 2010, Western Michigan University, Kalamazoo. Research and Teaching interests: Agricultural Economic Development, Econometrics, Health Economics, International Business, Demography Economics, and Program Evaluation.

JORGE A. GONZÁLEZ-SOTO, *Professor* (Agribusiness and Marketing), Ph.D., 1986, University of Missouri; J.D., 1995, Pontifical Catholic University of Puerto Rico. Research and Teaching interests: Agricultural Marketing, Agribusiness and Entrepreneurship.

ALEXANDRA GREGORY-CRESPO, *Associate Professor*, (Agricultural Economics), Ph.D., 2008, Kansas State University. Research and Teaching interests: Consumer Economics and Computers in business.

ALWIN J. JIMÉNEZ-MALDONADO, *Professor* (Agricultural Economics), Ph.D., 2011, Pennsylvania State University, University Park, PA. Research interest: Production and Risk Management.

LUIS R. MEJÍA-MAYMÍ, *Assistant Extension Specialist* (Agricultural Economics) M.S., 1986, University of Puerto Rico, Mayagüez Campus.

GERMÁN RAMOS-CARTAGENA, *Assistant Professor* (Sustainable Community Development), Ed.D., 2008, University of Puerto Rico.

ROBINSON RODRÍGUEZ-PÉREZ, *Professor* (Rural Sociology), Ph.D., 2005, State University of New York, Binghamton. Research and Teaching interests: Communities Development and Rural Development.

HÉCTOR S. TAVÁREZ-VARGAS, *Assistant Professor*, (Environmental Sciences, Economics), Ph.D., 2016, University of Idaho, Moscow. Research and Teaching interests: Environmental and Natural Resource Economics, Experimental Economics, Regional Development, Economic Valuation and Computers use.

AGRICULTURAL EDUCATION

Mission

- Contribute to improving the quality of life in our communities.
- Commitment to preparing formal and non-formal educators, communicators and leaders have a successful performance in educational institutions and community development.
- Serve as a catalyst in the College of Agricultural Sciences for the dissemination of knowledge and practices among farmers, youths, housewives and community leaders.
- Serve catalyst agent in the College of Agricultural Sciences to establish the impact on educational and research programs of the different academic programs.
- Contribute to the educational, cultural, social, technological and economic development of global society.
- Strengthen the training of educators and communicators leaders to facilitate the process of teaching-learning innovative and creative research.
- Encourage critical thinking to insert ourselves successfully in public policy issues affecting the agricultural sector and community welfare.
- Prepare researchers to work on social issues of agriculture, natural resources, youth and community development.

Vision

Being recognized locally, nationally, and internationally for driving research and disseminate information of good quality, to develop curricula and academic programs dynamic and relevant to education, both formal and non-formal; fully prepare educators for agriculture, natural resources, environmental management, individual development, family and community. Stand for excellence at the local, national and international level in the social research and the training of educators and communicators leaders for agricultural and community development, relevant to the times and global society.

General Education

The Department of Agricultural Education offers programs leading to a Master of Science degree with emphasis in Agricultural Education and Extension Education. In addition to the admission requirements of the Office of Graduate Studies, a

Bachelor of Arts in Home Economics, a Bachelor of Science degree in Agricultural Education, in Agriculture, in Home Economics or its equivalent is required.

Learning Outcomes

To provide an education of excellence that promotes competitive intellectual and scientific training. Promoting a program that is at the forefront of intellectual and scientific knowledge to respond in turn to the aspirations of students and the global society. Encourage leadership and teamwork among the faculty and students. Encouraging creativity of the university community through special research projects of an interdisciplinary nature which contribute significantly to the development of society. Fostering a climate of peaceful coexistence in which they use the human and physical resources to encourage reflection and critical thinking. Offer students guidance, counseling and skills necessary to facilitate the optimum development of their intellectual and personal potential. Encourage students to use the latest technology in the seeking knowledge and in everyday life.

Courses that fulfill the general education requirements

The minimum course work required for the Master of Science degree is 30 credits, including three research credits. Candidates for the Master of Science degree are required to prepare and present a thesis.

Graduate programs include the following areas: Teaching Methods, Farming Programs, Evaluation, Curriculum Designs and Construction, Adult Education, Program Planning, Organization and Administration in Education, Community Organization, Communication and Supervision.

AGRICULTURAL EDUCATION (EDAG)

Graduate Courses

EDAG 6601. ADVANCED METHODS IN TEACHING VOCATIONAL AGRICULTURE. Three credit hours. Three hours of lecture per week.

A comparative study of teaching methods and techniques.

EDAG 6602. FARMING PROGRAMS. Three credit hours. Three hours of lecture per week.

Study of farming programs at the all-day, young and adult farmer's level, with special emphasis on farm management, financing, recording and evaluating.

EDAG 6603. EVALUATION. Three credit hours. Three hours of lecture per week.

Study of the fundamentals of tests and measurements. Emphasis will be given to measures of central tendency and dispersion, measures for comparing differences and the significance of the difference at various confidence levels, interpretation of results, and formulation of plans of action.

EDAG 6605. TEACHER TRAINING. Three credit hours. Three hours of lecture per week.

Study of the problems of the rural farm population, with emphasis on youth and adult organizations, such as 4-H Clubs, Future Farmers, and Advisory Councils.

EDAG 6607. INVESTIGATION PROCEDURES. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Assembling, selecting, organizing, interpreting and reporting data pertinent to investigation made in the fields of education and related sciences.

EDAG 6608. PREPARATION OF TEACHING MATERIAL. Three credit hours. Three hours of work per week.

The preparation by the students of teaching materials such as samples, specimens, charts, graphs, pictures, slides, job analysis, lesson plans, basic units and enterprise units.

EDAG 6610. SEMINAR IN AGRICULTURAL EDUCATION. Three credit hours. Three hours of lecture per week.

A critical study of selected problems in vocational agriculture. Students are requested to make individual investigations and to report on their findings. Some aspects of the work will be conducted through committees.

EDAG 6611. CURRICULUM DEVELOPMENT. Three credit hours. Three hours of lecture per week.

The planning of course of study for young and adult farmer groups at a functional level.

EDAG 6612. ADULT EDUCATION IN VOCATIONAL AGRICULTURE. Three credit hours. Three hours of lecture per week.

A comprehensive study of the philosophy of this type of instruction, with emphasis on the organization of course content on a long-term basis. Teaching techniques, supervision, evaluation and reporting will be discussed.

EDAG 6631. ORGANIZATION AND ADMINISTRATION IN VOCATIONAL AGRICULTURE. Three credit hours. Three hours of lecture per week.

Study of the laws affecting agricultural education, criteria for selection of students, classroom management, farm management, Future Farmers of America and other phases of the vocational agriculture program.

EDAG 6671. PROGRAM PLANNING. Three credit hours. Three hours of lecture per week.

A detailed analysis of the job of the teacher of vocational agriculture, with special emphasis on the development of a sound philosophy of the program of instruction and the work.

EDAG 6999. RESEARCH IN AGRICULTURAL EDUCATION. Three to six credit hours. Three to six research periods per week.

The selection by students of topics in agricultural education for individual study; the preparation of designs; the determination of the adequate statistics to use; and the completion of the project.

AGRICULTURAL EXTENSION (EXAG)

Graduate Courses

EXAG 6601. COMMUNITY ORGANIZATION AND LEADERSHIP. Three credit hours. Three hours of lecture per week.

A study of how the community is organized and how it changes, the relationship of organization and change to work in adult education, community development and Extension work. Special attention will be given to the role of professional leadership in organization and change.

EXAG 6603. ORAL AND WRITTEN COMMUNICATION. Three credit hours. One hour of lecture and two three-hour laboratory periods per week.

The learning process and the principles involved in written and oral communication. The course is especially designed for Extension Agents, teachers of Vocational Agriculture, and others interested in improving their teaching abilities. Laboratory practice in the arts of communication is provided.

EXAG 6610. PRINCIPLES OF EXTENSION TEACHING. Three credit hours. Three hours of lecture per week.

The theories and principles of teaching and learning, and their application to Agricultural Extension.

EXAG 6612. PSYCHOLOGY IN EXTENSION EDUCATION. Three credit hours. Three hours of lecture per week.

The scientific study and interpretation of human behavior; basic psychological principles applied to Extension Education.

EXAG 6614. ADMINISTRATION AND SUPERVISION IN EXTENSION EDUCATION. Three credit hours. Three hours of lecture per week.

Theory and principles of personnel administration and supervision in Extension Education.

EXAG 6620. EXTENSION EVALUATION. Three credit hours. Three hours of lecture per week.

A study of the principles involved in Extension evaluation, and of adequate methods and processes for measuring and evaluating Extension work according to the results obtained. Questionnaire construction, sampling, interviewing, and analysis and interpretation of data will be discussed.

EXAG 6622. PROGRAM DEVELOPMENT IN EXTENSION. Three credit hours. Three hours of lecture per week.

The basic principles, procedures and problems in the process of Extension program development in both agriculture and homemaking.

EXAG 6628. ADVANCED SEMINAR IN EXTENSION PROBLEMS. Three credit hours. Three hours of lecture per week.

Study of problems from such fields as administration, supervision, personnel recruitment and training, and scope of programs. Selection will be made in the light of the special interest of seminar members.

EXAG 6630. PRINCIPLES AND PHILOSOPHY OF ADULT EDUCATION. Three credit hours. Three hours of lecture per week.

Critical comparison of present day schools of thought on the philosophy and principles of adult education programs; the nature, objectives, and functions of such programs. A term paper is required.

EXAG 6640. SOCIAL RESEARCH METHODS. Three credit hours. Three hours of lecture per week.

Methods and theory of investigation as applied to the social sciences. Emphasis is given to the collection, analysis and interpretation of information in connection with special problems of research. The student is required to plan research in his field of interest.

EXAG 6642. RURAL YOUTH PROBLEMS. Three credit hours. Three lectures per week.

Study of problems faced during adolescence, such as the adolescent value system, interests, and group life; the relationship of adolescent culture to adult culture; the relationship of the sociology of adolescence to educational programs such as the 4-H Clubs, Vocational Agriculture and the school.

DEPARTMENTAL FACULTY

A list of professors who engage in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

LORNA I. CAMPOS MUÑOZ, *Assistant Professor*, LND, RD, MHScN, 2002, University of Puerto Rico, Medical Sciences Campus, Río Piedras. **Research and Teaching Interests:** Register Dietitian Food and Nutrition Education, Renal, Diabetes and Inborn Errors of Metabolism Certifications.

NANCY J. CORREA MATOS, *Auxiliary Professor*, Ph.D., 2006, Illinois University. **Research and Teaching Interests:** Dietary Fiber, Adult and Childhood Obesity Nutrition, Community Nutrition, Nutrition Education, Nutrition and Biochemistry.

AMANDA DÍAZ DE HOYO, *Specialist*, M.A., 1987, University of Puerto Rico, Río Piedras. **Research and Teaching interests:** Communication and publication.

IVYS A. FIGUEROA SÁNCHEZ, *Auxiliary Professor*, DPH, 2009, University of Puerto Rico, Medical Sciences Campus. **Research and Teaching interests:** Public Health.

JUAN B. FREMAINT IRIZARRY, *Specialist II and Professor*, M.S., 1997, University of Puerto Rico, Mayagüez Campus. **Research and Teaching interests:** Computer Education.

CARMEN OLGA GÓMEZ BURGOS, *Professor*, M.A., 1999, University of Phoenix. **Research and Teaching Interests:** Children Youth and Family Relations.

JOSÉ M. HUERTA JIMÉNEZ, *Specialist and Professor*, Ph.D., 1993, Ohio State University. **Research and Teaching Interests:** Evaluation, and Rural Development.

ALAN E. IRIBARREN SÁNCHEZ, *Professor*, M.A., 1998, University of Puerto Rico, Mayagüez Campus. **Research and Teaching Interests:** Club 4-H, Program of Youth Organization.

ANGÉLICA MARTÍNEZ DÍAZ, *Professor*, M.A., 2003, University of Phoenix. **Research and Teaching Interests:** Community Resources Development.

GLORISELLE NEGRÓN RÍOS, *Professor, Specialist in Environmental Health*, M.A., 1994, University of Puerto Rico, Medical Sciences Campus. **Research and Teaching Interests:** Drinking and wastewater quality and air quality.

DAVID PADILLA VÉLEZ, *Professor*, Ph.D., 1993, Ohio State University. **Research and Teaching Interests:** Agricultural Education, Teacher Education.

ROBERTO L. RIGAU LLORÉNS, *Professor*, M.A., 1997, University of Phoenix. **Research and Teaching Interests:** External Resource.

MARÍA DEL C. RODRÍGUEZ RODRÍGUEZ, *Professor, Extension Specialist*, Ph.D., 1997, Cornell University. **Research and Teaching Interests:** Evaluation and Research in the Field.

EDLY SANTIAGO ANDINO, *Associate Professor*, Ph.D., 2005, Pennsylvania State University. **Research and Teaching Interests:** Teachers Preparation in Agricultural and Environmental Education, Adult Education, Curriculum Development, Active and Experiential Learning.

LUIS F. SILVA GUERRERO, *Professor*, Ph.D., 1988, Cornell University. **Research and Teaching Interests:** Curriculum Development, Higher Education, Development in International Agricultural Projects, Communications, Micro-Computers in Education.

CARLOS A. VIVONI REMUS, *Professor, Extension Specialist*, Ph.D., 1991, University of Massachusetts. **Research and Teaching Interests:** Communication and Community empowerment through access to media.

AGROENVIRONMENTAL SCIENCES

The Department of Agro Environmental Sciences offers a graduate curriculum leading to a Master of Science (M.S.) degree in the program areas of Agronomy, Crop Protection, Horticulture, and Soils. In addition to the admission requirements of the Office of Graduate Studies, a Bachelor of Science or its equivalent is required, but a degree in Agricultural Sciences is preferred.

The M.S. degree is oriented towards research, and students must present and defend a six credits thesis project. The research thesis will be supervised by the student's Primary Advisor and Graduate Committee. Although there are no specific course requirements, graduate students are expected to take at least a graduate seminar course, and 3 credits in agricultural biometrics. A minimum of 30 graduate credits are required for the completion of the M.S. degree, including the thesis research.

The graduate program of study emphasizes in sustainable and environmentally sound research that increases the efficiency of crop production, assists in the use and development of cropland, forest and water resources, and improves the overall quality of the human environment in rural and urban settings. Teaching and research facilities include laboratories, greenhouses, and an on-campus experimental farm, and seven research centers of the Agricultural Experiment Station located off-campus.

General areas of specialty within each program area are described below. Opportunities for development of thesis projects within these specialties can vary depending on departmental resources (external funding) and availability of academic faculty to supervise research. Applicants can contact the Department Director or individual faculty members to learn about research opportunities.

PROGRAM OF AGRONOMY

The program of Agronomy leads to a Master of Science. Students may specialize in plant breeding, production and management of crops, crop ecology, crop physiology, crop modeling, or management of forestry and water resources.

PROGRAM OF SOILS

The program of Soils leads to a Master of Science. Areas of specialization in soils include chemistry, fertility, soil and crop management, genesis and morphology, microbiology, mineralogy, and physics.

Advanced Undergraduate Courses in Agronomy and Soils

AGRO 5005. BIOMETRICS (I, S). Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: authorization of the Director of the Department.

Basic concepts of statistical reasoning applied to problems in agricultural, biological and environmental sciences. Data gathering, graphical description and numerical summarization. Concepts of probability and sampling. Estimation and hypothesis testing, analysis of variance, linear regression and correlation. Students describe and analyze real data sets and use statistical computing programs.

AGRO 5006. GENESIS, MORPHOLOGY AND CLASSIFICATION OF SOILS (I). Three credit hours. Three hours of lecture per week. Prerequisites: (AGRO 3005 or (AGRO 3011 and AGRO 3013)) or authorization of the Director of the Department.

Historical development of concepts of soil and systems of soil classification; principles and nomenclature of "Soil Taxonomy"; environmental factors and processes of soil formation; and field study of soil profiles. Field trips are required.

AGRO 5007. SOIL PHYSICS (I) (Even numbered years). Three credit hours. Two lectures and one three-hour laboratory per week.

Physical properties of soils, and factors affecting them; soil consistency, structure, water, air, temperature, tillage; evaluation and influence in determination of soil productivity.

AGRO 5008. SOILS OF PUERTO RICO (II). Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: AGRO

5006 or authorization of the Director of the Department.

Study of the genesis and distribution of the soils of Puerto Rico, based on environmental conditions; classification of soils using the "Soil Taxonomy" system; evaluation of the morphological, chemical, physical, and mineralogical properties of soils with respect to agricultural and not agricultural uses. Representative soil profiles are studied during field trips.

AGRO 5010. MANAGEMENT OF NATURAL FORESTS. Three credit hours. Two hours of lecture and one three hour laboratory per week. Prerequisites: BIOL 3435 or BIOL 3051 or CFIT 3005 or authorization of the Director of the Department.

Study of the composition and structure of the different forest systems of the tropics, such as wet forest, deciduous forest, dry forest, conifer forest and mangrove from the stand point of their multiple use and sustainability. Field trips required.

AGRO 5015. CONSERVATION, MANAGEMENT AND DEVELOPMENT OF NATURAL RESOURCES (I) (Even numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: AGRO 4035 or authorization of the Director of the Department.

Study of concepts, methods and techniques in the conservation, management and development of natural resources, and their effects on environmental quality. Contemporary issues and problems in the management and allocation of natural resources will be discussed.

AGRO 5501. AGRICULTURAL BIOTECHNOLOGY (II) (Even numbered years). Three credit hours. Three hours of lecture per week. Prerequisites: QUIM 3062 and (BIOL 3015 or BIOL 3300) and (BIOL 3770 or PROC 4016) or authorization of the Director of the Department.

Biological concepts for biotechnology: enzymes, nucleic acids, genetic transfer mechanisms, operons, plasmids, vectors, cloning, DNA sequencing, monoclonal antibodies, clonal production and hybridization.

AGRO 5502. AGRICULTURAL BIOTECHNOLOGY LABORATORY (II) (Even numbered years). One credit hour. One three-hour laboratory per week. Corequisite: AGRO 5501.

Experiments or demonstrations on microbial growth, DNA isolation, embryo transfer, protoplast

isolation, tissue culture, plant hybridization, mutagenesis, plasmid isolation, and DNA electrophoresis. Restriction enzymes and other DNA techniques.

Graduate Courses in Agronomy and Soils

AGRO 6005. USE OF STATISTICAL COMPUTER PACKAGES IN BIOMETRY. Two credit hours. Two hours of lecture per week.

Use of statistical computer packages in the analysis of experimental data.

AGRO 6300. SIMULATION OF AGRICULTURAL SYSTEMS. Three credit hours. Three hours of lecture per week.

Study of the principles of simulation of agricultural systems. The dynamics between crop growth and development in relation to soil water and nitrogen will be discussed. The use of models to simulate crop production and management practices will be emphasized.

AGRO 6505. ADVANCED SOIL FERTILITY. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Discussion of advanced topics in soil fertility including nutritional diagnosis, nutrient availability, limiting factors, recommendations for fertilization, soil management, and environmental impact.

AGRO 6600. ADVANCED BIOMETRICS (II). Three credit hours. Two hours of lecture and three hours of laboratory per week.

Advanced study of analysis of variance, covariance and multiple regression, design and analysis of experiments applied to research problems in agricultural, biological and environmental sciences. Students design experiments, analyze data and use statistical computing programs. Previous knowledge of basic statistics is required.

AGRO 6602. PASTURE CROPS AND MANAGEMENT. Three credit hours. Two lectures and one three-hour laboratory per week.

The relationship of pasture crops to types of rainfall, soils and other environmental factors as they affect the production, conservation, and utilization of forages.

AGRO 6604. SOIL-PLANT RELATIONSHIPS (I) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Study of the processes that affect root growth and development, methods of study of such processes, availability of nutrients and factors that affect their movement and absorption; growth as a function of dry matter accumulation, root proliferation and nutrient uptake.

AGRO 6607. SOIL CHEMISTRY (I) (Odd numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Chemical composition and properties of soils, chemical processes of weathering, soil solution reaction, chemical properties of clays, and ionic exchanges in soils.

AGRO 6612. MANAGEMENT OF TROPICAL SOILS (I) (Odd numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Application of principles of soil science in the interpretation and use of recent research relating to problems in the management and production of tropical soils.

AGRO 6624. SOIL MINERALOGY (I) (Even numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Identification of the constituent minerals of soils, and their relation to soil classification and agricultural practices.

AGRO 6651-6652. SEMINAR (I, II)-(I, II). One credit hour per semester. One research period per week each semester.

Discussion of assigned or selected readings of investigation related to problems in Agronomy, presentation of original work related to research in Agronomy.

AGRO 6995-6996. SPECIAL PROBLEMS (I, II, S)-(I, II, S). One to three credit hours per semester. One to three research periods per week each semester.

Advanced studies, investigations and special problems in Agronomy or related fields. Problems or topics will be assigned according to the interests and needs of the individual student.

AGRO 6997. SPECIAL TOPICS IN AGRONOMY (I, II, S). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Topics not covered in other courses or specialized studies in the areas of crops and soil sciences.

AGRO 6998. SPECIAL TOPICS IN AGRONOMY (I, II, S). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Topics not covered in other courses or specialized studies in the areas of crops and soil sciences.

AGRO 6999. RESEARCH (I, II, S). One to six credit hours. One to six research periods per week.

Organized research in crops at the Master's thesis level, including thesis presentation and discussion as part of the requirement for a Master of Science degree with a major in Crops.

CFIT 5006. PHYTOREMEDIATION. Three credit hours. Three hours of lecture per week. Prerequisites: ((BIOL 3435 or BIOL 3051) and (QUIM 3002 or (QUIM 3132 and QUIM 3134))) or authorization of the Director of the Department.

Discussion of the relevant concepts used in phytoremediation. Study of the principles use in phytoremediation such as the use of vascular plants for the phytoextraction, rhizofiltration, phytostabilization and phytovolatilization of organic and inorganic contaminants from the soils and water resources.

CFIT 6611. ADVANCED PLANT BREEDING (II) (Even numbered years). Three credit hours. Three hours of lecture per week.

Types of genetic action in plant breeding, use of the principle of population genetics and quantitative genetics in the improvement of crops; relationship of population structure to the induction of genetic variation and selectivity processes. Application of cytogenetics and polyploid concept to plant improvement.

CFIT 6644. ENVIRONMENTAL PHYSIOLOGY (On demand). Three credit hours. Three hours of lecture per week.

Environmental aspects of phytophysiology, including energy, nutrition cycles, pollution, and others.

CFIT 6645. ADVANCES IN BIOLOGICAL NITROGEN FIXATION (I) (Odd numbered years). Three credit hours. Two hours of lecture and one hour of seminar per week.

Mechanism by which atmospheric nitrogen is incorporated into plant proteins and modern techniques utilized for its study, organisms capable of fixing nitrogen in a free-living state or in symbiosis with plants, methodology to take advantage of this process in agriculture.

PROGRAM OF CROP PROTECTION

The program of Crop Protection leads to a Master of Science. Students may specialize in entomology, nematology, phytopathology, and weed science. Research is focused on developing sustainable, biologically-based, and crop management technologies to control economically important arthropods, nematodes, plant diseases, and weeds.

Advanced Undergraduate Courses

PROC 5005. PHYTOPATHOGENIC FUNGI (I) (Even numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: PROC 4006 or authorization of the Department Director.

Examination of the most interesting groups of fungi from the phytopathogenic point of view: their taxonomy, nomenclature, morphology, genetics, host-parasite relationship, physiology, and ecology. Distinctive characteristic of specific pathogens. Field trips for collection and observation are required.

PROC 5006. INSECTS OF TROPICAL CROPS. Three credit hours. Two hours of lectures and one three-hour laboratory per week. Prerequisite: PROC 4008 or CFIT 4008 or authorization of the Director of the Department.

Major insects affecting tropical crops, their biology and taxonomy; identification of damages in the field as well as in the laboratory; appropriate measures of control.

Graduate Courses

PROC 6008. CROP PROTECTION II. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisite: authorization of the Director of the Department.

Study of the morphology, taxonomy, ecology, physiology, and control of the most important pathogens of tropical crops including fungi, nematodes, bacteria, viruses and mycoplasmas.

Discussion of abiotic agents which cause diseases on plants.

PROC 6009-6010. SEMINAR (I, II)-(I, II). One credit hour per semester. One hour of discussion per week.

Discussion of topics on crop protection including results of research work.

PROC 6015. MOLECULAR ASPECTS IN PLANT PATHOLOGY. Three credit hours. Three hours of lecture per week.

Study of the biochemistry, physiology, and molecular biology of plant-pathogen interactions. Discussion of molecular mechanisms involved in the development of plant diseases caused by biotic agents such as fungi, bacteria, nematodes and viruses.

PROC 6601. PROPERTIES AND ACTIONS OF HERBICIDES. Three credit hours. Two hours of lectures and one three hour laboratory per week.

Classification and structure of chemicals used in weed control; the action of herbicides and their effects on the morphology and internal mechanisms of plants; physiological processes affected by herbicides, and edaphic and climatic factors influencing the performance of weed killers.

PROC 6603. METHODS OF RESEARCH IN PATHOLOGY (II) (Odd numbered years). Four credit hours. Two hours of lecture and two three hours laboratories per week. Prerequisite: Authorization of the Director of the Department.

A course intended to give the graduate student practice and skill in methods of laboratory and field research in Plant Pathology.

PROC 6604. DIAGNOSIS AND CONTROL OF PLANT DISEASES (II) (Even numbered years). Three credit hours. One hour of lecture and two three-hour laboratory periods per week.

Techniques used in diagnosis of plant diseases. Sources of descriptive information on phytopathogens, fungi identification, and control measures.

PROC 6605. URBAN PESTS. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Study of urban pests of major economic impact that infest residential, industrial and commercial

structures. Methods for the control of urban pests, with emphasis on arthropods.

PROC 6606. CROP EPIDEMIOLOGY. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisite: authorization of the Director of the Department.

Application of mathematical analysis to the field study of plant disease epidemics. Use of forecast and methods to detect and quantify the effects of epidemics on the yield and quality of crops.

PROC 6608. ADVANCED TROPICAL PHYTOPATHOLOGY (I) (Even numbered years). Four credit hours. Four hours of lecture per week. Prerequisite: PROC 6604 or CFIT 6604.

Study and analysis of the etiology, pathology, epiphytology, and control of major plant diseases of the most important economic tropical crops.

PROC 6609. INTEGRATED PEST MANAGEMENT (I). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Integrated management of agricultural pests based on the understanding of basic ecological principles and through the use of environmentally compatible pest management tactics and strategies which include ecological management, and the biological, mechanical, genetic, chemical and legal factors.

PROC 6620. TOXICOLOGY OF PESTICIDES (II) (Odd numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Classification, analysis, uses and toxicity of pesticides used in agriculture; methods in toxicology research; residual effects of pesticides on the environment, and on public health.

PROC 6624. MORPHOLOGY AND TAXONOMY OF PHYTOPARASITIC NEMATODES. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: PROC 4018 or CIFI 4018.

Morphology, anatomy, and taxonomy of phytoparasitic nematodes; rules and problems of nomenclature.

PROC 6625. TAXONOMY AND MORPHOLOGY OF ENTOMOPHAGOUS INSECTS. Four credit hours. Three hours of lecture and three hours of laboratory per week.

Analysis, application, and evaluation of the methods used in the morphology, taxonomy and systematics of entomophagous insects with emphasis on hymenopterans. Includes character differentiation, the construction and evaluation of keys, cladograms and

phenograms, analysis of the literature, and the taxonomy and morphology to family level.

PROC 6630. CONTROL OF PHYTOPARASITIC NEMATODES (I) (Even numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Study and evaluation of the physical, biological and chemical control of phytoparasitic nematodes.

PROC 6635. TROPICAL AGRONEMATOTOLOGY (I) (Odd numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A detailed study covering the most important aspects of plant nematodes in the tropics, especially those concerned with sugar cane, coffee, tobacco, citrus fruits, pineapple, plantains, bananas, rice, and vegetables.

PROC 6645. BIOLOGICAL CONTROL: CONCEPTS AND THEORIES (I) (Odd numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Ecological theories that study the use of beneficial organisms for the population density regulation of organisms noxious to crops of economic importance. Other topics to be studied are: the structure of the agroecosystem community, predator-prey ecological relations, types and components of predation, post-introduction programs and aspects of integration, perspectives and development of biological control strategies, with emphasis on insect control.

PROC 6650. PHYTOVIROLOGY (II) (Odd numbered years). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Fundamental concepts of plant viruses including transmission, vector identification, their effects on insect vectors, host range, classification, serology, and physical properties and methods of control. Research methods are emphasized in the laboratory.

PROC 6993. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Study of selected topics in Crop Protection not covered in existing courses.

PROC 6994. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Study of selected topics in Crop Protection not covered in existing courses.

PROC 6995-6996. SPECIAL PROBLEMS (I, II, S)-(I, II, S). One to three credit hours per semester. One to three study and research periods per week.

Study or investigation of a special problem in the field of crop protection.

PROC 6999. RESEARCH AND THESIS (I,II,S). Three to six credit hours.

Thesis research.

PROGRAM OF HORTICULTURE

The program of Horticulture leads to a Master of Science. Students may specialize in the application of ecological, sustainable, organic, and conventional concepts and principles to improve the production and management of vegetables, starchy crops, fruits, coffee, ornamentals, landscapes, and other intensively cultivated/high value commodities. Physiological regulation and manipulation in horticultural crops, and postharvest physiology and management are another areas of specialization.

Advanced Undergraduate Courses

HORT 5005. ADVANCED FLORICULTURE. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: HORT 4025 or authorization of the Director of the Department.

A comprehensive review of scientific literature and research on the ecology, physiology, propagation, improvement, and other growth processes of important flowering and foliage plants.

HORT 5006. ADVANCED VEGETABLE GARDENING. Two credit hours. One hour of lecture and one three-hour laboratory per week. Prerequisite: HORT 4008 or authorization of the Director of the Department.

This course aims to review the different phases of experimental work in vegetable growing with assigned field problems. Field trips required.

HORT 5015. HORTICULTURE OF TEMPERATE ZONES. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the basic and applied concepts in horticulture in temperate zones. Study of the effects of environmental factors on agricultural production and how they affect plant growth and development

of fruits, vegetables and ornamental crops, and urban forests. Emphasis will be given to different marketing systems for agricultural products and their postharvest physiology. The course consists of lectures and a ten-day trip to a temperate zone country.

Graduate Courses

HORT 6007/CITA 6007. SAFETY OF FRUIT AND VEGETABLE PRODUCTS. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Advanced study of intrinsic and extrinsic factors that determine the growth of microorganisms, during post-harvest, processing, storage, and transportation of fruits and vegetables that may affect public health.

HORT 6601. FOOD PROCESSING I (I). Three credit hours. Three hours of lecture per week.

Fundamentals and commercial practice of food preservation by heat treatment, drying, freezing, canning, irradiation and microwaves. Topics included are selection of raw material, preparation, unit of operations and processing, packaging and storage. Processes covered will include aseptic packaging of juice and milk as well as canning of fruits and vegetables.

HORT 6611. ADVANCED PLANT PROPAGATION (II). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Techniques in plant propagation through embryo culture, meristematic culture in vegetative propagation, culture of explants, and other advanced methods; review of recent findings in this field.

HORT 6616. ADVANCED TROPICAL FRUITS (II) (On demand). Three credit hours. Three hours of lecture per week.

A study of the problems encountered in the production of fruits of major economic importance, with special emphasis on tropical conditions. The influence of stocks, varieties, planting sites, soils and ecological factors will be stressed.

HORT 6650. POST HARVEST PHYSIOLOGY AND MANIPULATION OF HORTICULTURAL CROPS (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

The physiology of maturation and ripening, and the handling of horticultural crops to preserve quality and ensure storage life.

HORT 6652. PHYSIOLOGY OF VEGETABLE CROPS (II) (On demand). Three credit hours. Three hours of lecture per week.

The study of photoperiodism, thermoperiodism, deficiencies, growth substances, rooting, germination and fruit setting in each of the major vegetable crops.

HORT 6653. PHYSIOLOGY OF FRUIT PRODUCTION (I) (On demand). Three credit hours. Three hours of lecture per week.

The study of fruit production, including water, light, soil and nutrition relationships; pruning, fruit setting, and other growth and productivity factors.

HORT 6665. PLANT GENETIC TRANSFORMATION (I) (On demand). Four credit hours. Three hours of lecture and one four-hour laboratory per week.

Theory and practice of the concepts in the genetic transformation of plants by direct and indirect methods. Emphasis will be given to *Agrobacterium tumefaciens* mediated transformation.

HORT 6669. GROWTH REGULATORS IN HORTICULTURE (I). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

The use of growth regulators and other chemicals in the modification and alteration of natural plant processes; the application of these substances in the commercial production of fruits, vegetables, and ornamentals.

HORT 6705. GRADUATE SEMINAR. One credit hour. One hour of lecture per week. Prerequisite: authorization of the Director of the Department.

Discussion of topics in Horticulture including results of research work.

HORT 6990. SUPERVISED PROFESSIONAL OCCUPATIONAL EXPERIENCE FOR COOP STUDENTS. From three to six credit hours. Only 3 credits will be considered within the minimum of the required 30 credits for the graduate program.

Practical experience in Horticulture in cooperation with the private sector or government. To be jointly supervised by the academic department, the Coop program coordinator and an official from the

cooperating entity. A written report will be required upon completion of each work period.

HORT 6995-6996 (On demand). RESEARCH IN HORTICULTURE. One to three credit hours per semester. One to two research periods per week for a total of three to six hours each semester.

Research on an important horticultural problem. A thesis presentation is not required, but a report of the investigation should be made.

HORT 6997. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in plant propagation, production, management, physiology, genetic engineering, molecular biology, and other areas of interest in horticulture.

HORT 6998. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in plant propagation, production, management, physiology, genetic engineering, molecular biology, and other areas in horticulture.

HORT 6999. RESEARCH AND MASTER THESIS. Zero to six credit hours. Zero to six hours of research per week.

Organized research in horticulture at the master's thesis level, including thesis presentation and discussion as part of the requirements for a Master of Science degree with a major in Horticulture.

FACULTY

A list of professors who engage in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

EDWIN ABREU, *Professor - Ad Honorem*, M.S., 1977, University of Puerto Rico, Mayagüez Campus. Teaching and Research interests: General Entomology, Population Dynamics, Integrated Pest Management, Insect Biology, Biology, Biological Control, and Plant Mites.

WANDA ALMODÓVAR, *Professor*, M.S., 1989, University of Puerto Rico, Mayagüez Campus. Teaching and Research interest: Plant Pathology, Diagnosis and Control of Plant Diseases.

ADA ALVARADO, *Associate Professor*, M.S., 1992, University of Puerto Rico, Mayagüez Campus. Teaching and Research interest: Integrated Pest Management, Plant Pathology, Diagnosis and Control of Plant Diseases.

ARÍSTIDES ARMSTRONG, *Professor*, M.S., 1981, University of Puerto Rico, Mayagüez Campus. Teaching and Research interests: General Entomology, and Control of Insect Pests on Economic Crops.

ALBERTO BEALE-COSIO, *Professor*, Ph.D., 1979, University of Florida, Gainesville. Teaching and Research interests: Agronomy.

JAMES SCOTT BEAVER, *Professor*, Ph.D., 1980, University of Illinois at Urbana. Teaching and Research interests: Plant Breeding.

LINDA W. BEAVER, *Professor*, Ph.D., 1981, University of Illinois at Urbana. Teaching and Research interests: Plant Breeding.

BRYAN BRUNNER-FULTON, *Professor*, Ph.D., 1992, Michigan State University. Research and Teaching interests: Breeding and Germplasm Improvement (Fruits and Ornamentals).

IRMA CABRERA-ASENCIO, *Associate Professor*, M.S., 1987, University of Puerto Rico. Teaching and Research Interest: General Entomology, Biological Control.

JOSÉ A. CHAVARRÍA, *Professor*, Ph.D., 1997, University of Auburn, Alabama. Teaching and Research interest: Plant Pathology.

ROSA N. CHÁVEZ, *Assistant Professor*, Ph.D., 1995, University of Sao Paulo. Teaching and Research interest: Food Science.

JOAQUÍN ANDRÉS CHONG-NÚÑEZ, *Assistant Professor*, Ph.D., 2005, Clemson University, South Carolina. Research and Teaching interest: Plant and Environmental Science.

MAGALY CINTRÓN, *Assistant Professor*, M.S., 2003, University of Puerto Rico, Río Piedras Campus. Teaching and Research interest: Chemistry.

WINSTON DE LA TORRE, *Professor*, Ph.D., 1988, North Carolina State University. Teaching and Research interests: Plant Physiology and Plant Biochemistry.

JOSÉ A. DUMAS, *Professor*, Ph.D., 1999, University of Puerto Rico-Río Piedras. Research interest: Pesticide Residues Analysis. Teaching interest: Analytical Chemistry.

CONSUELO ESTÉVEZ-DE JENSEN, *Assistant Professor*, Ph.D., 2000, University of Minnesota. Teaching interests: Diagnostic and management of fungal diseases. Research interest: Etiology and control of soilborne diseases. Developing integrated disease management programs for vegetable cropping systems. Interactions between cropping systems, soil amendments, residue management, and tillage practices on the management of soilborne diseases. The effects of environmental and edaphic factors on host characteristics contributing to disease susceptibility.

MERARI FELICIANO, *Assistant Professor*, Ph.D., 2007, University of Kentucky. Teaching and interest: Plant Pathology.

FEIKO H. FERWERDA, *Assistant Researcher*, Ph.D., 2001, University of Florida. Research and Teaching interests: Plant Tissue Culture and Molecular Markers.

MARIO FLORES, *Assistant Professor*, Ph.D., 2009, University of Wisconsin. Teaching and interest: Soil Science.

ROSA A. FRANQUI, *Professor*, Ph.D., 1995, University of Wisconsin, Madison. Teaching and Research interest: General Entomology and Biological Control.

FERNANDO GALLARDO, *Professor*, Ph.D., 1990, Louisiana State University. Research and Teaching interest: Biological Control of Insects.

JOHN M. GILL, *Professor*, Ph.D., 1994, Rutgers University. Research and Teaching interests: Plant Tissue Culture and Plant Genetic Transformation.

MARTHA GIRALDO, *Assistant Professor*, PhD, 2010, Kansas State University. Research and Teaching interest: Plant Pathology.

RICARDO GOENAGA, *Ad Honorem*, Ph.D., 1986, North Carolina State University. Teaching and Research interest: Crop Physiology.

ÁNGEL L. GONZÁLEZ, *Professor*, Ph.D., 1997, University of Illinois, Urbana. Teaching and Research interests: General Entomology, Biological Control.

AGENOL GONZÁLEZ, *Professor*, MS 1983, University of Puerto Rico-Mayagüez Campus. Research and Teaching interest: Plant Pathology.

LIZZETTE GONZÁLEZ-GILL, *Professor*, Ph.D., 1996, Rutgers University. Research and Teaching interests: Ornamental Horticulture.

SALLY GONZÁLEZ-MIRANDA, *Specialist of Extension*, MLA, 1987, Ball State University. Research and Teaching interests: Landscape Design, Arboriculture and Urban Forestry, Urban Horticulture.

MARÍA DEL C. LIBRÁN-SALAS, *Professor*, Ph.D., 1996, University of Illinois. Research and Teaching interests: Ornamental Horticulture.

MARÍA DE L. LUGO, *Professor*, Ph.D., 1993, University of Arkansas. Teaching and Research interest: Weed Science.

WANDA LUGO, *Researcher*, M.S., 1982, North Carolina State University. Teaching and Research interest: Crop Protection.

RAÚL E. MACCHIAVELLI, *Professor*, Ph.D., 1992, Pennsylvania State University. Teaching and Research interests: Statistics, Biometry.

GUSTAVO MARTÍNEZ, *Professor*, Ph.D., 1995, Ohio State University. Teaching and Research interest: Soil Chemistry.

SILVERIO MEDINA-GAUD, *Emeritus Professor*, Ph.D., 1978, Iowa State University. Teaching and Research interest: Entomology.

JOSÉ P. MORALES PAYÁN, *Professor*, Ph.D., 1999, University of Florida, Gainesville. Teaching and research interests: Organic horticulture, fruit crops, biostimulants and physiology regulators, biopesticides and alternative management of weeds.

MIGUEL A. MUÑOZ, *Professor*, Ph.D., 1988, Ohio State University. Teaching and Research interests: Soil Chemistry and Soil Mineralogy.

EDNA NEGRÓN-DE BRAVO, *Professor*, Ph.D., 1987, The Pennsylvania State University. Research and Teaching interests: Food Science.

HIPÓLITO O'FARRILL, *Extension Specialist - Ad Honorem*, Ph.D., 1996, Pennsylvania State University. Teaching and Research interest: Entomology, Integrated Pest Management, Urban Entomology.

JULIA O'HALLORANS, *Associate Professor*, Ph.D., 2001, New Mexico State University. Teaching and Research interest: Soil Fertility.

LYNETTE ORELLANA, *Professor*, Ph.D., 2004, Washington State University. Teaching Interest: Food Microbiology, Food Processing, Food Toxicology, Food Safety, Food Laws and Regulations, Food Quality. Research interests: Food Microbiology, Food Processing, Pre and Post Harvest Handling, Edible Films, Natural Antimicrobials for Food Safety, Encapsulation of Natural Antimicrobials, Shelf life Studies.

CARLOS ORTIZ, *Professor*, Ph.D., 1993, University of Arkansas. Teaching and Research interest: Plant Breeding.

MARÍA PLAZA-DELESTRE, *Assistant Professor*, Ph.D., 2010, University of Florida, Gainesville. Teaching and Research interest: Food Science.

TIMOTHY PORCH, *Ad Honorem*, Ph.D., 2001, Cornell University. Teaching and Research interests: Plant Breeding.

YAMIL QUIJANO, *Associate Extension Specialist*, M.S., 1989, University of Puerto Rico, Mayagüez Campus. Teaching and Research interest: Pasture Management.

RAFAEL RAMOS-SANTANA, *Professor*, M.S., 1984, University of Puerto Rico, Mayagüez. Teaching and Research interest: Pasture Management.

DANIA RIVERA, *Assistant Professor*, Ph.D., 2011, Ohio State University. Teaching and Research interest: Horticulture and Crop Sciences.

LYDIA I. RIVERA-VARGAS, *Professor*, Ph.D., 1994, Ohio State University. Teaching and Research interests: Plant Pathology, Biochemistry of Host-pathogen Interaction.

LUIS E. RIVERA, *Researcher*, M.S., 1983, University of Puerto Rico, Mayagüez Campus. Teaching and Research interest: Agronomy.

WILFREDO ROBLES, *Associate Professor*, Ph.D., 2007, Mississippi State University. Teaching and Research interest: Weed Science.

ELVIN ROMÁN-PAOLI, *Professor*, Ph.D., 1997, Kansas State University. Teaching and Research interest: Agronomy.

JESSE ROMÁN, *Emeritus Professor*, Ph.D., 1968, North Carolina State University. Research and Teaching interests: Nematology, Taxonomy, Chemical Control, Biological Control of Nematodes and Insects.

EVELYN ROSA-MARQUES, *Associate Professor*, M.S., 1998, University of Puerto Rico. Teaching and Research interest: Plant Pathology, Diagnosis and Control of Plant Diseases.

CARLOS ROSARIO, *Professor*, Ph.D., 1988, Pennsylvania State University. Research and Teaching interests: Urban Entomology, Integrated Pest Management and Medical Entomology.

ALEJANDRO E. SEGARRA-CARMONA, *Professor*, Ph.D., 1985, University of Maryland. Teaching and Research interests: Entomology, Ecology and Behavior of Insects, Biotechnology and Agricultural Research Policy.

VÍCTOR SNYDER, *Professor*, Ph.D., 1980, Cornell University. Teaching and Research interest: Soil Physics.

DAVID SOTOMAYOR-RAMÍREZ, *Associate Professor*, Ph.D., 1996, Kansas State University. Teaching and Research interests: Soil Fertility, Nutrient Management.

RAMÓN I. TORRES-LÓPEZ, *Professor*, Ph.D., 1993, Texas A&M University. Teaching and Research interests: Plant Genetic and Physiology.

ELIDE VALENCIA, *Professor*, Ph.D., 1997, University of Florida. Teaching and Research interest: Pasture and Forage Management.

ROBERTO VARGAS, *Professor*, Ph.D., 1995, Auburn University. Teaching and Research interests: General Nematology, Plant Pathology, Biological Control, Rhizosphere Microecology, Organic Nematicides and Sustainable Agriculture.

JOSÉ C. VERLE-RODRIGUES, *Associate Professor*, Universidade de São Paulo, Brasil, 2001. Teaching and Research interests: Plant Virology.

JOSÉ ZAMORA-ECHEVARRÍA, *Associate Professor*, M.S., 1991, University of Puerto Rico, Mayagüez Campus. Research and Teaching interests: Tropical Fruit Crop Production and Management.

MILDRED ZAPATA, *Professor*, Ph.D., 1989, University of Nebraska. Teaching and Research interests: Plant Pathology, Phytobacteriology, Plant-microbe Interactions, Determinants of Pathogenicity of Phytopathogenic Bacteria, Diseases of Legumes, Vegetables and Ornamentals, Biological Control.

ANIMAL SCIENCE

The Department of Animal Science offers a program leading to a Master of Science degree in Animal Science. All applicants must have a Bachelor of Science degree in Agricultural Sciences or in a closely related field. They must meet the requirements for admission set by the Office of Graduate Studies, and the department and must conduct a research project and write a thesis on a subject related to animal science.

The graduate program in Animal Science is designed to develop research skills in subjects related to food producing animals, including dairy and beef cattle, swine, poultry, rabbits, fish, and small ruminants and pets. Available courses deal with production and management of the most important animal species as well as nutrition, breeding, reproduction, health, behavior, molecular biotechnology, molecular biology, and animal products' processing and manufacturing.

Students accepted to the program take advanced courses in statistics and biochemistry, and courses in management, nutrition, and physiology and other electives offered by the Department to complete their coursework.

Research facilities consist of up-to-date laboratories located on-campus and animal facilities located at research centers and agricultural experiment stations of the College of Agricultural Sciences. Our facilities for processing poultry, swine and cattle are located at the Lajas Experiment Station.

As part of their training, graduate students may apply for an assistantship and acquire teaching experience while serving as instructors in charge or as an aide in the laboratory sections of certain courses. Another option is a research assistantship which are awarded on a need basis by professors with research grants.

ANIMAL SCIENCE

Advanced Undergraduate Courses

CIAN 5005. USE OF ORGANIC BY-PRODUCTS IN ANIMAL NUTRITION. Three credit hours. Three hours of lecture per week. Prerequisite: INPE 4010 or CIAN 4010 or authorization of the Director of the Department.

Theory, concepts, and applications of the process of conversion of organic by-products into ingredients for animal use and their utilization in commercial feeds for livestock.

CIAN 5045. ENVIRONMENT AND MANAGEMENT OF FARM ANIMALS. Three credit hours. Three hours of lecture per week. Prerequisite: INPE 4005 or CIAN 4005 or authorization of the Director of the Department.

Study of the effects of the environment on the physiology and behavior of farm animals. Evaluation of management alternatives to minimize adverse environmental effects and to improve the productivity of livestock enterprises.

CIAN 5055. ANIMAL MOLECULAR BIOTECHNOLOGY. Four credit hours. Three hours of lecture and one four-hour laboratory per week. Prerequisites: ((QUIM 3062 or QUIM 3463) and BIOL 3300) or authorization of the Director of the Department.

Study and application of the principles and practice of molecular biology to the production and improvement of domestic animals. Discussion of transgenic animal production, molecular genetics, and marker assisted selection.

CIAN 5346. DAIRY BY-PRODUCTS (On demand). Three credit hours. Two lectures and one three-hour laboratory per week. Prerequisite: INPE 4008 or CIAN 4008 or authorization of the Director of the Department.

The manufacture of ice cream, cheese, and butter.

CIAN 5350. VETERINARY CLINICAL PARASITOLOGY. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: (INPE 4005 or CIAN 4005) and (INPE 4036 or CIAN 4036) or authorization of the Director of the Department.

Study of the interaction of the most common parasites of veterinary importance in domestic animals and the impact animal production.

Discussion and analysis of parasite pathology, clinical manifestations, life cycles and control methods.

CIAN 5355. ADVANCED BEEKEEPING (On demand). Three credit hours. Two hours of conference and three hours of laboratory per week. Prerequisite: (INPE 4016 or CIAN 4016) and authorization of the Director of the Department.

Commercial Management of apiaries. Including the bees, and the various methods used to obtain honey and wax.

CIAN 5356. DISEASE CONTROL AND BIOSECURITY (II). Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisite: INPE 4005 or CIAN 4005 or authorization of the Director of the Department.

Sanitary and management practices for the control and prevention of farm animal diseases. Discussion of management practices to prevent the transmission of zoonotic diseases.

CIAN 5357. SCIENCE AND TECHNOLOGY OF FRESH MEATS (I)(On demand). Three credit hours. Two hours of lecture and one four-hour laboratory per week. Prerequisite: INPE 4005 or CIAN 4005 or authorization of the Director of the Department.

Principles and practices in the handling, processing and preservation of beef, pork, and poultry meats.

CIAN 5365. GASTROINTESTINAL MICROBIOLOGY OF DOMESTIC ANIMALS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: ((INPE 4010 or CIAN 4010) and BIOL 3770 and QUIM 3062) or authorization of the Director of the Department.

Discussion of theory related to the microbial ecology of the gastrointestinal tract of domestic animals. Analysis of the role of intestinal microbes in the nutrition, health, and productivity of animals with emphasis on farm animals.

Graduate Courses

CIAN 6025. MINERAL NUTRITION AND METABOLISM (On demand). Three credit hours. Three hours of lecture per week.

Study of nutritional implications and metabolic roles of mineral in animal nutrition. Forms and location in the body, metabolic function, deficiencies, toxicity, interactions, and requirements of minerals in animal nutrition.

INPE 6600. DAIRY CATTLE MANAGEMENT (II). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Care and management of dairy cattle.

INPE 6601. ADVANCED ANIMAL BREEDING (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Advanced course in population genetics, with special emphasis on quantitative characteristics, breeding and selection of farm animals.

CIAN 6603. MEAT ANIMAL PRODUCTION (I). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A comprehensive review of recent advances in the research of various phases of meat animal production.

CIAN 6604. ANIMAL NUTRITION (I). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Physiological mechanisms involved in thirst and appetite; digestion, absorption and utilization of nutrients; respiration and body temperature regulation.

CIAN 6606. EXPERIMENTAL NUTRITION (I, II)(On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Study and application of the methodology used in animal nutrition research. Practice in *in vivo*, *in vitro*, and *in situ* digestibility trials and mathematical models to determine ruminal degradability and fermentation rates. Evaluation of experimental design for nutrition research.

CIAN 6607-6608. GRADUATE SEMINAR (I, II) (On demand). One credit hour. One meeting per week per semester.

Lectures, discussions and reports on selected topics in animal science.

CIAN 6609. ADVANCED DAIRY BACTERIOLOGY (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

The microbiology of milk and milk products.

CIAN 6611. RUMINANT NUTRITION (II). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Physiological and biochemical processes of digestion; relation of rumen function to animal response; chemical analyses and nutrient composition and requirements of feedstuffs, primarily forages; in vitro methodology for determining nutrient digestibility.

CIAN 6614. ADVANCED POULTRY PRODUCTION (II). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Commercial poultry farm operation, processing and marketing of poultry products.

CIAN 6615. ADVANCED SWINE PRODUCTION (I). Three credit hours. Three hours of lecture per week.

Study of the problems of modern swine production and on going research to solve them.

CIAN 6617. ADVANCED REPRODUCTION (I). Three credit hours. Three hours of lecture per week.

Anatomical, physiological, and pathological processes of reproduction in farm animals. Current concepts in endocrinology and their application in management and control of reproduction. Effect of tropical environment on reproduction.

CIAN 6618. PHYSIOLOGY OF LACTATION. Three credit hours. Three hours of lecture per week.

Study of the origin and evolution of mammals. Analysis of the similarities and differences in development, morphology and physiology of the mammary gland among species. Analysis of processes associated with synthesis of milk components and their relationship with commercial milk production. Discussion of the biological and chemical properties of milk and its significance on the neonate and human nutrition. Application of the basic processes associated with immunology of the mammary gland, methods of mastitis detection and management practices associated with its control in dairy herds.

CIAN 6625. ANIMAL ENERGY METABOLISM (On demand). Three credit hours. Three hours of lecture per week.

Study of energy metabolism and its relationship to cell structure; the concept and types of energy; laws of thermodynamics and their relationship to animal metabolism; energy utilization and requirements in animals; environmental effects and control systems in energy metabolism, as well as techniques utilized for its study.

CIAN 6626. ANIMAL PROTEIN METABOLISM (I). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Nutritional and biochemical aspects of animal protein metabolism; digestion and absorption; metabolism of free aminoacids; protein synthesis and turnover; excretion of nitrogenous products; nutritional value of proteins; protein requirements; general features of metabolic and hormonal control.

CIAN 6637. NEUROENDOCRINE AND CIRCULATORY PHYSIOLOGY(I). Three credit hours. Three hours of lecture per week.

Study of the processes of the nervous, endocrine and cardiovascular functions with emphasis on cellular control mechanisms in domestic animals.

CIAN 6638. RENAL, RESPIRATORY AND DIGESTIVE PHYSIOLOGY(II). Three credit hours. Three hours of lecture per week.

Study of the processes of the renal respiratory and gastrointestinal functions with emphasis in the cellular control mechanisms in domestic animals.

CIAN 6990. SUPERVISED PROFESSIONAL OCCUPATIONAL EXPERIENCE FOR CO-OP STUDENTS. From three to six credit hours. Prerequisites: authorization of the Director of the Department.

Practical experience in animal management and production and/or animal products in cooperation with the private sector or government. To be jointly supervised by the academic department, the Coop program coordinator and an official from the cooperating entity. A written report will be required upon completion of each work period.

CIAN 6995-6996. SPECIAL PROBLEMS (I, II, S)-(I, II, S). One to five credit hours. One to five research periods per week each semester.

Advanced studies in animal science problems and procedures. Problems will be assigned according to experience, interests and needs of the individual student.

CIAN 6997. SELECTED TOPICS (I,II). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in biotechnology, physiology, nutrition, reproduction, animal health and management of domestic species.

CIAN 6998. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in biotechnology, physiology, nutrition, reproduction, animal health and management of domestic species.

CIAN 6999. RESEARCH AND THESIS (I,II,S). One to six credit hours. One to six research periods per week.

Organized research in animal science at the master's thesis level, including thesis presentation and discussion as a part of requirements for a Master of Science degree with a major in animal science.

ANIMAL SCIENCE FACULTY

The following is a list of professors who engage in graduate activities in the Department, including the highest earned degree, date, and institution granting degree as well as research and teaching interests:

ENID ARCELAY, *Associate Professor*, Ph.D., 2009, University of Massachusetts. Andrology, Animal Reproduction, Cellular Physiology.

MIREILLE ARGÜELLES, *Assistant Professor*, Ph.D. 2011, North Carolina State University. Teaching and Research interest: Poultry Nutrition, Physiology.

AMÉRICO CASAS-GUERNICA, *Professor*, M.S., 1984, University of Puerto Rico. Teaching and Research interest: Beef Cattle Production-Ruminant Nutrition.

JAIME E. CURBELO-RODRÍGUEZ, *Associate Professor*, Ph.D., 2011, Mississippi State University. Teaching and Research interest: Dairy Science.

KATHERINE DOMENECH-PÉREZ, *Assistant Professor*, Ph.D., 2016, University of Nebraska, Lincoln. Teaching and Research interest: Meat Science and Technology

RENÉ F. ESTEVES-AMADOR, *Assistant Professor*, Ph.D. 2015, University of Puerto Rico-Mayagüez. Teaching and Research interest: Fresh and Salt Water Aquaculture, Marine Sciences

JOHN A. FERNÁNDEZ-VAN CLEVE, *Professor*, Ph.D., 1986, University of Kentucky. Teaching and Research interest: Reproductive Physiology.

ESBAL JIMÉNEZ-CABÁN, *Associate Professor*, Ph.D., 2008, The Ohio State University. Teaching and Research Interests: Swine Reproduction.

JOSÉ R. LATORRE, *Professor*, Ph.D., 1986, University of Arkansas. Teaching and Research interest: Poultry Production, Reproduction, Physiology, Food Safety.

ALEXANDER MESONERO-MORALES, *Associate Professor*, DVM 2008, Louisiana State University. Teaching and Research interest: Animal Health, Pathology.

GUILLERMO ORTIZ-COLÓN, *Associate Professor*, Ph.D., 2006, Michigan State University. Teaching and Research interests: Growth Physiology – Ruminant Nutrition.

MELVIN PAGÁN-MORALES, *Professor*, Ph.D., 2002, Michigan State University. Teaching and Research interests: Molecular Genetics & Growth Physiology.

LEYDA PONCE DE LEÓN-GONZÁLEZ, *Professor*, Ph.D., 1999, University of Wisconsin-Madison. Teaching and Research interest: Milk and Dairy Products Science and Technology.

PAUL F. RANDEL-FOLLING, *Researcher*, Ph.D., 1963, Louisiana State University. Teaching and Research interest: Ruminant Nutrition.

AIXA RIVERA-SERRANO, *Professor*, M.S., 1985, University of Puerto Rico. Teaching and Research interest: Beef Cattle Production.

ABNER RODRÍGUEZ-CARIAS, *Professor*, Ph.D., 1996, Michigan State University. Teaching and Research interest: Ruminant Nutrition; Microbiology.

TEODORO RUIZ-LÓPEZ, *Professor*, Ph.D., 1993, University of Florida. Teaching and Research interests: Dairy Cattle Nutrition; Forage Utilization.

HÉCTOR L. SÁNCHEZ-RODRÍGUEZ, *Assistant Professor*, Ph.D., 2011, Mississippi State University. Teaching and research interests: Dairy Science and Physiology of Reproduction.

CARMEN SANTANA-NIEVES, *Associate Professor*, Ph.D., 1993, University of Illinois. Teaching and Research interests: Swine Production; Environmental Physiology; Animal Behavior.

HÉCTOR L. SANTIAGO-ANADÓN, *Researcher*, Ph.D., 2002, Virginia Polytechnic Institute and State University. Teaching and Research interests: Poultry Production, Animal Growth. (on leave)

VÍCTOR SIBERIO-TORRES, *Professor*, Ph.D., 1996, Michigan State University. Teaching and Research interests: Swine Production; Non-ruminant Nutrition.

FOOD SCIENCE AND TECHNOLOGY PROGRAM

Please refer to the Interdisciplinary Programs section for information on this program.

COLLEGE OF ARTS AND SCIENCES

The School of Science was organized in 1943 according to the provisions of the University Act of 1942, and was authorized to grant the degree of Bachelor of Science in the fields of Biology, Chemistry, Geology, Mathematics, and Physics. A Division of General Studies was set up later, independently, with the purpose of offering a series of introductory or basic courses leading an incoming student to a better understanding of the physical, intellectual, and social world in which we live. The School of Science and the Division of General Studies were fused to form the College of Arts and Sciences of the Mayagüez Campus in 1959.

Graduate instruction at UPRM began in 1957 with the establishment of the Puerto Rico Nuclear Center. The construction of this facility in Mayagüez led to the beginning of graduate studies in the fields of nuclear science and technology, radiological physics and mathematics. At present the College offers graduate instruction leading to the degree of Master of Science in Biology, Chemistry, Geology, Marine Sciences, Mathematics and Physics as well as the Master of Arts in Hispanic Studies and the teaching of English as a second language. In 1972, the College initiated a program leading to the degree of Doctor of Philosophy in Marine Sciences. The Mayagüez Campus is the only institution in Puerto Rico offering a Ph.D. in this field. The Applied Chemistry Ph.D. program started on 2004. A multidisciplinary doctorate degree in Computer Information Science and Engineering is offered in collaboration between the Mathematics and the Electric and Computer Engineering Departments.

Depending on individual department regulations, the student may have various options for fulfilling Master degree requirements. Most departments require a thesis, while some may also offer the option of a project report or grant the degree under a non-thesis option.

BIOLOGY

The Department of Biology offers a program leading to a Master's degree in Science. Although there are no formal options, students are able to specialize in conservation biology, environmental microbiology, botany, cellular and molecular biology, ecology, physiology, genetics, mycology, virology, microbiology (bacteriology), parasitology, zoology, entomology, herpetology and limnology.

In addition to the admission requirements of the Graduate Studies Office, a Bachelor of Science degree in Biology or its equivalent is required. Generally, more than 90% of the admitted students had a 3.00 GPA or higher in the biology courses.

Requirements for the Master's Degree in the Department of Biology are met with the approval of a minimum of thirty credit hours of graduate courses including the thesis, of which a maximum of nine credits can be advanced undergraduate (5000) courses. BIOL 6689 (Biological Research Methods) and BIOL 6690 (Graduate Seminar) are core courses required to all students. All students are required to write a thesis, and to present a departmental seminar related to their thesis research prior to graduation. All other program requirements are those established by the Graduate Studies Office.

Departmental facilities include laboratories dedicated to research in botany, cellular and molecular biology, comparative physiology, entomology, virology, microbiology, mycology, and other areas of biology; a herbarium and a greenhouse; and zoological collections. In addition, the Biology Department operates a Microscopy Center and the Caribbean Genome Center.

Advanced Undergraduate Courses

BIOL 5005. ELEMENTARY PLANT ANATOMY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: BIOL 3435 or BIOL 3417 or authorization of the Director of the Department.

The study of simple and complex tissues of the organs of vascular plants; the study of the characteristics of parenchyma, sclerenchyma and collenchyma cells, as well as the elements composing the xylem and phloem tissues.

BIOL 5007. GENERAL PLANT MORPHOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: BIOL 3417 or BIOL 3435 or authorization of the Director of the Department.

The general principles of plant morphology, including evolutionary tendencies, phylogenetic lines and the life cycles of the principal groups of plants.

BIOL 5016. PLANT EVOLUTION. Two credit hours. Two hours of lecture per week. Prerequisite: BIOL 3417 or BIOL 3435 or authorization of the Director of the Department.

Analysis of the geological, morphological, anatomical, physiological, and geographical evidence showing how the different plant phyla have evolved, with emphasis on the evolution of tracheophytes. Assigned reading reports.

BIOL 5018. PLANT PHYSIOLOGY. Four credit hours. Three hours of lecture and one laboratory of three hours per week. Prerequisites: BIOL 3417 or BIOL 3435 or authorization of the Director of the Department. Co-requisite: QUIM 3032 or QUIM 3062 or QUIM 3463 or authorization of the Director of the Department.

Plant physiology: diffusion, transpiration, absorption and transport, mineral nutrition, metabolism, growth and development, hormones, effects of environmental factors.

BIOL 5038. BIOLOGICAL APPLICATIONS OF REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEMS. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: MATE 3172 or MATE 3005 or authorization of the Director of the Department.

Students will learn the theory of extracting information from remotely sensed data, its integration into geographical information system (GIS) databases, and its use for the study and

management of biological systems. Students will extract information of biological interest from remotely sensed data and other types of geographic data, will assemble at least one geographic database, and use that geographic database to study the relationships between one or several organisms and several environmental variables.

BIOL 5045. SCANNING ELECTRON MICROSCOPY (SEM). Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Theoretical and practical aspects of the scanning electron microscope (SEM) with emphasis on sample preparation for SEM, detection of the different types of signals emitted by the specimen, and image analysis.

BIOL 5055. EUKARYOTIC MOLECULAR GENETICS. Three credit hours. Three hours of lecture per week. Prerequisites: BIOL 3300 and QUIM 5071.

The eukaryotic genome, gene structure, transposable elements, regulation of transcription, mRNA processing, signal transduction and the genetics of development the cell cycle, and cancer. Discussion of research techniques in molecular genetics.

BIOL 5056. EUKARYOTIC MOLECULAR GENETICS LABORATORY. Two credit hours. Eight hours of laboratory per week. Prerequisites: (BIOL 3300 and QUIM 5071) or authorization of the Director of the Department. Corequisite: BIOL 5055.

Techniques used in eukaryotic molecular genetics such as: DNA preparation, polymerase chain reaction, restriction mapping, gene cloning, DNA sequencing, and construction of genomic and cDNA libraries.

BIOL 5057. INTRODUCTION TO BIOLOGICAL SEQUENCE ANALYSIS. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: BIOL 3300 or authorization of the Director of the Department.

Use of bioinformatics programs for the retrieval manipulation, and analysis of DNA and protein sequences. The subjects include: description of sequence data editing software, sequence database searches (nucleotide, proteins and genomes), comparative sequence alignments, applications for the design of specific or degenerate oligonucleotides for the detection of DNA sequences via PCR, and

construction of phylogenetic trees using distance, parsimony and maximum likelihood methods.

BIOL 5116. MOLECULAR BASIS OF EUKARYOTIC CELL SIGNALING. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: (BIOL 3010 and QUIM 5071) or authorization of the Director of the Department.

Principles of molecular signaling regulating membrane, cytoplasmic and nuclear events in eukaryotic cells. Emphasis on contemporary research methods and the principles of identifying and solving problems related to cellular signal transduction.

BIOL 5117. CELLULAR AND MOLECULAR BIOLOGY OF CANCER. Three credit hours. Three hours of lecture per week. Prerequisite: BIOL 3010 or authorization of the Director of the Department.

Discussion of topics related to cancer research and its clinical application. Emphasis on molecular mechanisms that lead to cancer development and tumor progression and how they relate to the clinical course of the disease. Discussion of recent discoveries in the area.

BIOL 5226. GENETICS AND EVOLUTION OF HUMAN POPULATIONS. Three credit hours. Three hours of lecture per week. Prerequisites: (BIOL 3300 or (CIBI 3032 and ANTR 3015)) or authorization of the Director of the Department.

Study of the biology of human populations, mainly from a genetic and evolutionary perspective. Includes the study of genetic elements, their evolution and their use in studies of the evolution and dispersal of human populations and domesticated species.

BIOL 5399. EUKARYOTIC GENOME ANNOTATION. Two credit hours. One hour of lecture and three hours of research per week. Prerequisite: BIOL 3300 or authorization of the Director of the Department.

Practical course covering the annotation of genomic fragments in different eukaryotic species, using the genome of an evolutionarily closely related species as a reference sequence. Includes the detailed study of the structure of diverse genetic elements, molecular evolution processes, and the use of applications and computer programs useful for studies in genomics. A final report is required.

BIOL 5416. HERPETOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A study of the biology, classification and morphology of amphibians and reptiles, with emphasis on local species. Field trips.

BIOL 5417. ICHTHYOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A study of the biology, classification and morphology of fishes, with emphasis on local species. Field trips.

BIOL 5585. MEDICAL AND VETERINARY ENTOMOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

This course offers the student interested in entomology, animal husbandry or veterinary science, an opportunity to become familiar with the recognition, characteristics, habits and control of insects, ticks, mites, and other arthropods that attack man and domestic animals.

BIOL 5755. VIROLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: BIOL 3770 or authorization of the Director of the Department.

The classification, structure, physiology and biochemical activities of viruses.

BIOL 5758. BACTERIAL GENETICS. Two credit hours. Two hours of lecture per week. Prerequisites: BIOL 3300 or BIOL 3770 or authorization of the Director of the Department.

DNA replication and expression in the prokaryotic cell; transfer of genetic information; the impact of genetic processes on the physiology and ecology of bacteria.

BIOL 5759. BACTERIAL GENETICS LABORATORY. Two credit hours. Two four-hour laboratory periods per week. Co-requisite: BIOL 5758.

Molecular techniques for the study of the genetics of bacteria and bacteriophages. Practical experiences in the processes of recombination, complementation, the control of genetic expression, and the transmission of genetic information among microorganisms.

BIOL 5760. BACTERIAL GENETICS LABORATORY. One credit hour. One four hour laboratory per week. Corequisite: BIOL 5758.

Practical experiences in the processes of recombination, complementation, the control of genetic expression, and the transmission of genetic information among microorganisms.

BIOL 5765. MYCOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: BIOL 3770 or authorization of the Director of the Department.

A study of the morphology, physiology, classification and relation of fungi to man. Emphasis is given to the isolation and identification of the different groups.

BIOL 5815. ANIMAL BEHAVIOR. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A study of activities and responses of animals in meeting their life requirements. Field trips.

BIOL 5955. INTRODUCTION TO RESEARCH METHODS IN ECOLOGY. Three credit hours. One hour of lecture and two three-hour laboratory periods per week. Prerequisite: BIOL 3125 or authorization of the Director of the Department.

Field and laboratory exercises serve to introduce the student to the basic methods used in ecological research. The student is trained in the use of computers for the analysis of ecological data.

BIOL 5990. FIELD BIOLOGY WORKSHOP. One to three credit hours. Thirty to sixty hours of workshop/practice per credit. Prerequisite: authorization of the Director of the Department.

Intensive practical experience in selected areas of field biology, in or outside of Puerto Rico. A final written report will be required.

Graduate Courses

BIOL 6008. PROKARYOTIC MOLECULAR GENETICS AND GENE REGULATION. Three credit hours. Three hours of lecture per week.

Presentation, description, and analysis of nucleic acid and chromosomal architecture of prokaryotes; the structure and function of biological components involved in the processes of replication, transcription, and translation. Discussion of the different levels and mechanisms of gene expression

and regulation with emphasis on their genetic and physiological consequences.

BIOL 6015. INSECT MORPHOLOGY. Four credit hours. Two hours of lecture and two two-hour laboratories per week.

A study of the general internal and external morphology of insects.

BIOL 6040. BIOGEOGRAPHY. Three credit hours. Three hours of lecture per week.

A study of the principles governing the distribution of organisms. Examples of the Caribbean area are used.

BIOL 6155. PLANT ECOLOGY. Four credit hours. Two hours of lecture and two three-hour laboratories per week. Prerequisite: authorization of the Director of the Department.

The interrelations of plants and environment; climatic, edaphic, and biotic factors in their relation to origin, development, and structures of vegetation; introduction to ecological fieldwork and the methods of ecological research. Practice is given in the recognition of associations, determination, and description of their structure, and relationships and measurements of environmental factors. Reports required.

BIOL 6199. BEHAVIORAL ECOLOGY. Three credit hours. Three hours of lecture per week.

Recent developments in behavioral ecology. Evolutionary and ecological models applied to the behavioral problems of survival and reproduction. Integration of theory with field and laboratory evidences. Field trips required.

BIOL 6369. POPULATION GENETICS. Three credit hours. Three hours of lecture per week.

Genetic variation in natural populations of both plants and animals in different communities, covering selection, migration, mutations, mating systems, and the effect of population size on the maintenance of genetic variation.

BIOL 6605. ENVIRONMENTAL POLLUTION AND DISTURBANCE. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

An ecological consideration of pollution and disturbance of the environment; the effects of industrial, domestic and other pollutants of the

ecosystem; the physical, chemical and biological parameters used in pollution control and abatement. Field trips.

BIOL 6607. POPULATION ECOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Study of populations for analysis of the control and interaction among them. Topics such as mortality, fertility, population growth, competition and predator-prey interaction will be discussed.

BIOL 6610. LIMNOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A study of the physical, chemical and biological characteristics and interrelations of these factors in aquatic situations; community structure in still and running water; studies of local streams and ponds.

BIOL 6617. ADVANCED GENETICS. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Discussion of selected topics in genetics.

BIOL 6631. CELLULAR BIOCHEMISTRY AND PHYSIOLOGY. Four credit hours. Three hours of lecture and one three-hour laboratory per week.

The interconversions of energy in living cells; photosynthesis and carbohydrate metabolism as energy sources; the utilization of metabolic energy for protein synthesis; solute and solvent movements; nerve and muscle phenomena. Emphasis on metabolic regulation and enzyme action.

BIOL 6635. MEDICAL MYCOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

A study of the fungi pathogenic to man.

BIOL 6637. TAXONOMY AND MORPHOLOGY OF FUNGI. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A thorough coverage of the phycomycetes, ascomycetes, deuteromycetes and basidiomycetes from a taxonomical and morphological approach, with emphasis on saprophytes, zoopathogens and phytopathogens.

BIOL 6642. ADVANCED MYCOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A study of fungi with emphasis on current literature and methods of research.

BIOL 6645. SYSTEMATIC MYCOLOGY. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of fungal systematics including historical aspects of classification, taxonomy, and nomenclature. Critical reading and analysis of historical and modern works that gave rise to the current classification of fungi and associated groups. Discussion of the phylogenetic relationships of fungi and other groups that are traditionally studied by micologists, as well as the characteristics used to establish such relationships.

BIOL 6650. BACTERIAL DIVERSITY. Three credit hours. Two hours of lecture and two hour-and-a-half laboratories per week. Prerequisite: consent of the Director of the Department.

The diversity of prokaryotic organisms in relation to ecophysiological and evolutionary perspectives, emphasizing their isolation, identification, and application.

BIOL 6688. SCIENTIFIC PHOTOGRAPHY FOR BIOLOGISTS. Two credit hours. Two three-hour laboratories per week. Prerequisite: authorization of the Director of the Department.

Photographic techniques in biological research. A presentation and a portfolio of the student's work are required.

BIOL 6689. BIOLOGICAL RESEARCH METHODS. Two credit hours. Two hours of lecture per week.

Methods and theory of investigation in the biological field, including study of the biological literature and sources of information from major institutions active in this field. The student is required to write a research proposal in his area of interest.

BIOL 6690. GRADUATE SEMINAR. One credit hour. Two hours of lecture per week.

Discussion of recent literature in biology and related fields. Students will discuss principal topics in their special fields.

BIOL 6705. ADVANCED FOOD

MICROBIOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Microbiology of food commodities. The nature and function of beneficial and harmful microorganisms. Foodborne diseases. Effects of food processing and storage on microorganisms.

BIOL 6805. SYMBIOSIS. Three credit hours. Three hours of lecture per week.

Study of common and unusual biological associations between distinct organisms, such as parasites, endosymbiotic bacteria, pollinators, and others. Analysis of organism interactions, from the endosymbiotic theory on the origin of eukaryotic cells to the ecological interactions between organisms and their evolution. A final oral presentation will be required.

BIOL 6806. BIOLOGICAL SYSTEMATICS. Three credit hours. Two hours of lecture and three hours of laboratory per week.

Study of the theory and practice of biological systematics, including parsimony analysis of morphological and molecular characters. Discussion of concepts and methods pertinent to the generation and evaluation of phylogenetic trees, and their application using current software packages. A course project on the phylogeny of a particular group or organisms is required.

BIOL 6990. RESEARCH . One to six credit hour periods per week.

Research for a thesis.

BIOL 6991-6992. SPECIAL STUDIES IN BIOLOGY. One to three credit hours per semester. One to three research periods per week each semester.

Supervised research in some special topics of biology other than a thesis problem, but designed to provide experience and training in scientific investigation.

BIOL 6993. SPECIAL TOPICS IN BIOLOGY I. One to six credit hours. One to six hours of lecture per week.

Selected topics in biology, botany, microbiology, and zoology.

BIOL 6994. SPECIAL TOPICS IN BIOLOGY II. One to six credit hours. One to six hours of lecture per week.

Selected topics in biology, botany, microbiology, and zoology.

BIOL 6997. SPECIAL TOPICS IN BIOLOGY: LABORATORY. One to six credit hours. One to six two-to four-hour laboratories per week.

Laboratory practice of selected topics in biology, botany, microbiology, and zoology.

Botany (BOTA)

BOTA 6006. PHYSIOLOGY OF BACTERIA. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

The physiology of bacteria and the biochemistry of microbic processes.

Zoology (ZOOL)

Advanced Undergraduate Course

ZOOL 5005. INVERTEBRATES OF PUERTO RICO. Three credit hours. Two hours of lecture and one-three hour laboratory per week.

Taxonomy and ecology of the most common invertebrates of Puerto Rico, especially Arthropoda (exclusive of insects and marine forms) and Mollusca. Field trips.

Graduate Courses

ZOOL 6019. ADVANCED PARASITOLOGY. Four credit hours. Three lectures and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Lectures, conferences, reading and laboratory work dealing with practical problems of classification, morphology and host relations of animal parasites.

ZOOL 6039. ANIMAL ECOLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

A study of the principles of ecology as applied to animals.

ZOOL 6058. INSECT TAXONOMY. Three credit hours. One hour of lecture and two two-hour laboratory periods per week.

The classification of the hexapoda. Construction of keys, preparation of description, nomenclatural problems, faunistic and monographic studies, catalogs and bibliographies.

BIOLOGY FACULTY

A list of professors who engage in graduate activities in the Department follows including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

CARLOS ACEVEDO-SUÁREZ, *Assistant Professor*, Ph.D., 2006, Vanderbilt University School of Medicine. Research interests: Cellular and Molecular Immunology. Teaching interests: Immunology, Cellular and Molecular Biology of Cancer.

DIMARIS ACOSTA-MERCADO, *Professor*, Ph.D., 2003, University of Guelph, Canada. Research Interests: Protist, Trophic Networks in Microecosystems, Ecology of Soil Protozoa, Biodiversity and Ecosystem Function. Teaching Interests: Ecological and Research Methods, Protistology.

JAIME A. ACOSTA-MARTÍNEZ, *Professor*, Ph.D., 1995, Virginia Polytechnic Institute and State University. Research Interests: Entomology, Biocontrol of Lepidoptera, Ecology of Fire Ants. Teaching Interests: Biology, Ecology, Zoology, Entomology.

MÓNICA ALFARO-LOZANO, *Professor*, Ph.D., 2002, University of Puerto Rico. Research Interests: Marine Biology, Ecology of Zooplankton. Teaching Interests: Marine Ecosystems, Zoology, Ecology, and Biological Sciences.

FERNANDO BIRD-PICÓ, *Associate Professor*, Ph.D., 1994, University of Kansas. Research Interests: Herpetology, Ecology and Population Genetics, Conservation Biology. Teaching Interests: Herpetology, Systematic Zoology, Population Genetics, Comparative Vertebrate Anatomy, Scientific Photography for Biologists and General Biology.

MATÍAS J. CAFARO, *Professor*, Ph.D., 2003, University of Kansas, Lawrence. Research Interests: Mycology, Symbiosis, Interactions between Arthropods and Fungi. Teaching Interests: Topics in Symbiosis, Advanced Mycology, Systematics of Fungi, Molecular Systematics.

NANETTE DIFFOOT-CARLO, *Professor*, Ph.D., 1992, Virginia Polytechnic Institute and State University. Research Interest: Molecular Studies of Viral Replication. Teaching Interests: Genetics, Virology.

SEAN A. LOCKE, *Assistant Professor*, Ph.D., 2010, Concordia University. Research Interests: Parasitology, Molecular Systematics, Community Ecology, Aquatic Ecosystems. Teaching Interests: Parasitology, Invertebrate Zoology, and Field Ecology.

SANDRA L. MALDONADO-RAMÍREZ, *Professor*, Ph.D., 2001, Cornell University, Ithaca, New York. Research Interests: Mycology, Aerobiology, Plant Pathology, Fungal Endophytes. Teaching Interests: Mycology, Aerobiology and General Biology.

JUAN C. MARTÍNEZ-CRUZADO, *Professor*, Ph.D., 1988, Harvard University. Research interests: Molecular Population Genetics and Evolution. Teaching Interests: Genetics, Molecular Genetics.

ARTURO A. MASSOL-DEYÁ, *Professor*, Ph.D., 1994, Michigan State University. Research Interests: Biodegradation, Microbial Diversity, Environmental Microbiology. Teaching Interests: Microbial Ecology, General Microbiology, Industrial Microbiology.

RAFAEL MONTALVO-RODRÍGUEZ, *Professor*, Ph.D., 2003, University of Nebraska. Research Interest: Extremophiles, Taxonomy, Physiology and Genetics of Archaea. Teaching Interest: Microbiology, Microbial Physiology, Bacterial Biodiversity, and General Biology.

ALEJANDRO ORTIZ-ACEVEDO, *Associate Professor*, Ph.D., 2000, University of California, Davis. Research interests: Embryology, Cellular Physiology. Teaching interests: General Biology, Human Physiology and Cell Physiology.

ALBERTO R. PUENTE-ROLÓN, *Assistant Professor*, Ph.D., 2012, University of Puerto Rico. Research Interests: Invasive Species, Herpetology, Wildlife Management, Conservation and Population Biology. Teaching Interests: General Biology, Ecology, Natural History, Animal Behavior, Zoology and Evolution.

LUIS A. RÍOS-HERNÁNDEZ, *Professor*, Ph.D., 2003, University of Oklahoma. Research Interests: Anaerobic Processes, Syntrophic Metabolism. Teaching Interests: General Microbiology, Microbial Physiology, Anaerobic Microbiology and General Biology.

CARLOS RIOS-VELÁZQUEZ, *Professor*, Ph.D., 2000, University of Wisconsin-Madison. Research Interest: Bacterial Genetics and Physiology, Microbial Biotechnology and Bioprospecting. Teaching Interest: Microbial Physiology, Prokaryotic Molecular Genetics and Gene Regulation, Microbial Biotechnology.

CARLOS M. RODRÍGUEZ-MINGUELA, *Associate Professor*, Ph.D., 2005, Michigan State University. Research Interest: Molecular Ecology of Antibiotic Resistance Genes, Development of Quantitative Molecular Methods for Microbial Source Tracking, and the Ecology of Microbial Processes Involved in the Removal of Environmental Pollutants. Teaching Interests: Microbiology, Microbial Ecology, Application of Bioinformatics to Molecular Microbial Ecology.

CARLOS J. SANTOS-FLORES, *Professor*, Ph.D., 2001, University of Wisconsin-Madison. Research Interests: Limnology, Freshwater Ecology, Taxonomy of Algae and Micro Invertebrates, Aquatic Fungi Taxonomy and Ecology. Teaching Interests: Limnology, Freshwater Biology, Plankton Ecology, Zoology and General Biology.

DIMUTH SIRITUNGA, *Professor*, Ph.D., 2002, Ohio State University. Research Interests: Plant Molecular Biology, Metabolic Engineering, Genetics, Diversity in Crop Genetics/Plants. Teaching Interest: Plant Molecular Biology, Plant Physiology, Genetics and Plant Biotechnology.

JOHN M. USCIAN, *Professor*, Ph.D., 1994, University of Nebraska. Research Interests: Marine Fish, Biochemistry/Physiology. Teaching Interests: Physiology, Cell Biology.

ALEX VAN DAM, *Assistant Professor*, Ph.D., 2013, University of California Davis. Research Interests: Entomology, Phylogenetics. Teaching Interests: Entomology, Phylogenetics, Bioinformatics, and General Biology.

BENJAMIN VAN EE, *Assistant Professor*, Ph.D., 2006, University of Wisconsin-Madison. Research Interests: Plant Evolution, Phylogenetics, Taxonomy, and Biogeography. Teaching Interests: Botany, Bioinformatics, Evolution, Taxonomy of Vascular Plants and General Biology.

MARÍA M. VARGAS-RODRÍGUEZ, *Professor*, Ph.D., 1997, Arizona State University. Research Interests: Mycology, Entomopathogenic Fungi, Microscopy. Teaching Interests: Mycology, Microbiology, Microscopy.

CHEMISTRY

The Department of Chemistry offers a program leading to a Master of Science Degree in Chemistry with applied research in both traditional and interdisciplinary fields of chemistry; and a Doctor of Philosophy Degree program in Applied Chemistry with cutting edge interdisciplinary research.

The department is housed in a four-story building (214,000 square feet) with modern facilities for teaching and research. It has forty research and twenty teaching laboratories, as well as ten lecture rooms, a computer center, a visualization center, and cold and dark rooms. Research facilities include a large variety of sophisticated instrumentation, including systems for femtosecond vibrational spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, electrothermal deposition systems, atomic force microscopy (AFM), scanning electron microscopy (SEM), state-of-the-art Raman microscopes; hyphenated inductively coupled plasma and high performance liquid chromatographs mass spectrometers, as well as, electroanalytical systems. In addition, there are two 2,000 square feet multi-user facilities with routine analytical instrumentation including gas and liquid chromatographs, electrothermal and flame atomic absorption spectrometers, fluorimeters, ultraviolet-visible and Fourier Transform infrared spectrometers; and ion selective electrodes and sensors. The department hosts a diverse and interdisciplinary number of research groups and three research centers: the Center for Protein Characterization and Function, the Center for Development of Chemical Sensors and the new Center for Education and Training in Agricultural and Related Sciences. An outreach program, Science on Wheels, is also housed within the departmental facilities.

There are 40 faculty members along with 3 joint professors from the fields of engineering and materials science (1) and chemical engineering (2). Approximately 30 faculty members have ongoing research projects in the research fields of biophysics; chemistry of materials; environmental chemistry; food and agricultural chemistry; organic, inorganic and bio-inorganic; synthesis, analytical; molecular spectroscopy; pharmaceuticals, computational chemistry, electrochemistry, and biochemistry.

The Master of Science Degree Program

Admission Requirements:

1. A bachelor's degree in chemistry from a recognized university or its equivalent, with a minimum general grade point average of 2.80 (or 3.00 in chemistry courses) in a scale of 0 to 4.00. Applicants who have a bachelor's degree which is not in chemistry may be considered.
2. The aptitude Graduate Record Examination (GRE) with a score of 2.0 or higher in the analytical section of the exam.
3. Proficiency in Spanish and English. **If there are deficiencies in either one of the languages the student must take remedial courses when they enter the program.**

Within the M.S. option, students are able to specialize in one of the following areas:

- Biophysics
- Chemistry of Materials
- Environmental Chemistry
- Analytical Chemistry
- Physical Chemistry
- Inorganic Chemistry
- Organic Chemistry
- Biochemistry

Program Requirements:

The requirements for the Master's Degree in the Department of Chemistry are met with the approval of at least seventeen credit hours of graduate courses in Chemistry, exclusive of the thesis. Three of the following core courses are required: Advanced Inorganic Chemistry I (QUIM 6011), Advanced Organic Chemistry I (QUIM 6401), Advanced Physical Chemistry (QUIM 6605), Advanced Analytical Chemistry (QUIM 6215), and Advanced Biochemistry (QUIM 6715). In addition, students are required to take QUIM 6005 and QUIM 6006, (Graduate Seminar I and II), and to write and defend a thesis.

Also, thirteen credits will be on elective courses in the area. Total credits are 30 for graduate.

Ph.D. in Applied Chemistry

The Ph.D. Program in Applied Chemistry emphasizes three principal fields of research: biophysical chemistry, chemistry of materials and environmental chemistry. The Department's web site: <http://www.uprm.edu/chemistry>, offers additional information on the program and the research interests of the professors involved in the program.

Admission Requirements:

1. A bachelor's or master's degree in chemistry from an accredited university or its equivalent, with a minimum general grade point average of 2.80 (or 3.00 in chemistry courses) in a scale of 0 to 4.00. Applicants within a field other than Chemistry may be evaluated on an individual basis.
2. Proficiency in Spanish and English. ***If there are deficiencies in either one of the languages the student must take remedial courses when they enter the program.***

Placement Tests:

Placement tests will be offered to the students who have been accepted to the Doctoral Program before the beginning of their formal studies. It consists of five parts which will evaluate the student's knowledge at the undergraduate level in the following areas: Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, Physical Chemistry and Biochemistry.

Program Requirements:

Research Proposal - Students will present a written research proposal that defines their doctoral dissertation project. This proposal will be presented and defended before the student's graduate committee.

Doctoral Exam - Students will take a Doctoral Exam which will assess their knowledge at the graduate level. This should occur during the third year of studies. The exam will include both, a written and oral component.

Internship ("Practicum") – Every student will work during four months or one semester in an academic, industrial, or government laboratory outside the UPR-Mayagüez Campus. Students are encouraged to make arrangements with their advisors early in their careers in order to properly fulfill this requirement.

It is recommended that the four month period be flexible, but cumulative to include a period of at least four months. This period may be distributed as follows:

1. A period of four months without interruption.
2. Two summer terms.

The internship period may include a maximum of three weeks in workshops related to the student's research. Each workshop should have a minimum duration of one week.

After returning from the internship, students must present a written progress report, make a presentation in the Graduate Seminar or in a scientific conference such as an ACS National Meeting; and receive a formal evaluation from the Practicum supervisor or host.

Upon approval of the report, the research advisor, as president of the student's Graduate Committee will submit a letter to the Department's Graduate Coordinator, notifying of the completion of this requirement.

As established by the Departmental Graduate Program Committee, the internship results and findings must also be a part of the student's dissertation.

Publications—Students will be required to have two accepted publications on a peer-reviewed journal before defending their doctoral dissertation.

The academic requirements to grant the degree are:

- A. A minimum of 52 credits, of which no more than nine credits (9) can be at the 5000 level and no less than 34 credits at the 6000 level or higher. Of the previous 34 credits, 18 credits are assigned to the

student's dissertation. Students are also required to take a minimum of nine credits hours of courses in an area other than their major.

- B. The minimum grade point average required for graduation is 3.00.

Course Distribution

Departmental Core Courses (3 elective courses @ 3 credit hours) – 9 credit hours
Grade Requirements – 28 credit hours
Recommended Courses and Electives by Area of Specialty – 15 credit hours

Advanced Undergraduate Courses

QUIM 5005. METHODOLOGY OF ENVIRONMENTAL CHEMICAL ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisites: ((QUIM 3055 or QUIM 3065) and (QUIM 3461 or QUIM 3450 or QUIM 3071 or QUIM 3061)) or authorization of the Director of the Department.

Methods of chemical analysis used for environmental studies in monitoring air, water, and soil, including the methodology required by federal, state, and local agencies. Discussion of sampling techniques for air, surface and waste water, soil, and other matrices. Practical description of analytical instrumentation, quality control, and data analysis.

QUIM 5065. CHEMISTRY OF SYNTHETIC DRUGS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 3032 or QUIM 3072 or QUIM 3450 or QUIM 3463 or authorization of the Director of the Department.

The chemistry of synthetic organic compounds of medical and physiological interest. Topics to be covered will include anesthetics, antispasmodics, antipyretics, analgesics, hypnotics, sedatives, anticonvulsants, anticoagulants, antihistamines, tranquilizers, antimalarials, and anthelmintics.

QUIM 5066. TOXICOLOGICAL CHEMISTRY (II). Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 3032 or QUIM 3072 or QUIM 3450 or QUIM 3062 or QUIM 3463 or QUIM 3464 or authorization of the Director of the Department.

Chemical properties, reactions, origin, and use of toxic substances, including chemical aspects of their effects upon biological systems, and their transformation and elimination.

QUIM 5071. GENERAL BIOCHEMISTRY I. Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 3463 or QUIM 3072 or QUIM 3450 or QUIM 3062 or authorization of the Director of the Department.

Chemical characterization of proteins, carbohydrates, lipids, and nucleic acids; principles of enzymology and bioenergetics; biological membranes and transport; recombinant DNA techniques; biological oxidations.

QUIM 5072. GENERAL BIOCHEMISTRY II. Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 5071 or authorization of the Director of the Department.

Biosynthesis and biodegradation of carbohydrates, lipids, amino acids, and nucleic acids; integration and regulation of animal metabolism; chemistry of genetic expression and regulation.

QUIM 5073. GENERAL BIOCHEMISTRY LABORATORY I. One credit hour. One four-hour laboratory per week. Corequisite: QUIM 5071.

Isolation and characterization of proteins, lipids, and nucleic acids; enzymatic processes; the use of recombinant DNA techniques.

QUIM 5074. GENERAL BIOCHEMISTRY LABORATORY II. One credit hour. Four hours of laboratory per week. Corequisite: MATE 3021 or MATE 3031 or MATE 3144 or MATE 3183.

The use of bioinformatics, structural genomics, and the molecular modeling in the spectroscopic characterization analysis of biological molecules.

QUIM 5085. FOOD CHEMISTRY (On demand). Four credit hours. Three hours of lecture and four hours of laboratory per week. Prerequisite: (QUIM 3072 and (QUIM 3463 or QUIM 3062)) or authorization of the Director of the Department.

A study of the chemistry of the principal food resources and food additives, their role in nutrition, and the effect of processing treatment on their chemical composition.

QUIM 5095. NUCLEAR CHEMISTRY (II). Three credit hours. Three hours of lecture per week. Prerequisites: (((QUIM 3042 or QUIM 3002) or (QUIM 3132 and QUIM 3134)) and (MATE 3183 or

MATE 3031 or MATE 3144)) or authorization of the Director of the Department.

A course describing the fundamental concepts of nuclear science. Selected topics on nuclear properties, nuclear forces and structure, radioactivity, mathematical relations of radioactive decay, statistics, nuclear reactions, effects of nuclear radiations and transitions, application of nuclear phenomena of chemistry and other related fields.

QUIM 5105. PRINCIPLES OF QUANTUM CHEMISTRY. Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 4042 or authorization of the Director of the Department.

Conceptual development, postulates, and models of quantum mechanics. Approximation methods to the solution of the time-independent Schrödinger equation.

QUIM 5125. CHEMICAL THERMODYNAMICS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 4042 or authorization of the Director of the Department.

Systematic analysis of the fundamental concepts of chemical thermodynamics and their applications.

QUIM 5135. PHYSICAL ORGANIC CHEMISTRY (On demand). Three credit hours. Three hours of lecture per week. Prerequisites: (QUIM 4042 and (QUIM 3450 or QUIM 3032 or QUIM 3072 or QUIM 3463)) or authorization of the Director of the Department.

A mathematical and quantitative study of organic chemical phenomena. Applications of modern theoretical concepts to the chemical and physical properties of organic compounds, and to the kinetics and mechanisms of organic reactions.

QUIM 5145. HETEROCYCLIC COMPOUNDS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 3032 or QUIM 3072 or QUIM 3450 or QUIM 3463 or authorization of the Director of the Department.

Structure, synthesis, and reactions of ring systems containing other atoms besides carbon. Alkaloids will be given special consideration.

QUIM 5150. SPECTROSCOPIC IDENTIFICATION OF ORGANIC COMPOUNDS (I). Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 3032 or QUIM 3072 or QUIM 3450 or QUIM 3463 or authorization of the Director of the Department.

Elucidation of the structure of organic compounds by spectroscopic methods, including infrared, ultraviolet, nuclear magnetic resonance, and mass spectrometry techniques.

QUIM 5165. POLYMER CHEMISTRY (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: QUIM 3450 or QUIM 3072 or QUIM 3032 or QUIM 3463 or authorization of the Director of the Department.

Structure, properties, syntheses, reactions, and physical behavior of polymers. Experimental methods used in their analysis.

QUIM 5175. EXPLOSIVES DETECTION AND ANALYSIS. Four credit hours. Three hours of lecture and one four-hour laboratory period per week. Prerequisites: (QUIM 4041 and (QUIM 3065 or QUIM 3055)) or authorization of the Director of the Department.

General aspects, chemical and physical properties, and analytical techniques for the detection and analysis of explosives.

QUIM 5205. PHARMACEUTICAL ANALYTICAL CHEMISTRY. Three credit hours. Three hours of lecture per week. Prerequisites: ((QUIM 3065 or QUIM 3055) and (QUIM 3072 or QUIM 3450) and QUIM 4041) or authorization of the Director of the Department.

Application of analytical methods and validation requirements oriented to pharmaceutical processes, materials, and regulations that apply to the pharmaceutical industry.

Graduate Courses

QUIM 6005-6006. GRADUATE SEMINAR (I, II)-(I, II). One credit hour per semester. One hour of lecture per week each semester.

Lectures, discussions, and reports on selected topics in chemistry.

QUIM 6007. SPECIAL TOPICS I. One to six credit hours. One to six hours of lecture per week.

Selected topics in inorganic organic, and analytical chemistry, and biochemistry.

QUIM 6008. SPECIAL TOPICS II. From one to three credit hours. From one to three hours of lecture per week.

Selected topics in inorganic chemistry, organic chemistry, analytical chemistry, physical chemistry, and biochemistry.

QUIM 6009. SPECTROSCOPY OF BIOLOGICAL MOLECULES. Three credit hours. Three hours of lecture per week.

Spectroscopy techniques to study the structures and conformational changes of biological molecules.

QUIM 6010. ADVANCED ENVIRONMENTAL CHEMISTRY. Three credit hours. Three hours of lecture per week.

Chemistry of the environment with emphasis in water, soil, and atmosphere; analysis and treatment of contaminants; environmental policy.

QUIM 6011. ADVANCED INORGANIC CHEMISTRY I (I). Three credit hours. Three hours of lecture per week.

Electronic properties; theories of bonding and structures of inorganic compounds, including metals and their complexes; reactions and applications of acid-base, coordination, and bioinorganic systems.

QUIM 6012. ADVANCED INORGANIC CHEMISTRY II (II). Three credit hours. Three hours of lecture per week.

Physical and chemical properties of elements; kinetics and reaction mechanisms of coordination compounds; organometallic chemistry.

QUIM 6016. BIOPHYSICAL CHEMISTRY. Three credit hours. Three credit hours of lecture per week.

Spectroscopic methods, molecular simulation, bioenergetics, reaction kinetics, and solution thermodynamics applied to nucleic acids, protein and other biological molecules.

QUIM 6017. APPLICATIONS OF RAMAN SPECTROSCOPY FOR ENVIRONMENTAL ANALYSIS. Three credit hours. Three hours of lecture per week.

Discussion of theory, methodology, implementation, and analytical aspects of Raman Spectroscopy, and its recent applications with an emphasis on environmental analysis. Includes topics related to techniques used in research in the areas of biophysics, chemistry and materials science.

QUIM 6026. SPECIAL TOPICS IN INORGANIC CHEMISTRY (On demand). Three credit hours. Three hours of lecture per week. Corequisite: QUIM 6011 or authorization of the Department Director.

Discussions of areas of inorganic chemistry that are expanding very rapidly or that have developed recently, including newly developing areas of inorganic chemical research.

QUIM 6028. CRISTALLOGRAPHY. Three credit hours. Three lectures per week. Prerequisite: QUIM 4042.

A study of X-rays, crystal geometry, symmetry group diffraction by lattices, the reciprocal lattice, powder and single crystal patterns, structure factors, the phase problem and structure determinations, and refinements including Fourier, Patterson and least square methods.

QUIM 6035. NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Department Director.

Fundamental concepts and practice of high-resolution nuclear magnetic resonance (NMR) spectroscopy emphasizing instrumentation with Fourier transform, pulse methods, and the information these provide.

QUIM 6036. CHEMICAL ASPECTS OF ENVIRONMENTAL PROBLEMS. Three credit hours. Three hours of lecture per week.

Chemical aspects of environmental problems with emphasis on those occurring in Puerto Rico such as those involving heavy metals, volatile organic compounds, pesticides, and solid wastes. Critical analysis on their effects on public health and the design of new technology for the solution and prevention of these problems will be conducted.

QUIM 6045. COMPUTATIONAL SIMULATION APPLIED TO MATERIALS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Use of molecular simulation to solve problems in materials science. Deterministic and stochastic methods such as molecular dynamics and Monte Carlo. Classical quantum energetic models.

QUIM 6055. TRACE ANALYSIS OF ENVIRONMENTAL CONTAMINANTS. Three credit hours. Three hours of lecture per week.

Sampling techniques and instrumental methods of analysis at trace levels of contaminants in water, air, and soil.

QUIM 6215. ADVANCED ANALYTICAL CHEMISTRY (On demand). Three credit hours. Three hours of lecture per week.

Advanced topics in chemical analysis including various electrochemical, chromatographic, and complexometric methods.

QUIM 6216. SURFACE ANALYTICAL CHEMISTRY. Three credit hours. Three hours of lecture per week.

Analytical and spectroscopic methods for characterization of surfaces and of chemical and electrochemical reactions on surfaces.

QUIM 6218. CHEMICAL SEPARATIONS. Three credit hours. Three hours of lecture per week.

Advanced techniques of chemical separations, and their analytical and preparative applications, recent methods of extraction, chromatography, electrophoresis and sedimentation.

QUIM 6335. FOOD ANALYSIS (II) (On demand). Four credit hours. Two hours of lecture and eight hours of laboratory per week.

Theory and practice of methods used in food analysis.

QUIM 6395. INFRARED SPECTROSCOPY AND MICROSCOPY. Three credit hours. Three hours of lecture per week.

Instrumentation and recent applications of infrared spectroscopy and microscopy.

QUIM 6401. ADVANCED ORGANIC CHEMISTRY (I). Three credit hours. Three hours of lecture per week.

Electronic theory, condensation reactions, molecular rearrangements, stereochemistry, reaction mechanisms, and free radicals.

QUIM 6605. ADVANCED PHYSICAL CHEMISTRY (II). Three credit hours. Three hours of lecture per week.

Chemical applications of statistical thermodynamics, selected topics in kinetic theory of gases, quantum chemistry and chemical thermodynamics.

QUIM 6606. ELECTROCHEMISTRY (On demand). Three credit hours. Three hours of lecture per week.

Theory of weak and strong electrolytes, activity coefficients, potentials, reference electrodes, electrochemical cells, etc. Consideration is also given to ionic transport phenomena and electro-deposition of metals.

QUIM 6705. PRINCIPLES AND PRACTICE OF TEACHING CHEMISTRY AT THE UNIVERSITY LEVEL. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

The teaching-learning process in chemistry: theories, teaching methods, and techniques applied to the

teaching of chemistry. Study of the fundamentals of measurement, evaluation and assessment.

QUIM 6707. SOLID STATE CHEMISTRY. Three credit hours. Three hours of lecture per week.

Discussion of the structure and properties of solid materials such as metals, semiconductors, and inorganic solids.

QUIM 6715. ADVANCED BIOCHEMISTRY. Three credit hours. Three hours of lecture per week.

Study of the structure and function of biological macromolecules, such as nucleic acids and proteins. Discussion of biological membranes as fundamental components in cellular function. Analysis of macromolecules by advanced instrumental techniques.

QUIM 6815. PLANT BIOCHEMISTRY. Three credit hours. Three hours of lecture per week.

Chemistry of plant constituents. Chemical processes occurring during the growth and development of plants; biochemistry of photosynthesis.

QUIM 6835. CHEMOMETRICS. Four credit hours. Three hours of lecture and four hours of laboratory per week.

Application of statistical methods to chemometrics. Quality analysis for the improvement of industrial processes. Design of experiments that optimize the information needed in order to understand and analyze chemical systems.

QUIM 6915. ENZYMES (On demand). Three credit hours. Three hours of lecture per week.

Fundamental principles of enzymatic reactions, including topics such as: mechanisms, kinetics, inhibitors, and activators.

QUIM 6994. SPECIAL TOPICS: LABORATORY. From one to three credit hours. From one to three laboratories of two to four hours per week.

Selected laboratory topics in inorganic chemistry, organic chemistry, analytical chemistry, physical chemistry, and biochemistry.

QUIM 6998. CHEMISTRY RESEARCH (I, II, S). Six credit hours.

The student will choose a member of the faculty as his adviser. Presentation of a thesis is required for credit.

QUIM 8008. SCIENTIFIC COMMUNICATION IN CHEMISTRY. Three credit hours. Three hours of lecture per week. Prerequisite: twelve credits in chemistry graduate courses.

Topics related to the preparation and organization of an effective presentation, and to the writing of proposals, scientific articles, and technical reports. Development, presentation and defense of an original research proposal required.

QUIM 8615. CHEMICAL KINETICS (On demand). Three credit hours. Three hours of lecture per week.

The discussion of measurements of reaction rates and theories of chemical reactions, study of gas phase and solution kinetics, and rates of biochemical, inorganic and organic reactions.

QUIM 8616. NUCLEIC ACIDS. Three credit hours. Three hours of lecture per week.

Study of nucleic acid structures and properties with emphasis on structure-function relationships. Discussion of instrumental techniques for structural analysis and selected applications.

QUIM 8980. DOCTORAL RESEARCH SEMINAR. One credit hour. One hour of seminar per week. Prerequisite: authorization of the President of the Graduate Committee (Research Counselor).

Oral presentation and discussion of the doctoral thesis work.

QUIM 8995. SPECIAL TOPICS IN APPLIED CHEMISTRY. One to nine credit hours. One to nine hours of lecture per week.

Selected topics in Applied Chemistry.

QUIM 8997. RESEARCH AND DOCTORAL THESIS. One to eighteen credit hours. Three to eighteen hours of research or thesis per week. Prerequisite: authorization of the President of the Graduate Committee.

Research that constitutes a significant contribution to the student's field of specialization. Preparation and defense of the dissertation is required.

GRADUATE FACULTY INVOLVED IN RESEARCH AND THEIR RESEARCH INTERESTS

ARNALDO CARRASQUILLO, *Professor*, Ph.D., 1995, Texas A&M. Research interests: Understanding the role played by electrode surface composition and structure in determining and controlling the electrochemical reactivity of species present at the electrode-solution interfaces. Study of electrocatalysis and of biosensor technologies by using XPS, AES, LEDD, TDMS, thin layer and classical electrochemical method.

MIGUEL E. CASTRO, *Professor*, Ph.D., 1991, University of Texas at Austin. Research interests: Synthesis and characterization of electronic materials; application of heterogeneous catalysis to drug synthesis; time resolved mass and infrared spectroscopy; time-of-flight measurements of oriented molecules.

JOSÉ E. CORTÉS, *Professor*, Ph.D., 1989, University of North Texas. Research interests: Synthesis and characterization of fullerene-transition metal complexes. Electronic and geometric structure of fullerene-transition metal complexes and the relationship of their structure with the complexes chemical reactivities. Integration of high school biology, chemistry, mathematics, and physics using calculator-based laboratory technology.

MARCO DE JESÚS, *Associate Professor*, Ph.D., 2004, University of Tennessee, Knoxville. Research interests: Study the potential health threats posed by exposure to trace aromatic pollutants, in particular pesticides, and PPCP's, in the environment. Use advanced air and water monitoring technologies in combination with information rich spectroscopies to evaluate the bioavailability of these chemicals in P.R.

MARITZA DE JESÚS, *Professor*, M.S., 1984, University of Puerto Rico-Mayagüez Campus. Research interests: Optimization of GC-MS and GC-FID tropical analysis of thermally labile essential oils in plants. Development of methodologies for the analysis of samples of environmental origin.

AIKOMARI GUZMÁN, *Assistant Professor*, Ph.D., 2007, University of California, San Diego. Research interest: Methodology; synthesis of chiral ligands for the development of stereoselective metal-catalyzed reactions. Total synthesis of cyclic depsipeptides and other bioactive molecules.

SAMUEL P. HERNÁNDEZ, *Professor*, Ph.D., 1986, Johns Hopkins University. Research interests: Molecular spectroscopy of crossed molecular beams and jets; Laser Raman and surface enhanced Raman spectroscopy of biomolecules and their interactions with heavy metal ions and carcinogenic compounds; molecular spectroscopy of coordination compounds, superconductors and explosives; theoretical calculations correlating measured spectroscopy properties.

MARTHA LAURA LÓPEZ, *Assistant Professor*, Ph.D., 2007, University of Texas at El Paso. Research interests: Environmental chemistry. Toxicity of nanomaterials in plants. Method development and validation. Experimental design. Phytoremediation. Biochemical studies on metal induced stress in plants. Mechanisms of metal translocation in plants. Phytohormones in plants. Nanomaterials.

JUAN LÓPEZ-GARRIGA, *Professor*, Ph.D., 1986, Michigan State University. Research interests: Study of the structure and function relationships in heme proteins using site directed mutagenesis, FT-IR, resonance Raman vibrational analysis, and NMR spectroscopy. Kinetic study of the reaction between hemoglobin and ligands (for example, O₂, CO, NO, and H₂S) using time-resolved infrared and resonance Raman techniques. Ultrafast geminate chemical dynamics analysis using time-resolved picosecond and femtosecond spectroscopy. Development and implementation of a coherent link between pre-college education and the university.

ENRIQUE MELÉNDEZ, *Professor*, Ph.D., 1990, University of Utah. Research interests: BioInorganic/BioOrganometallic Chemistry. Design of metal-based drugs and biosensors. Metallocene-steroid conjugates as target specific drugs are developed for the treatment of hormone-dependent and -independent cancers. The mechanistic aspects of these species are studied by spectroscopic methods such as NMR, UV-Vis, Fluorescence spectroscopy, electrochemistry and Molecular Modeling techniques. Another area of interest is the development of electrochemical biosensors to detect diseases, pathogens and contaminants.

NAIRMEN MINA, *Professor*, Ph.D., 1996, Baylor University. Research interests: FT-IR, Near IR, VIS and photoacoustic spectroscopy of organic compounds at cryogenic temperatures. Chemical kinetics and spectroscopy of CFC's.

LUIS A. MORELL, *Professor*, Ph.D., 1993, University of California, Riverside. Research interests: Organic synthesis and development of hetero Diels-Alder reaction. Conformational analysis of sugar derivatives.

ELSIE I. PARÉS-MATOS, *Professor*, Ph.D., 2000, Purdue University, Indiana. Research interest: Regulation of gene expression by DNA-protein and protein-protein interactions.

BELINDA PASTRANA, *Professor*, Ph.D., 1995, Rutgers University, New Jersey. Research interests: Use of recombinant DNA technology to express proteins for the biophysical study of protein-peptide and protein-ligand interactions. Molecular modeling studies of biological molecules.

ROBERT RIOS, *Professor*, Ph.D., 1995, Rutgers University, New Jersey. Research interests: Chemotherapeutic approach to the treatment of tumors and the chemistry involved in the synthesis of ligands. Methodology development for the synthesis of useful intermediates to be used in the construction of novel chemotherapeutic drugs.

JORGE L. RIOS-STEINER, *Associate Professor*, Ph.D., 1991, University of Puerto Rico. Research interests: Analysis and structural studies of macromolecules, natural products, organic and

inorganic molecules, utilizing X-ray crystallography as the main analytical tool.

LUIS A. RIVERA, *Researcher*, Ph.D., 1990, University of Puerto Rico. Research interests: Synthesis, spectroscopic studies and theoretical correlations of heterocyclic and substituted polycyclic aromatic compounds with potential activity. Analytical method development for trace detection of energetic compounds. Thermal stability studies of substituted polycarbonates, polyesters and other polymeric substances with potential applications as insulation materials in aircraft.

NILKA RIVERA-PORTALATÍN, *Professor*, Ph.D., 2006, University of Florida. Research interests: Isolation, purification and characterization of natural products extracted from plants, and biological assays for the determination of medicinal properties and cytotoxicity. Synthesis, pharmacological and toxicological evaluation of estrogen derivatives and natural supplements used as substitutes of hormone replacement therapies.

LOLITA RODRÍGUEZ, *Professor*, M.S., 1985, University of Puerto Rico-Mayagüez Campus. Research interests: In vitro evaluation of decoctions from plants of reputed ethnopharmaceutical activity to treat kidney stones disease. The project includes measurements of free and complex Ca²⁺ in solution, dissolution of calcium oxalate or calcium phosphate by plant decoctions, and inhibition of crystal or stone growth by plant extracts.

FÉLIX ROMÁN, *Professor*, Ph.D., 1989, University of Nebraska. Research Interests: Development of analytical method for the determination of trace levels of metals and pesticides in biological and environmental matrices.

RODOLFO ROMANACH, *Professor*, Ph.D., 1986, University of Georgia. Research interests: Development of near infrared, spectroscopic methods for use in the pharmaceutical industry. Development of analytical methods to study interactions between excipients in solid oral dosage forms and tablet surfaces. Continuing education and professional/personal development of chemists. Use of polarized light microscopy in chemical education.

ALBERTO SANTANA-VARGAS, *Professor*, Ph.D., 2003, University of Florida. Research interests: Our research deals with theoretical and computational aspects of molecular and materials science with particular emphasis on abinitio and DFT calculations, quantum molecular dynamics, density matrix theory, and classical molecular dynamics. It includes photoinduced phenomena in the gas phase, clusters, and at solid or metallic surfaces. We use quantum and statistical mechanics, mathematical, and computational methods to describe time-dependent phenomena such as femtosecond dynamics, photochemistry, and

quantum control in both simple and complex molecular systems.

JESSICA TORRES, *Assistant Professor*, Ph.D., 2004, John Hopkins University. Research interests: Surface chemistry, Solid State Chemistry, Atomic force microscopy, Chemical Education.

WILDELIZ TORRES, *Assistant Professor*, Ph.D., 2007, University of Puerto Rico. Research interests: Our research program focus on the development of robust metal-catalyzed methods for the synthesis of heterocyclic moieties from readily available starting materials. These methods should be user friendly, environmentally benign, and amenable to multi-gram scales. Synthetic efforts toward bioactive important compounds will be pursued to prove the synthetic value of our novel methodologies.

CARMEN A. VEGA, *Professor*, Ph.D., 1975, University of Florida. Research interests: Thermodynamics, electrochemistry and spectroscopy of solutions. HPLC studies of limits of detection of drugs in physiological fluids. Studies of the interaction of platinum drugs with amino acids and DNA.

GRADUATE FACULTY INVOLVED IN ACADEMIC WORK AND THEIR INTERESTS

MAYRA E. CÁDIZ, *Professor*, Ph.D., 1985, University of Puerto Rico. Research interests: Synthesis of derivatives of cisplatin; synthesis and interaction of platinum drugs with DNA; Synthesis of metal complexes as potential antitumor compounds.

ASTRID J. CRUZ, *Professor*, Ph.D., 1993, University of Massachusetts. Research interests: Theoretical studies of molecular scattering phenomena by means of wave packets and fast Fourier Transform techniques. Quantum finite temperature studies of molecule-surface energy transfer processes.

EMILIO DÍAZ, *Professor*, Ph.D., 1986, University of Wisconsin, Madison. Research interests: Isolation and characterization of oxidative enzymes from fungi; study of the role of oxidative enzymes on fungal pathogenicity. Isolation and inhibition studies of histidine decarboxylase from microorganisms which contaminate fish and dairy products. Study of the effects of antioxidants on the development of rancidity in frozen tilapia.

AIDALÚ DE LOS A. JOUBERT-CASTRO, *Associate Professor*, Ph.D., 1998, Washington State University, Pullman. Research interests: Evaluation of liquid chromatography- particle beam mass spectrometry as a technique for the analysis of vanadyl geoporphyrins. Implementation and development of new teaching techniques that relate chemical concepts and the direct application of such concepts to the classroom.

JORGE LABOY, *Professor*, Ph.D., 1993, University of Cincinnati. Research interests: Mid-infrared FT-IR spectroscopy of transient species and reaction intermediates, mainly radicals using matrix-isolation. Photochemical reactions and reactions dealing with semiconductor materials.

FRANCIS PATRON, *Professor*, Ph.D., 1997, Purdue University. Research interests: Chemistry education research on the teaching and learning of chemistry with particular interest in physical chemistry.

CYNTHIA ROBLEDO, *Professor*, Ph.D., 1981, University of Florida. Research interests: Synthesis of oligopeptides containing one or more aromatic amino acids; study of small molecule-nucleic acid interactions; synthesis of oligopeptides with unusual amino acids.

ISMAEL SCOTT, *Professor*, Ph.D., 1985, University of Florida. Research interests: Infrared and Laser-Raman spectroscopic studies of RNA and DNA bases, including both experimental and theoretical work; toxicological and environmental effects of chemicals.

MARISOL VERA, *Professor*, Ph.D., 1986, Purdue University. Research interests: Characterization of oligonucleotide structures and small molecule-nucleic acid complexes by NMR; analytical applications of multinuclear NMR Evaluation of pesticides in soils amended with compost.

DEPARTMENT OF ENGLISH

The Department of English offers a Master of Arts degree in English Education (MAEE).

In addition to the general prerequisites for admission to the Graduate School of the University of Puerto Rico at Mayagüez, the **Department of English** requires:

- Minimum 3.00 general and major grade point average. The Department Graduate Committee may consider applicants whose general and major GPA is 2.75-2.99 if compelling justification for the lower average is provided in the application.
- International students whose native language is not English must submit their TOEFL scores. The minimum score required is 550 for paper-based test, 213 for the computer-based test and 79 for the internet-based test.
- Applicants must submit a one-page, single spaced statement of purpose written in English with their on-line application.
- Applicants must also submit an academic writing sample (e.g. analytic essay).
- Three recommendations from faculty who are familiar with the applicant's academic and/or professional work. Formal letters should be attached to the recommendation form provided with the application.
- Personal interview with a member of the Department Graduate Committee and/or the Chair of the Department.
- Pre-requisites: The prospective students must take or have had taken the following undergraduate courses (or equivalent courses).

INGL 3351. American Literature to 1860 *or* INGL 3352. American Literature 1860 to modern period.

INGL 3321. English Literature to 1798 *or* INGL 3322. English Literature 1798 to modern period

INGL 3225. Introduction to Linguistics

INGL 4205. Morphology and Syntax *or* INGL 4206. Structure of English

****All letters of recommendation and evidence of the above material should be submitted to the Graduate School along with the regularly required material.**

Conditional Admission:

Students who lack up to 12 credits of course work may be admitted to the program on a conditional basis. These students are required to make up the deficiencies by passing relevant course work during their first year in the program.

Within the MAEE program, there are five core courses required for all students. Outside of the core, students may opt to tailor their programs to meet their individual interests, selecting from courses in linguistics, literature and pedagogy. Students in the MAEE Program choose from one of two options:

Option I: Thesis

Option III: Comprehensive Exam

The thesis option requires students to complete a thesis as the program requirement. The comprehensive exam option requires students to take an additional two courses and to pass an exam that has a three-part written component and an oral defense.

Each option is defined clearly in the English Department Graduate Handbook that is available on our website: uprm.edu/english.

Advanced Undergraduate Courses

INGL 5007. ORAL COMMUNICATION. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Communication theory and speaking techniques, including enunciation, intonation, phrasing, projecting the voice, and holding audience attention. Varieties of formal oral interpretation are studied and practiced, including drama and poetry reading, public speaking, and debate.

INGL 5009. CONTRASTIVE GRAMMAR (II) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Analysis of the descriptive grammars of English and Spanish to identify areas of divergences and to achieve an understanding of linguistic universals.

INGL 5010. PERSPECTIVES ON TEACHING ENGLISH AS A SECOND LANGUAGE (I) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department. Co-requisite: EDPE 4245 or authorization of the Director of the Department.

Historical overview of language teaching methods from grammar-translation to the most recent approaches; students will develop applications for teaching English as a second language.

INGL 5015. ENGLISH AND AMERICAN LITERARY CRITICISM (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Theory and practice of literary criticism within the tradition of English and American literature. A research paper will be required.

INGL 5018. STUDY IN THE BRITISH ISLES. Three credit hours. Twenty two point five (22.5) hours of lecture and twenty five hours of seminar per summer. Prerequisite: authorization of the Director of the Department.

Selected courses on various topics in English literature and culture, offered by international summer school programs in universities in the British Isles, such as the university of Cambridge, Oxford University, or University of Edinburgh. Includes plenary lectures on special topics in English literature and excursions to sites of historical and cultural interest.

INGL 5025. CURRENT APPROACHES IN LINGUISTIC THEORY (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Recent developments in linguistic theory and their application to related issues.

Graduate Courses

INGL 6605. RESEARCH METHODS IN LITERATURE. Three credit hours. One and a half hour of lecture and one and a half hour of seminar per week. Prerequisite: six credits in English Literature at the 3000 level or above.

Study of the materials and methodologies used in literary research. Development, documentation, and defense of a thesis proposal on a literary topic. Preparation of a paper suitable for a professional symposium or academic publication.

INGL 6006. RESEARCH METHODS (I). Three credit hours. Three hours of seminar per week.

Research techniques in language study with emphasis on English.

INGL 6008. BILINGUALISM AND LANGUAGE-CONTACT. Three credit hours. Three hours of lecture per week.

The linguistic and social-psychological aspects of bilingualism; the sociology of language-contact.

INGL 6009. MODELS FOR TEACHING LITERATURE(I). Three credit hours. Three hours of seminar per week.

The teaching of literature in English: explication of texts, literary theory and its value in the classroom, the establishment of historical context; problems of teaching literature to speakers of English as a second language.

INGL 6010. TESL MATERIALS AND TESTING (II). Three credit hours. Three hours of lecture per week.

Study and development of materials and techniques for the teaching and evaluation of English as a second language, with emphasis on oral communication skills.

INGL 6016. TOPICS IN SOCIOLINGUISTICS. Three credit hours. Three hours of lecture per week.

Selected topics based on current research interests in sociolinguistics.

INGL 6018. TOPICS IN PSYCHOLINGUISTICS. Three credit hours. Three hours of lecture per week.

Selected topics based on current research interests in psycholinguistics.

INGL 6020. SECOND LANGUAGE

ACQUISITION (I). Three credit hours. Three hours of lecture per week.

An overview of research topics in second language acquisition, and an in-depth study of one of these topics.

INGL 6025. STUDIES IN AMERICAN LITERATURE. Three credit hours. Three hours of lecture per week.

Study of selected themes and movements in American literature.

INGL 6028. PSYCHOLINGUISTICS AND THE READING PROCESS. Three credit hours. Three hours of lecture per week.

The reading process and the measurement of reading skills and comprehension in native and second languages; degree of transfer of reading skills from native to second language; current psycholinguistics research in the field of reading.

INGL 6030. THEORY AND PRACTICE OF COMPOSITION . Three credit hours. Three hours of lecture per week.

Practice in the techniques of writing. Study of its research and theory.

INGL 6040. PRACTICE IN THE TEACHING OF COMPOSITION . Three credit hours. Three hours of lecture per week.

Development and demonstration of materials and methods for the teaching of writing. Study of recent theory, research, and pedagogy.

INGL 6048. POETRY SINCE 1945. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

Discussion of the main poetic traditions that characterize the works of the major poets since the second half of the Twentieth Century, including a distinction between modern and postmodern poetry. Examination of movements, themes, and conventions associated with poetry of this period and identification of the common elements in poetry from 1945 to the present. Study of the relationship between primary sources taking into account their historical and cultural contexts. Development of a research project using literary critical theory.

INGL 6055. STUDIES IN LITERATURE I. Three credit hours. Three hours of lecture per week.

Study of selected authors, themes, or movements in the literature of the English language.

INGL 6056. STUDIES IN LITERATURE II. Three credit hours. Three hours of lecture per week.

Study of selected authors, themes, or movements in the literature of the English language.

INGL 6058. STUDIES IN LITERATURE III. Three credit hours. Three hours of lecture per week.

Study of selected authors, themes, and movements in the literature of the English language.

INGL 6075. DRAMA 1880-1945. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

Identification and analysis of the themes, elements, conventions and contexts of dramatic works of representative writers from the period 1880-1945, such as Oscar Wilde, John Synge, W.B. Yeats, Lillian Hellman, Bernard Shaw, Sean O'Casey, Clifford Odets, Christopher Isherwood, Maxwell Anderson, T.S. Eliot and Eugene O'Neill. Discussion of the relationship between the primary texts and their historical period through the use of critical theory. An original research project will be required.

INGL 6076. THE ROMANTIC MOVEMENT: THE SECOND GENERATION. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

Identification and analysis of the themes, elements, and conventions of the representative writers of the Second Generation of the Romantic Movement born after 1775, also known as the "Younger Generation." Development of analytical skills and use of critical theory through a historical perspective of the primary texts and their historical period. Development of a research project using secondary sources to analyze texts from the period.

INGL 6441. SHAKESPEARE: TEXTS AND CONTEXTS. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

Identification and analysis of the themes, elements, and conventions of Shakespeare's texts and contexts at an advanced level, including a study of the critical, textual, and scholarly traditions. Students will refine their critical reading and writing skills, acquire an

understanding of the relationship between the primary texts and their cultural/historical contexts, comprehend the critical theory pertinent to studying Shakespeare's texts, and apply critical theory in the reading of primary texts.

INGL 6448. THE VICTORIAN NOVEL. Three credit hours. Three hours of lecture and discussion per week.

Identification and analysis of the themes, elements, conventions, and authors of the novels of the Victorian period (1837-1901). A research project including the use of secondary sources to analyze texts is required.

INGL 6459. AMERICAN LITERATURE UNTIL 1820. Three credit hours. One and a half hours of lecture and one and a half hours of discussion per week.

Identification and analysis of the themes, elements, and conventions of American literature until 1820. Analysis of the relationship between the primary texts read in the course and their cultural/historical contexts. Application of critical theory in the analysis of Early American literature. A research project will be required.

INGL 6476. FICTION FROM 1900 TO 1945. Three credit hours. One and a half hours of lecture and one and a half hours of discussion per week.

A study of the main themes including a distinction between 'modernity' and 'modernism' that characterize the novels and short fiction of the major writers of the first half of the twentieth century, with emphasis on British and North American writers. Discussion of the conventions and themes associated with the fiction of this period and identification of common elements. Analysis of the texts and study of their relationship to their historical contexts through the use of critical theory.

INGL 6477. VICTORIAN POETRY AND PROSE. Three credit hours. One and a half hours of conference, one and a half hours of seminar per week.

Identification and analysis of the themes, elements and conventions of representative poets and non-fictional prose-writers of the Victorian period (1837-1901). Development of analytical skills and acquisition of a historical perspective of the relationship of the texts to their historical contexts through the use of critical theory.

INGL 6478. OLD ENGLISH LANGUAGE AND LITERATURE. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

An introduction to Old English, coupled with a study of Old English prose and lyric. Readings of representative texts such as the prose works of Bede, Aelfric, Wulfstan, the Anglo-Saxon Chronicle, and anonymous prose works, as well as poetry from the Anglo-Saxon verse anthology, *The Exeter Book*.

INGL 6479. NEOCLASSICAL POETRY, PROSE, DRAMA. Three credit hours. One and a half hour of lecture and one and a half hour of seminar per week.

Identification and analysis of the themes, elements, and conventions of the Works of the Restoration and Neoclassical periods with attention to poets, prose writers, and dramatists such as Congreve, Wycherley, Behn, Addison & Steele, Johnson, Sheridan, Dryden, Pope, Finch, Cowper, Gray, and Thompson. Development of analytical skills and a historical perspective of the relationship between the primary texts and their historical period through the use of literary critical theory. Development of a research project is required.

INGL 6487. THE BRITISH ROMANTIC MOVEMENT: THE FIRST GENERATION. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

Identification and analysis of the themes, elements, and conventions of the representative writers born between 1743 and 1775 of the First Generation of the Romantic Movement. Historical analysis of the relationship of the primary texts to their period through the use of critical theory. A research project that includes the use of secondary sources to analyze texts from the period is required.

INGL 6516. PUERTO RICAN LITERATURE IN ENGLISH. Three credit hours. Three hours of lecture per week.

Identification and analysis of the themes, elements, and conventions of Puerto Rican literature in English since 1898. Discussion of the relationship between the primary texts read in the course and the cultural/historical contexts. Application of critical theory in the reading of primary texts. An original research project will be required.

INGL 6525. TOPICS IN A LITERARY GENRE. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

A variable content course offering a detailed examination of a specific literary genre or mode, such as Science Fiction, Comedy, The Gothic and Magical Realism, among others.

INGL 6526. POSTCOLONIAL THEORY AND LITERATURE FROM BRITISH POSTCOLONIES. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

Identification and analysis of the themes, elements, and conventions of Anglophone postcolonial literary texts, by writers from former colonies or dependencies of the British empire and their diaspora. Text analysis from a historical perspective through the use of critical literary theory. A research project which includes the use of secondary sources to analyze the primary texts is required.

INGL 6527. NOVELS FROM THE BRITISH ISLES. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

Identification and analysis of the themes, elements and conventions of representative novelists from the British Isles such as Daniel Defoe, Henry Fielding, Jane Austen, Sir Walter Scott, William Thackeray, Charles Dickens, Emily Bronte, James Joyce, Virginia Woolf, John Banville, Zadie Smith, Hanif Kureishi, and Julian Barnes, among others. Students will refine their analytical skills and acquire an historical perspective of the relationship of the texts to their historical contexts through the use of critical theory. A research project which requires the use of secondary sources to analyze the primary texts will be developed.

INGL 6981. SPECIAL TOPICS IN ENGLISH STUDIES I. Three credit hours. Three hours of lecture per week.

A course that falls under the umbrella of the field of English Studies, which includes, but is not limited to, pedagogy, linguistics, communication, and literature.

INGL 6982. SPECIAL TOPICS IN ENGLISH STUDIES II. Three credit hours. Three hours of lecture per week.

A course that falls under the umbrella of the field of English Studies, which includes, but is not limited to, pedagogy, linguistics, communications, and literature.

INGL 6985. SPECIAL TOPICS I. Three credit hours. Three hours of seminar per week.

Selected topics in linguistics, literature, or pedagogy.

INGL 6986. SPECIAL TOPICS II. Three credit hours. Three hours of seminar per week.

Selected topics in linguistics, literature, or pedagogy.

INGL 6995. RESEARCH. One to three credit hours. Three to nine hours per week of research.

Research on a topic, which focus and breadth of study will be designed by the student and approved by the supervising professor prior to registration in the course.

INGL 6996. UNIVERSITY TEACHING DEVELOPMENT. One to three credit hours. One hour of discussion per week per credit.

Application of instructional theories and strategies to the teaching of English as a Second Language at the university level. A teaching portfolio is required.

INGL 6997. TOPICS IN A LITERARY GENRE. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week.

A variable content course offering a detailed examination of a specific literary genre or mode, such as Science Fiction, Comedy, The Gothic and Magical Realism, among others.

INGL 6999. THESIS. Three to six credit hours.

Research in the fields of English language and applied linguistics, and presentation of a thesis.

English Education (EING)

EING 6005. FOUNDATIONS OF ENGLISH EDUCATION (I). Three credit hours. Three hours of lecture per week.

Foundations of English education emphasizing an analysis of the social, economic, and political issues which affect the teaching of the language in Puerto Rico.

DEPARTMENT OF ENGLISH FACULTY

A list of professors who engage in graduate activities in the department follows including their highest earned degree, the date of completion, and the degree-granting institution. Research and teaching interests are also included.

NANDITA BATRA, *Professor*, Ph.D., 1987, University of Rochester. Research and teaching interests: British Literature (1660 to the present), Postcolonial Studies, Gender Studies, Disability Studies, Anthrozoological Studies, Literary Theory.

RICIA A. CHANSKY, *Associate Professor*, Ph.D. 2009, Illinois State University. Research and teaching interests: Auto/Biography Studies, Women's literatures and Feminist theories, diasporic literatures, transnational studies, postcolonial studies, visual cultures, pedagogy, and the horror genre.

LAURENCE CHOTT, *Assistant Professor*, Ph.D. 1985, Ball State University. Research and teaching interests: E.E. Cummings, Modern American Poetry, The Literature of Exploration, The Historical Background of Shakespeare's *The Tempest*.

ELIZABETH P. DAYTON, *Professor*, Ph.D. 1996, University of Pennsylvania. Research and teaching interests: Linguistics.

CATHERINE FLECK, *Professor*, Ph.D. 2003, Michigan State University. Research and teaching interests: Linguistics and Applied Linguistics—Bilingualism, Language Contact, Sociolinguistics, and Perceptual Dialectology.

LEONARDO L. FLORES, *Professor*, Ph.D. 2010, University of Maryland. Research and teaching interests: Poetry, Electronic Literature, American Literature, Film, Media and Writing, Science Fiction, and Fantasy.

JOCELYN A. GÉLIGA-VARGAS, *Professor*, Ph.D. 1999, University of Massachusetts-Amherst. Research and teaching interests: Cultural Identity and Representation; Film History and Criticism; Media Literacy and Critical Pedagogy; Race, Gender, and Representation; Ethnography and Action Research.

GAYLE W. GRIGGS, *Professor*, Ed.D., 2011, Nova Southeastern University. Research and teaching interests: Instructional Technology, Graduate TA Education, Online Learning, General Education learning theories and learning styles, Public Speaking, Communications, Writing & Pedagogy, Conversational English, Digital and Film

Production, Instructional Media, Assessment, and Research Integrity.

NICKOLAS HAYDOCK, *Professor*, Ph.D. 1995, University of Iowa. Research and teaching interests: Middle English, Middle Scots, Movie Medievalism, Film, Scottish Makkers, Robert Henryson, William Dunbar, David Douglas, Epic, History of English.

JOSÉ M. IRIZARRY, *Professor*, Ph.D. 1999, Indiana University of Pennsylvania. Research and teaching interest: Early 20th Century Puerto Rican Writing in the US, African American Intellectual Discourse, Autobiographical Discourse.

RAYMOND KNIGHT, *Professor*, M.A. 1986, Inter American University, San Germán. Research and teaching interests: Literacy, L2 Literacy, Integration of Computers in Teaching, Media Literacies, Composition and Identity.

ERIC D. LAMORE, *Associate Professor*, Ph.D., 2007, Illinois State University. Research and teaching interests: Early American Literature, African American Literature, Caribbean Literature, Critical Theory, The Early Black Atlantic, and Transatlantic Studies.

NEVIN LEDER, *Professor*, Ph.D. 2003, Michigan State University. Research and teaching interests: Linguistics, Syntax, Phonetics, ESL methods, literacy. Research interests: Sense and Reference (semantics), Literacy, Second Language Acquisition, Dialect Variation.

MARY LEONARD, *Professor*, Ph.D. 2003, University of the West Indies. Research and teaching interests: Film, Media, Twentieth and Twenty-First Century Literature, Visual Narration and Narratology.

ROBERTO LÓPEZ, *Professor*, M.A. 1972, New York University. Research and teaching interests: Translator for Center for Hemispherical Cooperation in Research and Education in Engineering and Applied Sciences. Teaching interests: American Literature; British Literature; Children's Literature and Folklore.

CATHERINE M. MAZAK, *Professor*, Ph.D. 2006, Michigan State University. Research and teaching interests: ESL Teaching and Teacher Training, Second Language Literacy, and Language Policy.

BETSY MORALES CARO, *Professor*, Ph.D. 1999, University of Texas at Austin. Research and teaching interests: Culture Studies, ESL, Linguistics, WID, English Education in Puerto Rico, Pedagogy.

WALESKA F. MORCIGLIO, *Assistant Professor*, MAEE. 1998, University of Puerto Rico at Mayagüez. Research and teaching interests: Second Language Writing, Basic Writing, and ESL.

ELLEN PRATT, *Professor*, Ph.D. 1999, Indiana University of Pennsylvania. Research and teaching interests: Writing Center Pedagogy, Writing in the Disciplines, Writing Theory and Pedagogy, ESL Writing.

SANDRA RÍOS, *Professor*, Ph.D. 2005, Rensselaer Polytechnic Institute. Research and teaching interests: Rhetoric, Environmental rhetoric, and Technical Writing.

MYRNA RIVERA-MONTIJO, *Professor*, MAEE. 1994, University of Puerto Rico at Mayagüez. Research and teaching interests: English Education and ESL.

ROSITA L. RIVERA, *Professor*, Ph.D. 2006, Penn State University. Research and Teaching interests: curriculum development and assessment, ESL teacher education, Pragmatics, and discourse analysis, sociocultural aspects of ESL teaching and learning.

AIXA L. RODRÍGUEZ, *Professor*, Ph.D. 1995, University of Massachusetts at Amherst. Research and Teaching interests: Environmental Journalism, Cultural Studies, Mass Media and Culture.

LINDA M. RODRÍGUEZ, *Professor*, Ph.D. 1994, University of Michigan. Research and teaching interests: Caribbean Writers, Women Writers, Creative Writing, and Film.

ROSA I. ROMÁN PEREZ, *Associate Professor*, Ph.D. 2007. Penn State University. Research and teaching interests: Critical Discourse Analysis; Critical Pedagogy and Teacher Education in Secondary Schools; Developmental Education and Student Retention; Media Literacy; ESL Writing, Disability Studies and Reading.

MARY E. SEFRANEK, *Professor*, Ed.D. 2006, Teachers College, Columbia University. Research and Teaching interests: Feminist and poststructuralist perspectives on qualitative narrative inquiry, multiliteracies and multimodality theorizing and practice in English classrooms,

Latin@ Studies and texts in English Education, Bilingual/Bicultural Education.

SANDRA L. SOTO SANTIAGO, *Assistant Professor*, Ph.D. 2014. University of Arizona. Research and teaching interest: superdiversity, migration, language learning and use, teacher education.

GREGORY K. STEPHENS, *Assistant Professor*, Ph.D. 1996, University of California-San Diego; 2nd M.A. in Spanish Literature, University of West Indies-Mona (2007). Research and teaching interests: Creative Writing; Multi-ethnic literature, Romance of Revolution, Latin American culture; Intercultural Communication and Race Relations; Visual Narrative; depth psychology; sustainability.

IRIS TORO-MANZANO, *Assistant Professor*, MAEE. 1997, University of Puerto Rico at Mayagüez. Research and teaching interests: English Education, ESL Student Attitudes, Motivation, and Listening Comprehension.

NANCY V. VICENTE, *Associate Professor*, Ph.D. 2009, Penn State University. Research and teaching interests: Decolonizing Methodologies: Narrative Inquiry, Testimonio, Auto-ethnography, Performance Studies, Latina/o Cultural Studies, Women's Studies, Popular Culture, Young Adult and Children's Literature, Fantasy and Science Fiction.

BILLY WOODALL, *Professor*, Ph.D. 2000, University of Washington. Research and teaching interests: Second Language Acquisition, Second Language Literacy, Psycholinguistics, and ESL.

GEOLOGY

The Department of Geology offers graduate study leading to a Master of Science degree. Applicants for admission should hold a Bachelor of Science degree in Geology or its equivalent from an accredited institution, have a minimum GPA of 2.80 (those with a GPA between 2.50 and 2.79 may be considered at the discretion of the Graduate Admission Committee), and have taken the Graduate Record Examination (the general GRE is required), in addition to the requirements of the Graduate Studies Office. Students who do not meet these requirements may be admitted on a provisional basis until deficiencies are removed.

A student enrolled in the Master's Degree program in Geology needs to approve a minimum of thirty-two (32) credit hours subsequent to the bachelor's degree. Of these 32 credit hours, three (3) to six (6) credit hours are for research for the Master's thesis, two (2) credit hours are for a graduate seminar (1 credit hour per semester for two semesters) and three (3) credit hours are for the course GEOL 6107 Geology and Tectonics of the Caribbean. Of the remaining credit hours, fifteen (15) to eighteen (18) credit hours have to be approved in geology courses (amount depends on number of credits given for research), and six (6) credit hours in courses outside of their field of specialization. The latter courses may be taken outside of Geology, or in areas within Geology but in specializations distinct from that of the student's major. Students will not be permitted to take more than six (6) credit hours of Special Topics to satisfy their graduation requirements. As per university regulations, students will only be allowed to take a maximum of nine (9) credit hours in 5000 level courses.

The aims of the academic program of the Department of Geology are to provide students with a firm understanding of the geological sciences, and advanced knowledge of techniques for data collection and analysis, and instruction at the forefront of their fields of specialization. Research emphasizes geological, geophysical, geochemical, and geobiological problems of the circum-Caribbean region with particular focus on surficial, tectonic, and volcanic processes and their associated hazards; the development of Cretaceous to Holocene reefs; carbonate petrology and stratigraphy; fluid history and hydrothermal mineralization; accessory mineral geochemistry; island arc formation and evolution;

and accretionary and transcurrent plate boundary tectonics.

Funding for students is available in the form of teaching and research assistantships both from departmental funds and from research grants.

The Department of Geology occupies the northern third of the Physics Building, shared by Geology, Physics, and Marine Sciences, and has separate facilities available in two other buildings. Equipment is available for a wide variety of geochemical and geophysical measurements. Geochemical instrumentation includes:

- SIEMENS D5000 X-ray Diffractometer
- Cameca – Electron Microprobe SX-50

and other ancillary equipment, all purchased through a grant from the National Science Foundation Minority Research Center of Excellence program. Wet chemistry facilities are also available. Equipment is available to prepare petrographic thin sections.

The Department also hosts the UPRM Stable Isotope Laboratory, a facility funded through a grant from the National Science Foundation Major Research and Instrumentation program and the University of Puerto Rico Central Administration. The Stable Isotope Laboratory features a GV (Micromass) Isoprime magnetic sector isotope ratio mass spectrometer for measurement of the stable isotopes of H, C, N, O, and S in dual inlet or continuous flow operation. Peripheral attachments include a Eurovector 3000 elemental analyzer, and a New Wave Micromill device. The laboratory routinely measures the stable isotopes of carbon and oxygen in marine carbonates using the continuous flow method, and also the stable isotopes of O and H in water samples.

The Department has a portable gravimeter, portable magnetometer, portable seismometer, and hand-held GPS equipment. Computing facilities consist of an extensive networked array of PC and Macintosh microcomputers, and several laser printers. The department hosts a computing facility with ~16 personal computers, a scanner and a printer for student use. It is used as teaching laboratory for courses in remote sensing, GIS, and seismology. The Geological and Environmental Remote Sensing Laboratory (GERS Lab) also has several computers for environmental monitoring with biogeo-optical

properties and digital images. Both teaching and research laboratories have installed ENVI, ArcGIS, and among other software.

Seismic Network

The Puerto Rico Seismic Network (PRSN, Red Sísmica de Puerto Rico) is under the administration of the Dept. of Geology. The mission of the PRSN is to produce high quality data and information to be able to respond to the needs of the emergency management, academic and research community and the general public. The network operates 25 digital real time broadband and short period seismic stations in Puerto Rico and the US and British Virgin Islands. Future plans include installing two stations in eastern Dominican Republic. The PRSN maintains a catalogue of earthquakes for the Puerto Rico region which extends from eastern Dominican Republic through the Virgin Islands. Continuous waveforms from all of its stations are also archived. As of 2007, the PRSN is also operating a network of 6 tsunami ready tide gauge stations. The data from these stations will be incorporated into the Tsunami Warning System for Puerto Rico and the Caribbean which has been under development at the PRSN since 2000. The information and data generated are distributed among the scientific and academic community, emergency management organizations, and the general public. It maintains an active education and outreach program which focuses on K-12 and emergency management. The PRSN is staffed by scientists, technicians, administrative personnel and students.

Advanced Undergraduate Courses

GEOL 5005. MARINE GEOLOGY. Three credit hours. Two hours of lecture and two hours of laboratory per week. Prerequisite: GEOL 4046 or authorization of the Director of the Department.

Discussion of the broad morphotectonic features of the sea floor and of coastal zones. Sediments, their origin, mode of formation, methods of study and interpretation. Reefs. Sea bottom topography and geomorphology. Study of changes of the level of the sea. Emphasis on the Caribbean region.

GEOL 5006. SEDIMENTATION. Three credit hours. Two hours of lecture and one two-hour laboratory per week. Prerequisite: GEOL 4046 or authorization of the Director of the Department.

Erosion, transportation, and deposition of sediments; classification of sediments; sedimentary environment; sedimentary history of depositional sites; significance of grain size in the sedimentary environment.

GEOL 5008. MICROPALEONTOLOGY. Three credit hours. Two hours of lecture and two hours of laboratory per week. Prerequisite: GEOL 4003 or authorization of the Director of the Department.

Foraminifers, structure and morphology of the test, stratigraphy and paleoecology, fundamentals of classification, tintinnids, radiolarians, conodonts, ostracods, dicoasterids.

GEOL 5009. SCANNING ELECTRON MICROSCOPY. Three credit hours. Two hours of lecture and one four-hour laboratory per week. Prerequisite: GEOL 4005 or authorization of the Director of the Department.

Introduction to the basic principles of scanning electron microscopy, including sample preparation and interpretation of micrographs. Emphasis will be placed on the aspects with each student being assigned a problem according to his interest.

GEOL 5011. PRINCIPLES OF PALEONTOLOGY I (I, Odd numbered years) (On demand). Three credit hours. Two hours of lecture and one two-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Morphology and classification of fossils with emphasis on the invertebrates. General stratigraphic distribution. The most significant fossil groups will be studied in the laboratory.

GEOL 5015. OPTICAL MINERALOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: GEOL 3056 or authorization of the Director of the Department.

Optical crystallography, detailed microscopic study of rock forming minerals.

GEOL 5020. ADVANCED GEOPHYSICS (Odd numbered years) (On demand). Three credit hours. Three hours of lecture per week. Prerequisites: GEOL 4057 or authorization of the Director of the Department.

The principal physical processes related to the dynamics and evolution of the earth, including energetic activity, gravitational and magnetic fields, heat flow, tectonics, and convection.

GEOL 5025. GEOLOGY OF THE CARIBBEAN (Every year). Three credit hours. Three hours of lecture per week. Prerequisite: GEOL 4009 or authorization of the Director of the Department.

The geological and geophysical history and evolution of the Caribbean region, with special emphasis on Puerto Rico; mineral resources; geological hazards; relation of the region to global tectonics.

GEOL 5026. TECTONICS (Odd numbered years) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: GEOL 4009 or authorization of the Director of the Department.

Theory of global plate tectonics as a synthesis of diverse geological themes, with emphasis on the Caribbean region.

GEOL 5027. METALLOGENESIS AND GLOBAL TECTONICS (Even numbered years) (On demand). Three credit hours. Three hours of lecture per week.

The relationship of the genesis and distribution of ore deposits to the tectonic environments.

GEOL 5565. EARTHQUAKE SEISMOLOGY. Three credit hours. Three hours of lecture per week. Prerequisites: (GEOL 4057 and MATE 3032 and FISI 3152) or authorization of the Director of the Department.

The use of local and global networks to determine the location, magnitude, and source parameters of earthquakes; global seismicity; theory of wave propagation; point sources; inversion of the Earth's structure; source properties.

GEOL 5605. GEOLOGICAL HAZARDS. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: GEOL 3025 or GEOL 4015 or authorization of the Director of the Department.

Mechanisms, distribution, and mitigation of geological hazards, including earthquakes, surface fault ruptures, volcanoes, landslides, floods, and ground subsidence. Analysis of case histories. Field trips are required.

GEOL 5985. SPECIAL TOPICS IN PALEONTOLOGY. One to three credit hours. Prerequisite: authorization of the Director of the Department.

Recent developments in paleontologic principles. Field trips required.

GEOL 5993. ADVANCED GEOCHEMISTRY. One to three credit hours. One to three hours of lecture per week.

Advanced topics in geochemistry. Field trips required.

GEOL 5994. SPECIAL TOPICS IN PALEONTOLOGY WITH LABORATORY. One to three credit hours. Prerequisite: authorization of the Director of the Department.

Special topics in paleontology. Field trips required.

GEOL 5998. ADVANCED PETROLOGY I. One to three credit hours. One to three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Advanced topics on the origin of volcanic, plutonic, and metamorphic rocks. Course content will vary depending on the interests of the professor and students. Field trips required.

Graduate Courses

GEOL 6105. GROUND FAILURE IN THE TROPICS (Even numbered years) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Modes and mechanisms of ground failure including landslides, sinkholes collapse, and soils expansion; slope stability analysis; aerial photos interpretation and their use in mapping of landslides and sinkholes. Analysis of case histories. Field trips are required.

GEOL 6106. ADVANCED GEOMORPHOLOGY. Three credit hours. One hour of lecture, one hour of discussion and one hour of laboratory per week.

In-depth investigation into geomorphologic processes and landforms. Targeted studies of landscape evolution, hillslopes, rivers, drainage basins, tectonic geomorphology and biogeomorphology. Analysis of interactions between climate and geomorphology. Identification of special geomorphologic concerns in Puerto Rico. Application of the concepts discussed and employed in class or field trips for the development of class projects. Integration of geographical information systems (GIS) data and geomorphologic processes.

GEOL 6107. GEOLOGY AND TECTONICS OF THE CARIBBEAN (Every year). Three credit hours. Three hours of lecture per week.

The geologic and tectonic evolution of the Caribbean plate and adjacent areas.

GEOL 6115. VOLCANIC HAZARDS (Odd numbered years) (On demand). Three credit hours. Three hours of lecture per week.

Volcanic hazards: causes, effects, assessment, mitigation, prediction, and management. Analysis of case histories.

GEOL 6117. VOLCANIC PROCESSES AND DEPOSITS (I, Even numbered years) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Volcanic processes and the deposits they produce.

GEOL 6119. VOLCANIC PETROGENESIS (II, Even numbered years) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Mineralogy and geochemistry of volcanic rocks in relation to their petrogenesis.

GEOL 6120. GPS GEODESY IN GEOSCIENCES. Three credit hours. Two hours of lecture and one two-hour laboratory per week.

Quantitative methods of cartography and geodesy in map-making; surveying, and surface deformation study for the geosciences with an emphasis on differential GPS and the generation of hypsometric and geophysical data from airborne and satellite platforms. Examples of environmental, geological, and natural hazard mitigation applications from the Caribbean.

GEOL 6135. INSTRUMENTAL ANALYSIS OF SOLID MATERIALS (Odd numbered years) (On demand). Four credit hours. Two hours of lecture and two three-hour laboratories per week.

Modern instruments used in the analysis of solid materials: theoretical background, training in their use, and interpretation of the measurements.

GEOL 6145. MICROFACIES ANALYSIS (Odd numbered years) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Paleontological and sedimentary criteria for the recognition of environments of limestone deposits. Field trips are required.

GEOL 6147. CARBONATE GEOLOGY (Even numbered years) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Identification and classification of carbonate sediments and rocks; environments of deposition; variations in styles of accumulation through time; diagenetic modifications. Field trips are required.

GEOL 6155. HYDROGEOLOGY (Even-numbered years). Three credit hours. Three hours of lecture per week.

Principles of hydrogeology: chemical and physical properties of surface and subsurface water; rock-water interaction; effects and behavior of contaminants; water resources management.

GEOL 6157. BASIN ANALYSIS (Odd numbered years) (On demand). Three credit hours. Three hours of lecture per week.

Origin and evolution of sedimentary basins; mechanisms, controls, and mathematical models of their subsidence.

GEOL 6175. PALEOECOLOGY (Even numbered years) (On demand). Three credit hours. Three hours of lecture per week.

Use of geological evidence and the ecology of living organisms to understand the nature and development of past environments.

GEOL 6195. IGNEOUS PETROLOGICAL SYSTEMS (Odd numbered years) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Theory and methodology of igneous petrology.

GEOL 6205. ADVANCED SEISMOLOGY (Even numbered years) (On demand). Three credit hours. Three hours of lecture per week.

Modern aspects of seismology including wave propagation in an inhomogeneous medium, attenuation and scattering, and source theory; recent contributions to the understanding of the physical processes of the Earth's interior.

GEOL 6207. GEOPHYSICAL TIME SERIES ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisites: Authorization of the Director of the Department.

Study of the use of digital signal processing as applied in geophysical studies. Application of the

fundamental principles and analysis of the consequences of sampling theorem, waveform convolution and deconvolution, the Z and Fourier transforms, windowing and filters in geophysical analysis.

GEOL 6208. GEODYNAMICS. Three credit hours. Three hours of lecture per week. Prerequisites: authorization of the Director of the Department.

Advanced study of the Earth's plate tectonics and mantle convection and how the forces generated by the Earth's heat engine govern geologic surface processes including earthquakes, volcanism and mountain building. Application of fundamental concepts used for quantitative analysis of mantle convection, lithospheric flexure and fracture, heat transfer within the Earth, the geodynamo and deformation mechanisms.

GEOL 6215. ENVIRONMENTAL GEOLOGY (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Geology and its relationship to the environment: internal and surface processes, resources, pollution and waste disposal, medical geology, environmental laws, and land use planning. Analysis of case histories. Field trips are required.

GEOL 6225. ADVANCED GEOLOGICAL REMOTE SENSING. Three credit hours. Two hours of lecture and one two-hour laboratory per week.

Theory and techniques of remote sensing for the geosciences with an emphasis on quantitative analysis, error estimation, and image enhancement; digital processing, analysis, and interpretation of image data from a variety of operational platforms.

GEOL 6228. STRUCTURAL ANALYSIS OF DEFORMED TERRAINS. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Advanced methods of structural analysis with an emphasis on microcrystalline deformation, foliation development, and rheological models; techniques for measuring strain, differentiation between simple and complex fabrics on the stereographic projection, and balancing cross sections. Examples from the geology of Puerto Rico and the Caribbean will be used.

GEOL 6505. GRADUATE SEMINAR I (On demand). One credit hour. One hour of seminar per week.

Oral presentation and discussion of recent developments or classical works in the geosciences.

GEOL 6506. GRADUATE SEMINAR II (On demand). One credit hour. One hour of seminar per week.

Oral presentation and discussion of recent developments or classical works in the geosciences.

GEOL 6991. SPECIAL PROBLEMS IN APPLIED GEOLOGY (On demand). One to three credit hours.

Individual research on selected topics in applied geology with special emphasis on the Caribbean.

GEOL 6992. SPECIAL PROBLEMS IN STRATIGRAPHY (On demand). One to three credit hours.

Individual research on selected topics in stratigraphy with special emphasis on the geology of the Caribbean.

GEOL 6993. SPECIAL PROBLEMS IN GEOPHYSICS (On demand). One to three credit hours.

Individual research on selected topics in geophysics with special emphasis on the geology of the Caribbean.

GEOL 6994. SPECIAL PROBLEMS IN PETROLOGY (On demand). One to three credit hours.

Individual research on selected topics in petrology with special emphasis on the geology of the Caribbean.

GEOL 6995. SPECIAL PROBLEMS IN EARTHQUAKE SEISMOLOGY. One to three credit hours. One to three hours of discussion and research per week.

Reading and discussion of topics related to earthquake seismology. Course themes will be selected according to the objective delineated by the professor. Students will present a final project related to a specific problem in earthquake seismology.

GEOL 6996. SPECIAL PROBLEMS IN SEISMIC EXPLORATION. One to three credit hours. One to three hours of discussion and research per week. Prerequisites: GEOL 6116 or authorization of the Director of the Department.

Reading and discussion of topics related to seismic exploration seismology. Course themes will be selected according to the objective delineated by the professor.

GEOL 6997. SPECIAL PROBLEMS IN GEOPHYSICAL COMPUTATION. One to three credit hours. One to three hours of discussion and research per week.

Reading and discussion of topics related to computational geophysics. Course themes will be selected according to the objective delineated by the professor. Students will present a final project related to a specific problem in computational geophysics.

GEOL 6998. SPECIAL PROBLEMS IN GEOLOGICAL NATURAL HAZARDS. One to three credit hours. One to three hours of discussion per week.

Discussion of topics related to geological natural hazards.

GEOL 6999. RESEARCH AND THESIS (I, II). Three to six credit hours.

Research in geology and presentation of a thesis.

GEOLOGY FACULTY

A list of professors who engage in graduate activities in the Department follows including the highest earned degree, and institution granting the degree. Research and teaching interests are also included.

LYSA CHIZMADIA, *Associate Professor*, Ph.D., 2004, University of New Mexico. Research interests: Planetary geology, meteorites. Teaching interests: Crystallography, Mineralogy, Electron Microscopy, Economic Geology, Planetary Geology.

FERNANDO GILBES, *Professor*, Ph.D., 1996, University of South Florida. Research interests: Environmental remote sensing, GIS.

THOMAS HUDGINS, *Assistant Professor*, Ph.D., 2015, University of Michigan. Research interests: Igneous petrology and Geochemistry. Teaching interests: Petrology, Geochemistry, Instrumental Analysis of Solid Materials.

VÍCTOR HUÉRFANO, *Researcher*, Ph.D., 2003, University of Puerto Rico, Mayagüez. Research interests: Real Time Seismic Network Operations, Early Warning Systems (Tsunamis and Earthquakes), Tsunami Generation and Modeling, Crustal Structure

and Local Field Seismic Inversion. Teaching interests: Earthquake Seismology, Physics of Tsunamis, Numerical methods in Real Time Seismology.

K. STEPHEN HUGHES, *Assistant Professor*, Ph.D., 2014, North Carolina State University. Research interests: Orogenic studies; field mapping; geochemistry; geochronology. Teaching interests: Structural geology, Tectonics.

JAMES JOYCE, *Professor*, Ph.D., 1985, Northwestern University, Illinois. Research interests: Caribbean geology; neo-tectonics; Quaternary geology; metamorphic petrology. Teaching interests: Caribbean geology; metamorphic petrology; structure and tectonics; Quaternary geology.

ALBERTO M. LÓPEZ, *Associate Professor*, Ph.D., 2006, Northwestern University, Illinois. Research and teaching interest: Seismology, Plate Tectonics, Tsunami Earthquakes, Tsunami Modeling, GPS, Ocean bottom seismometers, and seismic instrumentation.

WILSON RAMÍREZ, *Professor*, Ph.D., 2000, Tulane University, Louisiana. Teaching and Research interests: Carbonate petrology, low temperature geochemistry, ground water, geology of reef systems.

LIZZETTE RODRÍGUEZ, *Associate Professor*, Ph.D., 2007, Michigan Technological University. Research interests: Volcanology, Volcanic hazards, Volcano monitoring (especially gas and deformation), Volcano-atmosphere interactions. Teaching interests: Volcanology, Volcanic hazards, Natural hazards, Volcanic degassing.

HERNÁN SANTOS, *Professor*, Ph.D., 1999, University of Colorado. Research interests: Carbonate sequence stratigraphy; biostratigraphy; paleontology. Teaching interests: Sedimentology; stratigraphy; paleontology.

ELIZABETH VANACORE, *Assistant Researcher*, Ph.D., 2008, Rice University, Texas. Research interests: Distribution and nature of mantle heterogeneity, structure of the Deep Earth: D", ultra-low velocity zones (ULVZ's), inner/outer core structure, computational seismology, evolution and formation of continental lithosphere, array seismology.

HISPANIC STUDIES

The Department of Hispanic Studies offers a program leading to the Master of Arts degree. All students enrolled in the M.A. program must choose one of two concentrations:

- Hispanic Studies with concentration in Spanish Linguistics; or
- Hispanic Studies with concentration in Spanish Literature and Cultures

In addition to the admission requirements of the Graduate Studies Office, the Hispanic Studies Department requires:

- Minimum 3.00 general and 2.75 major grade point average in a scale of 0 to 4.00.
- An academic writing sample.
- Three recommendation letters from professionals who are familiar with the applicant's academic and/or professional work.

Applicants who choose the concentration in Spanish Linguistics must take or have had taken the following undergraduate courses (or equivalent courses):

- LING 4010 o LING 5010 - Introduction to Linguistics
- LING 5030 – Introduction to Generative Syntax
- LING 5040 - Introduction to Generative Phonology
- LING 5060 – Compositional Semantics

Applicants who choose the concentration in Spanish Literature and Cultures must take or have had taken the following undergraduate courses (or equivalent courses):

- ESPA 3211 o ESPA 3212 - Introduction to Spanish Literature I or II
- ESPA 4221 o ESPA 4222 – Spanish-American Literature I or II
- ESPA 4231 o ESPA 4232 - Puerto Rican Literature I or II
- ESPA 4046 – Introduction to Critical Theory and Literary Analysis.

Students who do not meet these requirements may be admitted on a provisional basis until deficiencies are removed.

Students in the M.A. Program choose from one of two options:

- Option I: Thesis
- Option III: Comprehensive Exam or two research papers

The thesis option requires students to complete a thesis as the program requirement. The comprehensive exam or research papers option requires students to take an additional two courses. Each option is defined clearly in the Hispanic Studies Graduate Handbook.

* Graduate Courses

(* Graduate courses do not require prerequisites.)

ESHI 6005. STYLISTICS (On demand). Three credit hours. Three hours of lecture per week.

An analysis of the phenomenon of "style" in Hispanic literature and the schools of thought dedicated to the study of stylistics.

ESHI 6006. DON QUIJOTE (On demand). Three credit hours. Three hours of lecture per week.

A critical reading of the immortal novel of the Golden Age, and analysis of Cervantes' style and themes, with special attention to research.

ESHI 6007. POETIC CREATION FROM RUBEN DARIO TO GARCIA LORCA (On demand). Three credit hours. Three hours of lecture per week.

Study and appreciation of the aesthetics embodied in Modernism and the poetic world of García Lorca.

ESHI 6008. THEATER OF THE GOLDEN AGE (On demand). Three credit hours. Three hours of lecture per week.

Critical reading of the great works of the dramatists of the Golden Age, with emphasis on the criticism of Spanish Classical Drama.

ESHI 6015. GONGORISM (On demand). Three credit hours. Three hours of lecture per week.

A study of Gongorism as a conception of the literary language in different periods of Spanish and Spanish American Literature.

ESHI 6016. SPANISH NOVEL OF THE 19th CENTURY (On demand). Three credit hours. Three hours of lecture per week.

A study of the works of Galdós as the main figure of the renaissance in the Spanish novel of the 19th Century.

ESHI 6017. THE CONTEMPORARY SPANISH ESSAY (On demand). Three credit hours. Three hours of lecture per week.

A critical study of the Spanish essay of the twentieth century through the reading and discussion of texts representative of the contemporary Spanish thought.

ESHI 6018. ROMANTICISM AND MODERNISM IN THE LITERATURE OF PUERTO RICO (I). Three credit hours. Three hours of lecture per week.

A study and analysis of the most significant aspects of Puerto Rican Romanticism and Modernism.

ESHI 6027. GENERAL LINGUISTICS (On demand). Three credit hours. Three hours of lecture per week.

A study of the development of linguistics, analysis of schools, fundamental methods and fields in which modern linguistics operate. Discussion of new trends.

ESHI 6028. THE NOVEL OF THE HISPANIC ANTILLES (On demand). Three credit hours. Three hours of lecture per week.

A study of the origin and development of the novel in Cuba, Puerto Rico and the Dominican Republic, analysis of the outstanding works of each country, with special attention to their common characteristics and differences.

ESHI 6029. THE LITERARY GENERATION OF THE THIRTIES IN PUERTO RICO (On demand). Three credit hours. Three hours of lecture per week.

A study of the artistic tendencies and literary forms in the works of the main authors of the Generation of the Thirties in Puerto Rico.

ESHI 6035. PUERTO RICAN LITERATURE OF THE GENERATION OF 45 (On demand). Three credit hours. Three hours of lecture per week.

Reading and analysis of various forms of poetry, short story, novel, drama, and the essay whose roots evolve from the generation of 1930 to form the so called generation of 1945.

ESHI 6037. EVOLUTION OF GRAMMAR IN THE SPANISH LANGUAGE (Odd numbered years). Three credit hours. Three hours of lecture per week.

Study of the morphology and syntax of the Spanish language from its origin up to the present; diachronic study of Spanish grammar. Discussion and analysis.

ESHI 6045. THESIS RESEARCH (I, II). Six credit hours.

A study of the methods and techniques in linguistic and literary research in Hispanic Studies. Full accreditation of this course is given upon completion and approval of the Master's thesis.

ESHI 6047. MEDIEVAL SPANISH LITERATURE (Even numbered years). Three credit hours. Three hours of lecture per week.

The popular anonymous creations and the works of learned poets with special attention given to XV Century literature, already influenced by the Renaissance and culminating in La Celestina.

ESHI 6059. EIGHTEENTH-CENTURY SPANISH LITERATURE. (On-demand) Three credit hours. Three hours of lecture per week.

Study of the literary development in Spain from 1726 to 1816. Description and analysis of the discourses, stylistic tendencies, and literary genres, emphasizing the interaction between the aesthetic, social, and political aspects of the time, in light of current theoretical approaches.

ESHI 6067. CONTEMPORARY SPANISH AMERICAN SHORT-STORY (On demand). Three credit hours. Three hours of lecture per week.

The Spanish American short story from the decade of 1940 to the present; tendencies and

techniques; most representative authors: Borges, Cortázar, Arreola, Rulfo, Roa Bastos, Fuentes, Carpentier, Paz, Di Benedetto, García Márquez, Yáñez, Vargas Llosa, Donoso.

ESHI 6070. PUERTO RICAN FOLKTALE. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Discussion on folklore and folktale as an expressive manifestation. Identification and description of the different types and characteristics of the genre in Puerto Rico. Analysis of the meanings construed by these texts and study of their possible uses in the classroom.

ESHI 6079. CONTEMPORARY PUERTO RICAN SHORT STORY. Three credit hours. Three hours of lecture per week.

Study of short story development in Puerto Rico from the generation of 1945-1950 until the 21st century, with emphasis on writers who have emerged since the 1970's. Analysis of the generations in relation to their ideologies, stylistic tendencies, and the manner in which each continues or breaks with the previous tradition.

ESHI 6096. DIALECTOLOGY AND SOCIOLINGUISTICS IN THE CARIBBEAN SPANISH. (On demand) Three credit hours. One-and-one-half hours of lecture and one-and-one-half hours of seminar per week.

Explore linguistic and extra-linguistic aspects of the regional and social variety of Caribbean Spanish, from both a diachronic and synchronal perspective.

ESHI 6405. THE SPANISH LANGUAGE IN AMERICA. (On demand) Three credit hours. Three hours of lecture per week.

A comparative study and analysis of the characteristics that define the unity and the variety of our vernacular language in Puerto Rico, in the rest of the Spanish American countries, and in Spain.

ESHI 6406. SPANISH LANGUAGE IN PUERTO RICO. (On demand) Three credit hours. Three hours of lecture per week.

A comparative study and analysis of the characteristics that define the unity and the variety

of our vernacular language in Puerto Rico, in the rest of the Spanish American countries, and in Spain.

ESHI 6407. SPECIAL TOPICS IN HISPANIC LANGUAGE AND LITERATURE. One to six credit hours. One to six hours of lecture per week.

Selected topics in Hispanic language and literatures.

ESHI 6561 (On demand). THE NOVEL IN SPANISH AMERICA. Three credit hours. Three hours of lecture per week.

Lectures with textual analysis of the major works in the history of the Spanish-American novel, from its beginnings in the 19th Century to the present.

ESHI 6562 (On demand). THE NOVEL IN SPANISH AMERICA. Three credit hours. Three hours of lecture per week.

Lectures with textual analysis of the major works in the history of the Spanish-American novel, from its beginnings in the 19th Century to the present.

ESHI 6605. CONTEMPORARY THEORY AND LITERARY CRITICISM. Three credit hours. Three hours of lecture per week.

Study of the theoretical-critical main currents in the literary study from the beginning of the 20th Century to the present. Examination of the theoretical concepts and the fundamental critical methodologies, mainly from the reading of primary sources. Evaluation of critical essays and practical application of methods of analysis. Writing of a bibliographical or critical essay from one of the studied approaches. The course may be updated as new theories, tendencies or methodologies of analysis arise.

ESHI 6606. SEMINAR IN LITERARY CRITICISM. Three credit hours. Three hours of seminar per week.

Study of a particular critical approach chosen by the professor who teaches it. Reading, discussion of primary sources, and application of this critical approach to texts of Hispanic Literature. Writing of a theoretical critical article that applies this approach to a text.

ESHI 6607. “RAÍZ Y ALAS”: CONTEMPORARY SPANISH AMERICAN POETRY. Three credit hours. Three hours of lecture per week.

Analysis of the Literary Works of the Spanish American Poetry Masters during the 20th and 21st Centuries.

ESHI 6609. HISPANIC AMERICAN LITERATURE AND POST-COLONIAL STUDIES. Three credit hours. Three hours of lecture per week.

Application of the postcolonial theory to the diachronic study of representative Hispanic American literary texts from the independence from Spain to the end of the 20th century.

LING 5030. INTRODUCTION TO GENERATIVE SYNTAX. Three credit hours. Three hours of lecture per week. Prerequisites: LING 4010 or ESPA 4201 or INGL 3225 or authorization of the Director of the Department.

Study of syntactic structures in natural languages, with particular attention to Spanish. Description and classification of syntactic features, categories, functions and operations. Representation of subordinate clauses, clitics, negation, and sentence informational structure. Analysis of phrase and sentence constituents through the application of recent generative syntactic theoretical models.

LING 5040. INTRODUCTION TO GENERATIVE PHONOLOGY. Three credit hours. Three hours of lecture per week. Prerequisites: LING 4010 or ESPA 4201 or INGL 3225 or authorization of the Director of the Department.

Study of phonological structures in natural languages, with particular attention to Spanish. Description and classification of articulate sounds and distinctive features of segments and suprasegments. Representation of phonological rules, feature geometry, intonation, and metrical stress. Analysis of phonological patterns and processes as well as prosodic structures through the application of recent generative phonological theories.

LING 5050. MORPHOLOGICAL THEORY. Three credit hours. Three hours of lecture per week. Prerequisites: LING 4010 or ESPA 4201

or INGL 3225 or authorization of the Director of the Department.

Representation of morphological structures, processes, and operations in natural languages through models proposed in generative morphology. Study of the nature of the lexicon, morphology as an autonomous module of grammar, and the interface of morphology with phonology and syntax. Revision of theories of Lexical Morphology, Prosodic Morphology, and Optimality. Application of linguistic theory to the analysis of morphological data in natural languages.

LING 5060. COMPOSITIONAL SEMANTICS. Three credit hours. Three hours of lecture per week. Prerequisites: LING 4010 or ESPA 4201 or INGL 3225 or authorization of the Director of the Department.

Introduction to the study of linguistic meaning and its relationship with syntactic structure according to the principles of compositional semantics. Application of formal methods and basic tools like set theory, propositional logic, and model theory to semantic analysis. Exploration of types and relations of meaning, predication, quantification, modification, temporal relations, modal contexts and possible world theories.

LING 5075. LANGUAGE ACQUISITION AND DEVELOPMENT. Three credit hours. One and a half hours of lectures and one and a half hours of seminar per week. Prerequisites: LING 4010 or ESPA 4201 or INGL 3225 or authorization of the Director of the Department.

Survey of research and theoretical perspectives in natural language acquisition and development in children. Discussion and examination of child language data from Spanish and other languages. Exploration of universal principles and biological aspects of language acquisition and development, the logical problem of language acquisition, infant speech perception and production, development of phonology, morphology, syntax, semantics and the lexicon, Universal Grammar and the language bioprogram, and child creation of creole languages.

LING 5080. COMPUTATIONAL LINGUISTICS. Three credit hours. One and a half hours of lectures and one and a half hours of seminar per week. Prerequisites: LING 4010 or

ESPA 4201 or INGL 3225 or authorization of the Director of the Department.

Study of the computational properties of human language and models of natural language processing. Analysis and evaluation of deterministic and nondeterministic systems for computational models of language learning and processing. Representation of phonological, morphological, syntactic, and semantic structures by means of parsers based upon these computational models. Survey of on-line tools, such as tagged corpora, parsers and semantic webs. Discussion of computational models' applications in language processing technologies, such as orthographic and grammar checkers, computer translation, search engines, and information extraction.

LING 5090. FORMAL FOUNDATIONS OF LINGUISTIC THEORY. Three credit hours. Three hours of lecture per week. Prerequisites: LING 4010 or ESPA 4201 or INGL 3225 or MATE 3171 or authorization of the Director of the Department.

Study of the logical and mathematical foundations needed to formulate linguistic theory and formally describe properties of languages. Introduction to formal tools and basic concepts of set theory, relations and functions; infinities; propositional calculus and predicate logic; Model Theory; algebras, lattices, and automata. Application of formal methods to the analysis of the syntax and semantics of quantifiers, natural and formal languages, and types of grammars.

LING 5100. PHILOSOPHICAL FOUNDATIONS OF LINGUISTIC THEORY. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week. Prerequisites: (LING 4010 and (INGL 3225 or ESPA 4202 or ESHI 6027)) or authorization of the Director of the Department.

Critical-historic reconstruction of the fundamental concepts in linguistic theory, such as levels of adequacy in a theory of grammar; rules, representations and derivations; restrictions and locality; principles and parameters of Universal Grammar; hierarchy of formal languages and automata; the relation between thought, language and reality; I-language, meaning, truth, sense and reference, virtual conceptual necessity, dualism and methodological minimalism. Discussion of the development of linguistic theory from

Cartesian rationalism to the biocognitive approach within modern and contemporary scientific thinking.

LING 5110. FOUNDATIONAL ISSUES IN BIOLINGUISTICS. Three credit hours. One and a half hours of lecture and one and a half hours of seminar per week. Prerequisites: ((LING 4010 and ESPA 4202) or ESHI 6027 or INGL 3225) or authorization of the Director of the Department.

Critical review and analysis of the canonical issues and debates in biolinguistics such as the biological factors in language design; the architecture of the language faculty; universal grammar, recursion and innatism in language acquisition and development; linguistic competence within a comparative ethological context; the nature of the genetic endowment and evolution of the language faculty; the neurological implementation and computational models of the language components and interfaces. Discussion of the contributions of anthropology, psychology, molecular and evolutionary biology, neuroscience, and computational sciences to problems in theoretical linguistics, as well as the implications of findings in biolinguistics for some controversies in these disciplines.

LING 5120. PSYCHOLINGUISTICS. Three credit hours. One and a half hours of lectures and one and a half hours of seminar per week. Prerequisites: LING 4010 or ESPA 4201 or INGL 3225 or authorization of the Director of the Department.

Introduction to the study of the mental representations and processes involved in language implementation, including the comprehension, production and storage of spoken and written linguistic information. Survey of sentential, discursive and conversational structure processing models. Exploration of the psychological reality of linguistic representations. Discussion of the contributions of psychology, computational sciences and Artificial Intelligence to problems in the design of models of natural language processing, as well as the implications of findings in psycholinguistics for some controversies in these disciplines.

LING 6130. SYNTACTIC THEORY I. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the universal principles and parameters of variation that explain the formation and structure of syntactic constituents. Analysis of syntactic structures and the relations and operations that occur between lexical items during the derivation leading to different levels of syntactic representation. Description of the syntactic interfaces with the phonological and semantic component. Application of generative syntactic theory to problems in natural languages.

LING 6140. PHONOLOGICAL THEORY I. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analysis of segmental and suprasegmental structures of natural languages according to the different theories proposed in generative grammar. Formulation of phonological rules and representations using derivational and non-derivational models. Application of theoretical models to data analysis in the phonology and morphology of natural languages.

LING 6160. SEMANTIC THEORY. Three credit hours. Three hours of lecture per week. Prerequisites authorization of the Director of the Department.

Study of denotation and meaning composition in natural languages. Application of formal tools and models, such as set theory, propositional and predicate logic, semantic type theory, and lambda calculus, to compute the meaning of linguistic expressions. Formal representation of semantic rules and principles. Extensional analysis of predicates, modifiers, definite descriptions, relative clauses, pronouns, and quantificational determiners. Comparison and evaluation of restrictions in convert movement versus type-shifting rules in the interpretation of variables and generalized quantifiers.

LING 6795. SEMINAR IN METHODS OF LINGUISTIC RESEARCH. Three credit hours. One hour of discussion and two hours of seminar per week. Prerequisite: authorization of the Director of the Department.

Theory and practice of methods and strategies for research in contemporary Hispanic linguistics. Formulation and investigation of a research topic. Different procedures for the collection of data and research design will be studied. A written and

oral presentation of an original thesis proposal will be required.

HISPANIC STUDIES FACULTY

A list of professors who engage in graduate activities in the Department follows including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

MARIBEL ACOSTA-LUGO, *Associate Professor*, Ph.D., 2004, University of Connecticut. Research and Teaching Interests: Spanish American Literature with emphasis on Puerto Rico and the Hispanic Caribbean; Novel, Theater and Short Story.

HILTON ALERS-VALENTÍN, *Associate Professor*, Ph.D., 2000, University of Massachusetts at Amherst. Research and Teaching Interests: Syntactic Theory, Phonological Theory, Generative Grammar, Formal Semantics.

AMARILIS CARRERO-PÉÑA, *Professor*, Ph.D., 2001, The Pennsylvania State University. Research and Teaching Interests: Latin American Literature, Brazilian Literature, Spanish Literature (17th Century-Golden Age). Studies in Short Story, Poetry and Novel.

CAMILLE CRUZ-MARTES, *Associate Professor*, Ph.D., 2001, Brown University. Research and Teaching Interests: Hispanic Caribbean and Latin American Colonial Literature.

KATZMÍN FELICIANO-CRUZ, *Professor*, Ph.D., 2004, University of Puerto Rico. Research and Teaching Interests: Spanish Literature.

MANUEL FIGUEROA-MELÉNDEZ, *Professor* Ph.D., 1997, University of Puerto Rico. Research and Teaching Interests: Spanish Literature, Novel, Poetry, Love in Literature, Theater. Poet, Essay and Short Story Writer.

FRANCISCO GARCÍA-MORENO BARCO, *Professor*, Ph.D., 1992, Michigan State University. Research and Teaching Interests: Spanish Literature, Narrative and Writing.

LEILANI GARCÍA-TURULL, *Assistant Professor*, Ph.D., 2000, University of Wisconsin-Madison. Research and Teaching Interests: Latin American Literature with emphasis on Contemporary Chronicle in Puerto Rico and Mexico, Cultural Studies, Studies on Performance and Afro-Hispanic Literature.

JACQUELINE GIRÓN-ALVARADO, *Professor*, Ph.D., 1993, Pennsylvania State University. Research and Teaching Interests: Spanish American Poetry and Theater (20th Century), Puerto Rican Literature, Feminist Literature Criticism. Short Story Writer, Poet, Critic.

MIRIAM GONZÁLEZ-HERNÁNDEZ, *Professor*, Ph.D., 1994, Florida State University. Research and Teaching Interests: Puerto Rican and Spanish American Literature, Short Story and Writing, Puerto Rican Women Writers. Short Story Writer.

MELVIN GONZÁLEZ-RIVERA, *Associate Professor*, Ph.D. 2011, Ohio State University. Research and Teaching Interests: Syntactic Theory, Semantics, Pragmatics, Caribbean Spanish Language.

MAGDA GRANIELA-RODRÍGUEZ, *Professor*, Ph.D., 1987, University of Illinois, Urbana. Research and Teaching Interests: Spanish American, Mexican and Puerto Rican Literature, Novel, Theater, Poetry and Writing. Poet, Essayist and Critic.

JAIME L. MARTELL-MORALES, *Professor*, Ph.D., 2000, State University of New York-Stony Brook. Research and Teaching Interests: Puerto Rican and Spanish American Literature, Latin American Colonial Literature, Literary Theory, Novel and Poetry. Essayist and Critic.

DORIS MARTÍNEZ-VIZCARRONDO, *Professor*, Ph.D., 1998, Universidad Autónoma de Madrid. Research and Teaching Interests: Linguistics, Discourse Analysis.

ALFREDO MORALES-NIEVES, *Professor*, Ph.D., 1987, University of California at Irvine. Research and Teaching Interests: Spanish American and Hispanic Caribbean Literature; XIX Century, Essay, Philosophy and Studies of Nationhood, Race, Gender in Literature, Writing. Poet and short story writer.

DAVID L. QUIÑONES-ROMÁN, *Professor*, Ph.D., 1988, University of Massachusetts at Amherst. Research and Teaching Interests: Spanish Literature (17th Century-Golden Age, Fiction, Cervantes), Spanish Literature (Medieval Period), Spanish American Literature (from Colonial Period to Modernism). Poet.

IVONNE N. RECINOS-AQUINO, *Assistant Professor*, Ph.D. 2002, The University of Pittsburgh. Teaching Interests: Central American Literature, Colonial and 19th Century Mexican Literature and Culture. Research and Teaching Interests: Gender, Slavery, Citizenship, and Ethnic Relationships, and the Construction of Regional and National Identities in Central America Showed in Literary and Non Literary Colonial and 19th Century documents.

CARMEN M. RIVERA-VILLEGAS, *Associate Professor*, Ph.D., 1997, Vanderbilt University. Research and Teaching Interests: Puerto Rican Poetry and Contemporary Mexican Literature.

JOSÉ E. SANTOS-GUZMÁN, *Associate Professor*, Ph.D., 1999, Brown University. Research and Teaching Interests: Spanish Literatures of the 18th and 20th Centuries (Jovellanos, Olavide, Cadalso, Pérez Galdós, Generation of 1898, Spanish Novel from the Post-Civil War Era to the Present); Hispanic Linguistics (Language Variation).

MARINE SCIENCES

The Department of Marine Sciences (DMS) is a graduate department of the University of Puerto Rico (UPR) at Mayagüez, offering instruction leading to a Master of Science Degree in Marine Sciences and Doctor of Philosophy. The doctoral program of the DMS was established in 1972 and was the first doctoral program established at the Mayagüez Campus.

The Department had its origins in the Institute of Marine Biology, established at the Mayagüez Campus in 1954 to promote and conduct research in this discipline. With expansion in both its scope and capabilities, the Institute became in August 1968, the Department of Marine Sciences. It has continued to broaden and strengthen its academic and research activities and currently sponsors active programs of investigation and instruction in the fields of physical, chemical and geological oceanography, marine biology, and marine biotechnology. The faculty consists of 12 members offering approximately 50 courses which encompass a wide range of topics in marine sciences.

The aim of the Department is to promote a greater understanding of the marine environment. This is achieved primarily through the education and training of marine scientists, and through basic and applied research. Emphasis on excellence in academic and research programs has placed the DMS at the forefront of marine science and in a position to serve the needs of the maritime nations of Latin America and the Caribbean.

The aims of its academic programs are to provide students with a firm grounding in marine sciences, an advanced knowledge of techniques for data collection and analysis, and instruction at the forefront of their fields of specialization. Students specialize in a particular discipline but are required to gain knowledge of other disciplines comprising the broad field of marine sciences. This is achieved by means of required core courses in biological, chemical, geological and physical oceanography and a seminar course in current topics.

Financial support to DMS students include research assistantships from external sources, teaching assistantships at other departments and activities related to outreach organized by the DMS. Assistantships from research funds are awarded at the discretion of the principal and co-principal investigators.

Mayagüez

The Department of Marine Sciences facilities on the main campus in Mayagüez are located in a wing of the Physics-Geology-Marine Sciences Building, built in 1972. These facilities include departmental administrative offices, a number of laboratories and faculty offices. Housed in this wing is the Marine Sciences Library Collection containing over 1,000 books, 17,000 serial volumes, 5,800 documents, plus numerous maps and reprints. It is one of the largest specialized collections in the Caribbean. The collection is complemented by additional holdings in the Mayagüez Campus General Library, and the Sea Grant Library.

The Departments of Geology and Biology maintain and operate scanning electron microscopes (SEM) which are available to the DMS personnel.

Isla Magueyes (Magueyes Island)

The principal departmental facilities are located at the field station on Isla Magueyes. A complex of 7 buildings, with a combined area approaching 35,000 square feet, houses faculty and student offices, research laboratories and classrooms and laboratories for teaching.

The DMS maintains a seawater system, unique in Puerto Rico supplying up to 85 gal/min. This system provides opportunity for research that depends on a constant supply of seawater to maintain specimens and to conduct experiments. Laboratories possess research instrumentation and dedicated equipment covering a wide spectrum of marine research topics. Instrumentation to conduct work on marine chemistry is available including, conductivity, temperature and depth (CTD's), fluorometers, spectrophotometers and pH meters either to use in the field or in the laboratory. The bio-optical laboratory routinely conducts field measurements of inherent and apparent optical properties of the water column in coastal and offshore marine environments and operates an aerosol and radiation network to study the impact of aerosols on climate and air quality. Two fully functional molecular biology laboratories are located on Magueyes as well.

A general use computer center on Magueyes Island houses computers for students and visitors. Isla Magueyes has 100% wifi coverage. All computers at Magueyes Island are linked to a

network and all laboratories have internet connectivity.

The Department maintains a complete diving facility including a dive locker, maintenance shop, a compressor room equipped with an electric compressor that provides compressed air and nitrox tanks. Tanks, regulators and other diving equipment are maintained and available for staff and students. The department is at present a member of the American Academy for Underwater Sciences (AAUS).

The marine research fleet can perform offshore and inshore research. Offshore work and heavy equipment deployment is accomplished using two research vessels. Four high speed outboard boats are operated for trips to outlying areas and thirteen smaller boats are used for inshore studies.

The R/V *Sultana* is a 42-ft vessel, outfitted for CTD profiling water and sediment sampling, as well as to sample local species of plankton, fish and invertebrates. Ships electronics provide depth, position and sea-floor topography.

The R/V *Gaviota* is a 35-ft Downeast vessel. It is equipped with VHF radio and depth sounder. The *Gaviota* provides an excellent dive platform, and it is suitable for coastal studies.

Maintenance facilities are housed in four main buildings, which include workshops, a marine mechanic's shop, and a small boat and outboard motor repair shop. Two auxiliary diesel generators provide electricity during power failures.

A 1,500 sq. ft. dormitory is located at the field station and is available to the many visiting researchers who come to Magueyes each year. Complete with kitchen and bath facilities, the dormitory can accommodate up to 20 persons.

Associated Centers Managed by DMS Professors

The Caribbean Coastal Ocean Observing System (CariCOOS).

CARICOOS is the observing arm of the Caribbean Regional Association for Integrated Coastal Ocean Observing (CaRA) <http://cara.uprm.edu/>. This effort, funded by the NOAA IOOS office <http://ioos.noaa.gov/>, is one of eleven coastal observing systems and regional

associations which along with federal agencies constitute the national coastal component of the US Integrated Ocean Observing System. For more information on the regional associations, please visit <http://www.ioosassociation.org> This web page brings together coastal ocean data and forecasts from a variety of sources including satellites, ocean instruments and numerical models to give the user an integrated view of past, present and forecasted ocean conditions in the US Caribbean region. Data are provided online by a number of organizations including NOAA, NASA, ONR Universities and others to whom credit is given. Data and graphics, other than NOAA National Weather Service products, are presented as experimental products. CaRA assumes no responsibility for the validity of the data for planning or executing marine activities. For official information and forecasts on marine weather you should consult with the National Weather Service at <http://www.nws.noaa.gov/> and its San Juan office at <http://www.srh.noaa.gov/sju/>

High Performance Computing Physical Oceanography Laboratory

After the 2004 Sumatra tsunami Puerto Rico and the US Virgin Islands became part of the USA National Tsunami Hazard and Mitigation Program (NTHMP). The Puerto Rico Tsunami Warning and Mitigation Program (PRTWMP), established in the Department of Marine Sciences with a grant from FEMA in 2000, became the Puerto Rico Component of the USA National Tsunami Hazard and Mitigation Program with NWS/NOAA subsidy, and administered by the Puerto Rico Seismic Network. Since then the Physical Oceanography Laboratory in Mayaguez collaborates with the PR-NTHMP by producing tsunami flood maps for whatever event(s) the PRSN deems possible, using state-of-the-art numerical models and making use of the Laboratory computers.

In the topic of hurricane hazards, the work of the Laboratory goes back to the 1980's when, under a FEMA grant, a coastal Flood Insurance Study was carried out resulting in the revision of FEMA's Flood Insurance Rate Maps, which were used throughout Puerto Rico and the . The Laboratory was involved in the creation of the Puerto Rico and USVI Storm Surge Atlases.

In cooperation with several federal agencies and universities, the Laboratory is involved in testing

potentially operational models of storm surge, hurricane-forced waves (including infragravity waves and runup) robust enough to be of use in the complex bathymetry of Puerto Rico and the USVI, and that could be of use to the local office of the NWS during hurricane threats.

Caribbean Coral Reef Institute

The Caribbean Coral Reef Institute (CCRI) was founded in 2003 under a cooperative agreement between the University of Puerto Rico at Mayagüez and the U.S. National Oceanographic and Atmospheric Administration to enhance the application of science to the management of coral reef ecosystems. The CCRI organizes research related to shallow and mesophotic reefs a wide range of topics in coral reef ecology.

Collaborating Organizations

The *University of Puerto Rico Sea Grant College Program* (<http://seagrantpr.org>) is an educational program dedicated to the conservation and sustainable use of coastal and marine resources in Puerto Rico, the US Virgin Islands, and the Caribbean region. Its mission is twofold: (1) to fund scientific research in the thematic areas of conservation and the use of coastal and marine resources; (2) to offer marine extension services by making use of its experience and by applying the scientific knowledge that is generated through their research to the problems and issues that the community of users face everyday.

Since the beginning of the 1980's, Sea Grant has operated through the University of Puerto Rico, Mayagüez and Humacao Campuses. Sea Grant's work is based on collaborations with universities, industries, governmental agencies, and resource users. Its projects are carried out through research, education, and public service. The Sea Grant College Program has three components: Research, Education, and Marine Advisory; all of which are supported by their Communications section.

MARINE SCIENCES (CIMA)

Advanced Undergraduate Course

CIMA 5005. INTRODUCTION TO OCEANOGRAPHY (I, II) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Basic knowledge, techniques, and areas of interest of the different disciplines of marine sciences. The interaction and research aims in Physical, Geological, Chemical and Biological Oceanography.

Graduate Courses

CIMA 6999. RESEARCH AND THESIS (I, II, S). One to six credit hours.

Up to a maximum of six credits representing the research and thesis may be granted towards the master of science degree.

CIMA 8785. CURRENT TOPICS SEMINAR (II). Two credit hours. Two hours of lecture per week.

Recent topics in marine sciences and related fields.

CIMA 8998. SPECIAL PROBLEMS (I, II, S). One to three credit hours. One to three sessions per week.

Tutorial discussion and/or laboratory and library research on a special topic.

CIMA 8999. DOCTORAL RESEARCH AND DISSERTATION (I, II, S). Up to twelve credit hours.

Up to a maximum of twelve credits representing the dissertation may be granted toward the Doctor of Philosophy degree.

MARINE SCIENCES BIOLOGICAL OCEANOGRAPHY (CMOB)

Advanced Undergraduate Courses

CMOB 5015. FISHERIES BIOLOGY (I, II). Three credit hours. Three hours of lecture per week.

A study of the principles and methods of fisheries investigation with emphasis on the fisheries of North America and the Caribbean. Field trips.

CMOB 5017. MARINE ECOLOGY AND RESOURCE MANAGEMENT. Five credit hours. Three hours of lecture and two three-hour laboratories per week. Prerequisite: authorization of the Director of the Department.

Description of the marine environment and familiarization with the major tropical marine communities; data-gathering and biological sampling techniques; human impact on the marine environment from the standpoint of pollution, exploitation, protection, and regulation; jurisprudence in major litigation involving marine resources; management practices.

CMOB 5018. MARINE ECOLOGY. Six credit hours. Ten hours of lecture and eighteen hours of laboratory per week. Prerequisite: authorization of the Director of the Department.

A study of marine communities and their environment, with special consideration of ecosystems in the sea.

Graduate Courses

CMOB 6018. MARINE ECOLOGY (I, II) (On demand). Four credit hours. Three hours of lecture and one three-hour laboratory per week.

Structure and function of marine ecosystems; flux of energy and materials in biogeochemical cycles.

CMOB 6077. ZOOPLANKTON ECOLOGY (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Aspects of zooplankton ecology in relation to oceanographic processes in estuarine, neritic, and oceanic ecosystems. Includes experiences in sampling techniques and experimental design.

CMOB 6078. ANALYSIS OF SPATIAL DATA IN MARINE ECOLOGY. Three credit hours. Three hours of lecture per week.

Collection and analysis of spatial data in marine ecology within a geographic information system and landscape ecological context with applications to ecological problems. Emphasis on ecological issues in the marine environment and their application to marine resources management. A research project is required.

CMOB 6079. DNA DATA ANALYSIS OF MARINE ORGANISMS. Six credit hours. Three hours of lecture and six hours of laboratory per week.

Introduction to modern marine population genetics and phylogenetics of marine species. Study of the different types of molecular data and their collection; phylogeny reconstruction by parsimony, distance, and likelihood methods; tests of the molecular clock for dating speciation events; Darwinian selection at the molecular level, interspecies variation, detection of population structure; and genomic evolution. Analysis of real data from the marine scientific literature with computer software in population genetics and phylogenetics.

CMOB 6618. BIOLOGICAL OCEANOGRAPHY (I). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Marine life and its relationship to geological, physical and chemical aspects of the ocean; basic techniques fundamental to marine research. Demonstrations and field trips.

CMOB 6619. BIO-OPTICAL OCEANOGRAPHY (I) (On demand). Four credit hours. Three hours of lecture and one three-hour laboratory per week. Prerequisite: Authorization of the Director of the Department.

Integrated study of the role of light in aquatic ecosystems including the physics of light transmission within water, the biochemistry and physiology of aquatic photosynthesis, and the ecological relationships that depend on the underwater light environment. Field trips required.

CMOB 6635. RESEARCH METHODS IN MARINE SCIENCES (II). Three credit hours. Three hours of lecture per week.

Techniques of data collection, analysis, and interpretation with emphasis on research problems relevant to the marine ecosystems of Puerto Rico.

CMOB 6645. MARINE PLANKTON BIOLOGY (I, II) (On demand). Two credit hours. One hour of lecture and one three-hour laboratory per week.

Study of the marine plankton with emphasis on systematics, morphology, life histories, physiology, feeding, and reproduction. Importance of plankton on the economy of the sea, particularly in their role as primary and secondary producers. Field trips required.

CMOB 6655. MOLECULAR MARINE BIOLOGY (I, II) (On demand). Four credit hours. Two hours of lecture and two three-hour laboratories per week. Prerequisite: Authorization of the Director of the Department.

Theory, practice, and applications of molecular marine biology.

CMOB 8635. MARINE MICROBIOLOGY. Three credit hours. Two lectures and one three-hour laboratory per week.

A study of the biology of marine microalgae, bacteria and protzoa, with emphasis on the techniques of pure cultures and the physiology and ecology of marine organisms, both autotrophic and heterotrophic.

CMOB 8649. CRITICAL ANALYSIS OF READINGS IN MARINE ECOLOGY (II) (On demand). Two credit hours. Four hours of seminar per week.

Study of classical and recent readings in marine ecology. Analysis of authors' aims, methods, results, and interpretations.

CMOB 8665. MORPHOLOGY OF MARINE INVERTEBRATES (II) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Form, structure and function of representative marine invertebrates.

CMOB 8667. ADVANCED FISHERIES BIOLOGY (I, II) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: authorization of the Director of the Department.

Population dynamics of exploited species, management and conservation principles for commercial fisheries.

CMOB 8676. SYSTEMATICS OF MARINE INVERTEBRATES (I) (On demand). Four credit hours. Three hours of lecture and one four-hour laboratory per week.

Taxonomy, phylogeny and distribution of marine invertebrates with special attention to local forms.

CMOB 8678. MARINE POPULATION BIOLOGY (I, II) (On demand). Three credit hours. Three hours of lecture per week.

Principles of population biology and their application to the organization of marine communities.

CMOB 8679. MARINE BOTANY (I, II). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A study of the flora of the sea, with emphasis on the morphology, ecology and taxonomy of algae.

CMOB 8686. ICHTHYOLOGY I (II) (On demand). Three credit hours. Two hours of lecture and one three hour laboratory per week.

Study of the morphology, physiology and ecology of fishes, with emphasis on marine forms.

CMOB 8687. ICHTHYOLOGY II (I) (On demand). Three credit hours. Two hours of lecture and one three hour laboratory per week.

Study of the systematic, evolution and distribution of fishes, with emphasis on marine forms.

CMOB 8690. CULTURE TECHNIQUES EMPLOYED IN ALGAE RESEARCH. Three credit hours. One hour of lecture and two two-hour laboratories per week. Prerequisite: CMOB 8679 or CMOB 8685.

Algae culture and its research methodology to determine the life history of red algae.

CMOB 8708. BIOLOGY OF THE CORAL REEF. Five credit hours. Three hours of lecture and five hours of laboratory per week. Prerequisite: CMOB 8676.

Exploration of the systematic, evolution, and biological characteristics (structure, modularity, life cycles, reproduction, etc.) of the main organisms forming coral reef communities. Field trips to coral reef communities and laboratory work are required.

CMOB 8709. ECOLOGY AND ZOOGEOGRAPHY OF CORAL REEFS. Five credit hours. Three hours of lecture and one six-hour laboratory per week. Prerequisite: CMOB 8708 or authorization of the Director of the Department.

Study of the ecology and geographical distribution of corals and coral reefs. Field trips are required.

CMOB 8715. ECOLOGICAL CONCEPTS IN MARINE RESEARCH (I, II) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Advanced ecological concepts with special emphasis on the marine environment; energy relationships in ecological systems; application of quantitative biology and experimental methods in ecological research.

CMOB 8716. ECOLOGY OF MARINE COMMUNITIES SEMINAR (II) (On demand). Two credit hours. Two sessions per week.

Composition and quantitative structure of selected marine assemblages, and their energetic and trophic relationships.

CMOB 8994. A, B, C. SPECIAL PROBLEMS IN MARINE INVERTEBRATES (I, II) (On demand). One to three credit hours. One to three sessions per week.

Supervised study or research on specific selected aspects of marine invertebrates, or techniques pertaining to their study.

CMOB 8995. A, B, C. SPECIAL PROBLEMS IN FISHERIES BIOLOGY (I, II). One to three credit hours. One to three sessions per week.

Individual student research on the biology of commercial fish and invertebrates, and on commercial fisheries.

MARINE SCIENCES CHEMICAL OCEANOGRAPHY (CMOQ)

Graduate Courses

CMOQ 6615. CHEMICAL OCEANOGRAPHY (II). Three credit hours. Three hours of lecture per week.

General survey of chemical oceanography, including application of basic concepts of physical and analytical chemistry to the marine environments, chemical interactions of major and minor constituents of seawater, the influence of chemical processes on physical, biological, and geological processes.

CMOQ 6617. MARINE POLLUTION (II) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: CMOQ 6615 or CIMA 6615.

Deleterious effects on living resources, human health, marine activities, and water quality caused by the anthropogenic introduction of substances or energy into the marine environment.

CMOQ 8616. OCEANOGRAPHIC TECHNIQUES (I). Three credit hours. One hour of lecture and one six-hour laboratory period per week; also a three days duration training cruise. Pre-requisite: authorization of the Director of the Department.

Training in the use of standard shipboard and laboratory techniques in physical, chemical, geological and biological oceanography. Planning and execution of a trip on a cruise. Data collection, processing and analysis.

CMOQ 8638. CHEMICAL OCEANOGRAPHY LABORATORY (I). Three credit hours. One hour of lecture and six hours of laboratory per week.

Laboratory experience in techniques of sampling and handling of marine samples, and the analyses of these samples for major, minor and trace constituents.

CMOQ 8991. A, B, C. SPECIAL PROBLEMS IN CHEMICAL OCEANOGRAPHY (I, II) (On demand). One to three credit hours. One to three sessions per week.

Laboratory studies of specific problems in chemical oceanography. Topics to be chosen by the student and approved by the professor.

MARINE SCIENCES GEOLOGICAL OCEANOGRAPHY (CMOG)

Advanced Undergraduate Course

CMOG 5001. INTRODUCTION TO CLIMATE CHANGE. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Overview of the principles of Earth's climate covering a broad range of phenomena that influence climate at various regional and global time scales and resolutions. Discussion of climate forced by external controls. Description of the effects of internal forces and their variability, and human-induced climate change. Emphasis on the role of greenhouse gases and rates of change of these processes. Discussion of the future climate change scenarios and possible mitigating steps.

Graduate Courses

CMOG 6616. GEOLOGICAL OCEANOGRAPHY (II). Three credit hours. Two hours of lecture and one three-hour laboratory per week. For students not majoring in Geological Oceanography.

A review of the basic concepts of geology; geomorphology and structure of the ocean basins and continental shelves; techniques of marine exploration and research; study of the tectonic theories on the origin of marine basins and structural processes; the distribution of sediments, and marine sedimentary processes.

CMOG 6618. COCCOLITHOPHORES. Four credit hours. Three hours of lecture and one four-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Comprehensive survey of coccolithophores including: structure, taxonomy, biogeochemical and its role in stratigraphy, paleoceanography, and biogeochemical cycles.

CMOG 8606. COASTAL GEOMORPHOLOGY (II) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

The origin of coastal features and their relationships with shore problems relative to the basic sciences; presentation of the forces that modify the shores. Discussion and field trips.

CMOG 8618. MARINE GEOLOGY OF THE CARIBBEAN (I, II) (On demand). Four credit hours. Two hours of lecture and two three-hour laboratory periods per week. Prerequisite: 15 credit hours in Geology.

Synthesis and analysis of the marine geology of the Caribbean, using published data and cruise information; survey of our present knowledge of bathymetry, and of the structure, sediments and stratigraphy of the Caribbean.

CMOG 8655. MARINE BIOGEOGRAPHY (I, II) (On demand). Three credit hours. Three hours of lecture per week.

The origin, speciation and distribution of marine plants and animals in relation to the physical, chemical and physiological aspects of the ocean, with special emphasis on tropical biota.

CMOG 8675. ADVANCED GEOLOGICAL OCEANOGRAPHY (I, II) (On demand). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A comprehensive review of the geomorphology and structure of the ocean basins; analysis of tectonic theories and structural processes operating in the marine environment; distribution of marine sediments.

CMOG 8698. BIOGEOLOGY SEMINAR (II) (On demand). Three credit hours. Three one-hour sessions per week.

Introduction to the problems of biota-sediment interaction; influence of biological factors on geological processes. Guest lecturers will be invited. Each student will be required to make an oral presentation of at least one topic during the semester.

CMOG 8706. STRUCTURE OF CORAL REEF. Three credit hours. One hour of lecture and two three-hour laboratories per week.

Structure, development, and methods of study of coral reefs. Field trips required.

CMOG 8717. SPECIAL PROBLEMS IN MARINE GEOLOGY (II) (On demand). One to three credit hours. One to three hours of lecture and one three-hour laboratory per week.

Supervised study or research on specific aspects in marine geology.

MARINE SCIENCES PHYSICAL OCEANOGRAPHY (CMOF)

Advanced Undergraduate Courses

CMOF 5005. COASTAL STRUCTURES. Three credit hours. Three hours of lecture per week.

Types of coastal structures; their purpose, design, construction, and environmental impact.

CMOF 5015. PHYSICAL OCEANOGRAPHY FOR ATMOSPHERIC SCIENCES. Three credit hours. Three hours of lecture per week. Prerequisites: (MATE 4009 and (FISI 3172 or FISI 3162)) or authorization of the Director of the Department.

Introduction to topics in physical oceanography such as heat budget, physical properties of seawater, oceanic mixing processes, and equations of conservation of heat, salt, and momentum. Analysis of the origin of marine currents by applying the concepts of potential vorticity conservation and Sverdrup circulation. Description of the mechanics of surface and deep currents.

Graduate Courses

CMOF 6005. METHODS OF OCEANOGRAPHIC DATA ANALYSIS (II) (On demand). Three credit hours. Three hours of lecture per week.

Oceanographic data analysis emphasizing computer techniques: exploratory data analysis, regression analysis, scalar and vector spectral analysis, maximum entropy spectral analysis, empirical orthogonal eigen functions, filters, complex demodulation.

CMOF 6006. ATMOSPHERIC AND OCEANIC TURBULENCE (I, II) (On demand). Three credit hours. Three hours of lecture per week.

Fundamental concepts of turbulence and their application to the study of geophysical fluids.

CMOF 6445. REMOTE SENSING IN OCEANOGRAPHY I. Four credit hours. Two hours of lecture and two three-hour laboratories per week. Prerequisite: Authorization of the Director of the Department.

Remote sensing and its application in oceanography, including comparison with field data. Field trips are required.

CMOF 6617. PHYSICAL OCEANOGRAPHY (I). Three credit hours. Three hours of lecture per week.

General introduction to the study of physical processes in the sea; physical properties of sea water, heat budget, water budget, temperature-salinity relationships, light in the sea, equations of motion, vertical stability, Coriolis effect geostrophic motion, general oceanic circulation, waves and tides.

CMOF 6631-6632. GEOPHYSICAL FLUID DYNAMICS I-II. Three credit hours. Three hours of lecture per week each semester. Prerequisite: authorization of the Director of the Department.

The dynamics of large-scale motions in the ocean and the atmosphere. Theories of stratified fluids in rotation and of geophysical waves.

CMOF 6655. OCEAN SURFACE WAVE MECHANICS. Three credit hours. Three hours of lecture per week.

Study of the mechanics of ocean surface gravity waves, including theory, kinematical properties, statistics, spectra, and forces.

CMOF 6665. MATHEMATICAL MODELING OF MARINE SYSTEMS. Three credit hours.

Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Theory and practice of the modeling of biological, chemical, and physical marine systems, emphasizing multidisciplinary ecological problems. Programming skills required.

CMOF 6667. MECHANICS OF COASTAL SEDIMENT TRANSPORT. Three credit hours. Three hours of lecture per week.

Development of mathematical models to represent coastal sediment transport.

CMOF 8446. REMOTE SENSING IN OCEANOGRAPHY II. Four credit hours. Two hours of lecture and one six-hour laboratory per week. Prerequisite: CMOF 6445.

Advanced concepts of remote sensing and their application in oceanography, including comparison with field data. Field trips are required.

CMOF 8607. ESTUARINE CIRCULATION (I) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: CIMA 6617.

Definition, classification, and description of estuaries; estuarine circulation patterns; physical oceanography of adjacent waters; the dynamics of circulation and its relation to the environment.

CMOF 8619. COASTAL OCEANOGRAPHY. Three credit hours. Three hours of lecture per week.

Interactions between long and short period waves and the shore; tides, storm surges, seiches, shoaling wave theories, wave refraction and diffraction, breakers, run-up, longshore currents, near shore sediment transportation, foreshore processes.

CMOF 8625. DYNAMICAL OCEANOGRAPHY (On demand). Three credit hours. Three hours of lecture per week.

Introduction to the dynamical processes in the sea; geopotential axes, Lagrangian and Eulerian Kinematics, Eulerian expansion, equation of continuity, circulation and vorticity. Navier-Stokes equations, vertical stability, inertial motion, Coriolis effect, geostrophic motion, diffusion and turbulent processes, Ekman motion, small amplitude wave theory, open and closed basin resonance.

CMOF 8659. COMPUTER MODELING IN OCEANOGRAPHY AND METEOROLOGY (I, II) (On demand). Three credit hours. Three hours of lecture per week.

Finite difference methods for the solution of the hydrodynamic equations that appear in numerical models of the atmosphere and the ocean, emphasizing the solution of the linear and non-linear advection equation, numerical filtering techniques, and mesh systems.

CMOF 8669. PHYSICAL OCEANOGRAPHY LABORATORY (II) (On demand). One credit hour. One three-hour laboratory per week.

Map projections, use of charts and oceanographic atlases, preparation of diagrams, instrumentation at sea and ashore; observation aboard an oceanographic vessel.

CMOF 8990. A, B, C. SPECIAL PROBLEMS IN PHYSICAL OCEANOGRAPHY (I, II) (On demand). One to three credit hours. One to three sessions per week.

Selected topics in physical oceanography.

MARINE SCIENCES FACULTY

The following is a list of professors engaged in academic activities in the Department, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

ROY ARMSTRONG, *Professor*, Ph.D., 1990, University of Puerto Rico. Research and Teaching interests: Remote Sensing, Water Optics, Underwater Robotics, Benthic Communities.

MIGUEL CANALS SILANDER, *Adjunct Associate Professor*, Ph.D. University of Hawaii at Manoa. Research and Teaching interests: Ocean Observing Systems, Coastal Engineering Applications; Physical Oceanography.

JUAN J. CRUZ MOTTA, *Assistant Professor*, Ph.D., 2005. University of Sydney, Australia. Research and Teaching interests: Quantitative Ecology, Environmental Impacts Detection, Biometry, Multivariate Methods.

JUAN GONZALEZ LAGOA, *Professor Emeritus*, Ph.D. 1973. University of Rhode Island. Research Training and Teaching Interests. Plankton, Bioluminescent Bays and Outreach.

AURELIO MERCADO-IRIZARRY, *Professor*, M.S., 1973, University of Puerto Rico. Research and Teaching interests: Geophysical Fluid Dynamics, Physical Oceanography, Computer Modeling of Coastal Hazards, Climate Change, Beach and Nearshore Processes.

JULIO MORELL, *Researcher*, M.S., 1983, University of Puerto Rico. Research interests: Biochemistry and Environmental Chemistry. Observational Oceanography. Applied Ocean Science.

GOVIND NADATHUR, *Professor*, Ph.D., 1982, Gujarat University of India. Research and Teaching interests: Microbiology, Genetics and Biotechnology of Marine Organisms.

ERNESTO OTERO MORALES, *Researcher*, Ph.D., 1998, University of Georgia. Research interests: Microbial Biogeochemistry, Microbial Ecology, Biogeochemistry, Water Quality, Microbial Source Tracking. Applied Marine Sciences.

NIKOLAOS SCHIZAS, *Professor*, Ph.D., 1999, University of South Carolina. Research and Teaching interests: Evolution of Marine Invertebrates.

WILFORD E. SCHMIDT, *Associate Professor*, Ph.D., 2003, University of California, San Diego. Research and Teaching interests: Oceanography Applied Ocean Science.

CLARK E. SHERMAN, *Professor*, Ph.D., 2000, University of Hawaii. Research and Teaching interests: Marine Geology, Carbonate Sedimentology, Coral Reefs, Quaternary Geology.

ERNESTO WEIL, *Professor*, Ph.D., 1992, University of Texas at Austin. Research and Teaching interests: Coral Systematics, Ecology, and Evolution, Coral Reef Ecology.

MATHEMATICAL SCIENCES

The department of Mathematical Sciences offers two programs leading to a Master of Science degree: one in Mathematics with tracks in 1) pure mathematics, 2) applied mathematics, 3) statistics mathematics or 4) Teaching Mathematics at Secondary Level and the other in Scientific Computing. The department of Mathematical Sciences also participates in an interdisciplinary program leading to a Ph.D. in Computing and Information Sciences and Engineering. Please refer to the Interdisciplinary Programs section for information on this doctoral program.

Students have access to the central Computing Center and to other equipment of the Mathematics Department. Two special purpose laboratories, the Scientific Computing and the Visualization Laboratory are available to students with research projects in computational mathematics.

MASTER OF SCIENCE IN MATHEMATICS

Students entering this program may specialize in Pure or Applied Mathematics, Statistics Mathematics or Teaching Mathematics at Secondary Level.

Applicants for applied mathematics should have an undergraduate degree in Mathematics or its equivalent. Candidates are expected to have approved undergraduate courses in Multivariable Calculus, Linear Algebra, Ordinary Differential Equations, Numerical Analysis and Advanced Calculus. It is also recommended to have some programming experience using a high level language such as C/C++, and/or a mathematical package such as Matlab and Mathematica.

Applicants for pure mathematics should have an undergraduate degree in Mathematics or its equivalent. Candidates are expected to have approved undergraduate courses in Linear Algebra, Algebraic Structures, basic Topology and Advanced Calculus.

Applicants for statistics mathematics should have an undergraduate degree in Mathematics or its equivalent. Candidates are expected to have approved undergraduate courses in Linear Algebra, Multivariable Calculus and Statistics. Knowledge of computer programming is highly desirable.

Applicants for teaching mathematics at secondary level should have an undergraduate degree in Mathematics or its equivalent and the Mathematics Teachers Certification from the Education Department of Puerto Rico or its equivalent or 3 years of experience as teacher in private or public school in Puerto Rico.

In addition to the requirements of the Office of Graduate Studies, the Master of Science degree in Mathematics includes approving nine credits of core courses, two seminar credits, nine credits in the area of specialization, six credits outside the major area, and six thesis credits. In addition the student must pass qualifying exams:

1. Pure mathematics track: one exam from Abstract Algebra, Real Analysis or Topology.
2. Applied Mathematics track: one exam from Real Analysis, Numerical Analysis or Partial Differential Equations.
3. Statistics Mathematics track: one exam from two of the following areas: Probability, and Statistical Methods or, Regression and Theory of Statistics.

Specific course requirements for each area are available at <http://math.uprm.edu>

MASTER OF SCIENCE IN SCIENTIFIC COMPUTING

Applicants for admission should have an undergraduate degree in Mathematics or its equivalent, or an undergraduate degree in Science or Engineering. Candidates are expected to have approved courses in multivariable calculus, differential equations, linear algebra, numerical analysis and data structures, as well as having programming experience using a high level language such as C/C++.

In addition to the requirements of the Office of Graduate Studies, the Master of Science degree in Scientific Computing includes approving the following core courses: Numerical Mathematical Analysis, MATE 6672, Numerical Linear Algebra, Mate 6025, Analysis of Algorithms, COMP 6785, and High Performance Computing COMP 6786, six credits outside the area, nine credits in the area of specialization, three thesis credits and two internship or seminar credits. In addition, the candidate must pass one qualifying exam from Numerical Analysis, Numerical Linear Algebra or Analysis of Algorithms.

MATHEMATICS (MATE)

Advanced Undergraduate Courses

MATE 5016. GAME THEORY (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Mathematical theory and solution of different classes of games, such as two-person, rectangular or matrix, and multipersonal games.

MATE 5047. INTERMEDIATE DIFFERENTIAL EQUATIONS (I) (Odd numbered years). Three credit hours. Three hours of lecture per week. Prerequisites: (MATE 4009 and MATE 4031) or authorization of the Director of the Department.

Existence, continuity and differentiability of solutions; stability and Lyapunov's theorem.

MATE 5049. CALCULUS OF VARIATIONS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 4009 or authorization of the Director of the Department.

Origin and historical development of the calculus of variations; first variation of a functional; canonical forms of Euler's equations; second variation; sufficient conditions for weak and strong extremals; applications to problems in geometry, mechanisms and physics.

MATE 5055. VECTOR ANALYSIS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 3063 or authorization of the Director of the Department.

Introduction to vector analysis as a tool for mathematicians. The algebra and calculus of vectors, including gradient, divergence and curl, Stokes' and Green's Theorems, curvilinear coordinates, and simple N-Dimensional space. Applications in physics and geometry.

MATE 5056. TENSOR ANALYSIS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 3063 or authorization of the Director of the Department.

Cartesian tensors, Cartesian tensor fields, gradient vector, Laplacian, covariant and contravariant tensor fields, the differential line-element and the fundamental tensors, covariant differentiation and the Riemann-Christoffel tensor.

MATE 5150. LINEAR ALGEBRA (I). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 4008 or authorization of the Director of the Department.

Study of the essentials of linear algebra, including finite dimensional vector spaces. Linear equations, matrices, determinants, bilinear forms, inner products, Spectral Theorem for normal operators, and linear transformations.

Graduate Courses

MATE 6005. COMBINATORICS (On demand). Three credit hours. Three hours of lecture per week.

Enumerative analysis and optimization techniques: permutations and combinations, generating functions, recurrence relations, the principle of inclusion and exclusion, rudiments of graph theory, transport network, and linear programming.

MATE 6006. THE MATHEMATICS OF CONTINUOUS MEDIA MODELS. Three credit hours. Three hours of lecture per week.

Presentation of the mathematical foundations of the mechanics of continuous media, which allows the development of new mathematical models and the understanding of existing ones in related areas of science and engineering. Description of mathematical methods based on principles of invariance and determinism. Discussion of general theorems that interconnect various formal theories of continuous media.

MATE 6025. NUMERICAL LINEAR ALGEBRA. Three credit hours. Three hours of lecture per week.

Matrix analysis techniques fundamental to problem solving and the development of optimization methods and numerical solution of differential equations. Topics include: eigenvalue and eigenvector problems, numerical methods, singular value decomposition, special problems, and applications.

MATE 6026. NUMERICAL OPTIMIZATION. Three credit hours. Three hours of lecture per week.

Modern optimization methods and their application to various problems in science and engineering. Topics include: optimization on convex sets, minimization methods of nonlinear problems, nonlinear equations, conjugate methods, and special structure problems.

MATE 6035. TOPICS IN OPERATIONS RESEARCH I (II) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Selected topics in operations research.

MATE 6036. TOPICS IN OPERATIONS RESEARCH II (I) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Selected topics in operations research.

MATE 6045. OPTIMIZATION THEORY (II) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Classical optimization techniques: linear, non-linear, geometric programming, dynamic programming, the path method.

MATE 6101. NUMBER THEORY I. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Fundamental non-analytic theory. Theory of congruences. Wilson and Euler theorems and applications. Sums of two squares. Primitive roots. Quadratic reciprocity law.

MATE 6201. ABSTRACT ALGEBRA (II)-(I). Three credit hours per semester. Three hours of lecture per week each semester. Prerequisite: authorization of Director of the Department.

A survey of abstract algebra. Algebraic systems studied include groups, ring, fields, Galois theory, modules over rings, partially ordered algebraic systems and theory of categories.

MATE 6202. ABSTRACT ALGEBRA (II)-(I). Three credit hours per semester. Three hours of lecture per week each semester. Prerequisite: authorization of Director of the Department.

A survey of abstract algebra. Algebraic systems studied include groups, ring, fields, Galois theory, modules over rings, partially ordered algebraic systems and theory of categories.

MATE 6261. THEORY OF FUNCTIONS OF A REAL VARIABLE I (I). Three credit hours. Three hours of lecture per week.

Set theory, the axiom of choice and Zorn's lemma, structure of the real number system, metric and topological spaces, Borel sets and Baire functions, limit theorems, properties of continuous and semicontinuous functions, derivatives and

sequences of functions, functions of bounded variation, Riemann-Stieltjes integration.

MATE 6262. THEORY OF FUNCTIONS OF A REAL VARIABLE II (II). Three credit hours. Three hours of lecture per week.

An introduction to measure theory and Lebesgue integration, covering the following topics: inner and outer measure, measurable sets, Lebesgue measurable sets, Vitali's covering theorem, measurable functions, convergence in measure, the Lebesgue integral for real functions of a real variable, the Radon-Nykodym theorem, multiple integrals, Fubini's theorem, L spaces, convergence in the mean.

MATE 6301. THEORY OF FUNCTIONS OF A COMPLEX VARIABLE (II) (Even numbered years). Three credit hours. Three hours of lecture per week.

This course provides a rigorous foundation in the theory of functions of a complex variable. Topics include theory of analytic functions, contour integration and infinite series.

MATE 6530. DIFFERENTIAL GEOMETRY I (II) (Even numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 6670.

Study of Riemannian metrics, affine and Riemannian connections, geodesics, curvatures, Jacobi fields, immersions.

MATE 6531. DIFFERENTIAL GEOMETRY II (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 6530.

Study of complete manifolds, spaces of constant curvature, variations of energy, Rauch comparison theorem, Morse index theorem, fundamental group of manifolds of negative curvature, sphere theorem.

MATE 6540. TOPOLOGY (II). Three credit hours. Three hours of lecture per week.

An introductory course devoted to set-theoretic topology. Properties of topological spaces, including connectedness, compactness, bases, sub-bases, product spaces, quotient spaces, and the separation axioms.

MATE 6551. ALGEBRAIC TOPOLOGY (On demand). Three credit hours. Three hours of lecture per week.

Homotopy and homology groups associated with a topological space.

MATE 6622. TOPICS IN THE THEORY OF FUNCTIONS OF A COMPLEX VARIABLE (I) (Even numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 6301.

Conformal mapping. Riemann surfaces, harmonic functions, the Dirichlet problem.

MATE 6627. TOPICS IN ANALYSIS (I)-(II on demand). Three credit hours per semester. Three hours of lecture per week. Prerequisite: authorization of Director of the Department.

The content of this course will vary according to interest and demand. In any given semester the course may deal with one of the following topics: Functional Analysis, Harmonic Analysis, Theory of complete normed algebras, Theory of uniform algebras, Integral Equations, Spectral Theory of Differential Operators from Physics, advanced topics in ordinary differential equations or other analogous topics.

MATE 6628. TOPICS IN ANALYSIS (I)-(II on demand). Three credit hours per semester. Three hours of lecture per week. Prerequisite: authorization of Director of the Department.

The content of this course will vary according to interest and demand. In any given semester the course may deal with one of the following topics: Functional Analysis, Harmonic Analysis, Theory of complete normed algebras, Theory of uniform algebras, Integral Equations, Spectral Theory of Differential Operators from Physics, advanced topics in ordinary differential equations or other analogous topics.

MATE 6631. TOPICS IN MATHEMATICAL LOGIC (I)- (On demand). Three credit hours per semester. Three hours of lecture per week each semester. Prerequisite: authorization of the Director of the Department.

The content of this course will vary from time to time, depending on demand and interest. In any given semester, the course would be devoted to a topic such as one of the following: theory of formal systems, axiomatic set theory, model theory, theory of computability and decidability, theory of finite automata, mathematical linguistics, and others.

MATE 6651-6652. INTRODUCTION TO HIGHER GEOMETRY (I, Even numbered years)-(On demand). Three credit hours per semester. Three hours of lecture per week each semester.

Homogeneous Cartesian coordinates, linear dependence of points and lines, harmonic division, line coordinates, cross-ratio; transformation; metric, affine, and projective geometries; points and line curves, space geometry.

MATE 6670. DIFFERENTIABLE MANIFOLDS (I, Every two years) (On demand). Three credit hours. Three hours of lecture per week.

Differentiable manifolds, vector fields, the Frobenius theorem, differential forms and tensor fields, Lie groups, homogeneous spaces, integration on manifolds.

MATE 6672. NUMERICAL MATHEMATICAL ANALYSIS (I). Three credit hours. Three hours of lecture per week.

Mathematical methods of computation applicable to automatic digital computers, choice and use of tables, finite differences, roots of equations, numerical differentiation and integration, curve fitting, least squares, harmonic analysis.

MATE 6673. NUMERICAL MATHEMATICAL ANALYSIS LABORATORY (I). One credit hour. One three-hour laboratory per week. Corequisite: MATE 6672.

Each student will prepare and run the solution of assigned problems on a digital computer.

MATE 6674. NUMERICAL METHODS FOR DIFFERENTIAL EQUATIONS. Three credit hours. Three hours of lecture per week.

Fundamentals of mathematical modeling with partial differential equations and numerical methods for their solution with the computer. Convergence and stability of distinct schemes of finite differences or finite elements for various types of partial differential equations.

MATE 6675. MATHEMATICS OF MODERN SCIENCE I (I). Three credit hours. Three hours of lecture per week.

A more advanced study of some topics covered in Mathematics of Modern Science. Complex variables, partial differential equations, special functions, and transform calculus.

MATE 6676. MATHEMATICS OF MODERN SCIENCE II (II). Three credit hours. Three lectures per week. Prerequisite: MATE 6675.

A more advanced study of some topics covered in MATE 4071-4072. Sturm-Liouville systems, calculus of variations, integral equations, tensors, and finite differences.

MATE 6677. ELEMENTARY PARTIAL DIFFERENTIAL EQUATIONS (I) (Even numbered years). Three credit hours. Three hours of lecture per week.

General theory of partial differential equations of the first and second order, linear partial differential equations, study of some of the important types of differential equations of mathematical physics.

MATE 6678. SPECIAL TOPICS IN PARTIAL DIFFERENTIAL EQUATIONS (II) (Odd numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 6677.

Solution of boundary value problems, using integral transform methods, such as Laplace, Fourier, Mellin, etc.; introduction to integral and integro-differential equations.

MATE 6693-6694. TOPICS IN ALGEBRA (II odd numbered years)-(On demand). Three credit hours per semester. Three hours of lecture per week each semester. Prerequisite: authorization of the Director of the Department.

Selected topics from algebra. Varied content to be offered from time to time as need exists and as faculty interests and time permit.

MATE 6705. PROJECT (On demand). Three credit hours. Independent study.

Application of mathematics to the solution of a specific problem. A final written report is required.

MATE 6991-6992. SEMINAR (I, II)-(I, II). One to three credit hours per semester. One to three one-and-one-half-hour lectures per week each semester.

Discussions and reports of special topics in mathematics.

MATE 6993. TOPICS IN DIFFERENTIAL GEOMETRY I (II) (Odd numbered years). One to three credit hours. One to three hours of lecture per week.

Selected topics in differential geometry.

MATE 6994. TOPICS IN DIFFERENTIAL GEOMETRY II (On demand). One to three credit hours. One to three hours of lecture per week.

Selected topics in differential geometry.

MATE 6995. SPECIAL TOPICS (On demand). One to three credit hours. One to three hours of lecture per week. Prerequisite: authorization of Department Director.

Selected topics in Mathematics. Themes will vary according to the needs and interests of students and faculty.

MATE 6999. THESIS (I, II). Zero to six credit hour.

Every student working towards the degree of Master of Science in Mathematics is required to write a thesis on a topic selected in consultation with his advisor.

COMPUTER SCIENCE (COMP)

Advanced Undergraduate Courses

ICOM/COMP 5015. ARTIFICIAL INTELLIGENCE. Three credit hours. Three hours of conference per week. Prerequisite: ICOM 4035 or authorization of the Director of the Department.

An introduction to the field of artificial intelligence: Lisp language, search techniques, games, vision, representation of knowledge, inference and process of proving theorems, natural language understanding.

COMP 5045. AUTOMATA AND FORMAL LANGUAGES (I). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Finite automata and regular languages; pushdown automata and context-free languages; Turing machines and recursively enumerable sets; linearly bounded automata and context-sensitive languages; computability and the halting problem; undecidable problems.

COMP 5055. PARALLEL COMPUTATION (II). Three credit hours. Three hours of lecture per week. Prerequisite: MATE 4061 and authorization of the Director of the Department.

The use of supercomputers: parallel architecture, design of algorithms for scientific computation and their implementation with parallel multiprocessors, and performance analysis.

INEL/ICOM/SICI/COMP 5318.

INTERMEDIATE ROUTING, SWITCHING AND WIDE AREA NETWORKS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL/ICOM/SICI/COMP 4308 or authorization of the Director of the Department.

Study and configuration of link state protocols. Study of intermediate level concepts such as switching, wide area network or WAN standards, virtual local area networks or VLAN, network design, and redundancy. Presentation and study of strategies for managing and saving address space such as variable length subnet masks and network address translation.

Graduate Courses

COMP 6025. SCIENTIFIC VISUALIZATION. Three credit hours. Three hours of lecture per week.

Use of computer graphics technology to aid the understanding of data acquired by physical measurement, numerical computation or simulation.

COMP 6315/ESMA 6315. DATA MINING. Three credit hours. Three hours of lecture per week. Prerequisite: ESMA 6305 or authorization of the Director of the Department.

Concepts and techniques of data mining, based on statistical methodology. Study and application of diverse data-preprocessing techniques. Application of data visualization techniques in two and three dimensions, linear and non-linear supervised classifiers, clustering methods, and outlier detection. Application of association rule and text mining techniques.

COMP 6785. ANALYSIS OF ALGORITHMS (II). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analysis of algorithms: graph algorithms, algorithms for classical problems in linear algebra. Integer and polynomial arithmetic, complexity, and NP-completeness.

COMP 6786. HIGH-PERFORMANCE COMPUTING. Three credit hours. Three hours of lecture per week. Prerequisite: COMP 6785.

Concepts and methods for the design, implementation, and evaluation of high-performance algorithms for large-scale scientific and technological problems in a multiprocessing environment.

COMP 6787. INTERNSHIP. Two credit hours. One hundred and twenty hours of practice during the summer. Prerequisites: MATE 6672, MATE 6025 and COMP 6786.

Participation in a research project at a scientific computing center, to be selected in consultation with the Graduate Committee, preferably in a National Laboratory, NASA or DOD. A final oral and written presentation is required.

COMP 6838. TOPICS IN COMPUTER SCIENCE (I). Three credit hours. Three hours of lecture per week.

Selected topics in Computer Science.

COMP 6839. TOPICS IN COMPUTER SCIENCE (II). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Selected topics in Computer Science.

COMP 6995. PROJECT IN SCIENTIFIC COMPUTING. Zero to three credit hours.

Development of a project in scientific computing. Presentation and approval of a written report is required.

COMP 6998. THESIS. Zero to three credit hours.

Research in scientific computing. Presentation and approval of a thesis is required.

STATISTICS MATHEMATICS (ESMA)

Advanced Undergraduate Course

ESMA 5015. STOCHASTIC SIMULATION. Three credit hours. Three hours of lecture per week. Prerequisite: ESMA 4001 or authorization of the Director of the Department.

Basic methods of simulation, modeling of complex systems, simulation languages, generation of random numbers, model validity, analysis of solutions, variance reduction techniques, and the design of experiments.

Graduate Courses

ESMA 6205. APPLIED REGRESSION (II). Three credit hours. Three hours of lecture per week.

Simple linear regression, multiple linear regression, robust regression methods and analysis of residuals. Problems and remedial measures in the design of regression models. Selection of independent variables. Non-linear regression.

ESMA 6305. STATISTICAL METHODS (I). Three credit hours. Three hours of lecture per week.

Populations and samples, probability distributions, sampling distributions, statistical inference, linear and multiple regression and correlation, analysis of variance and covariance. Use of statistical computer package.

COMP 6315/ESMA 6315. DATA MINING. Three credit hours. Three hours of lecture per week. Prerequisite: ESMA 6305 or authorization of the Director of the Department.

Concepts and techniques of data mining, based on statistical methodology. Study and application of diverse data-preprocessing techniques. Application of data visualization techniques in two and three dimensions, linear and non-linear supervised classifiers, clustering methods, and outlier detection. Application of association rule and text mining techniques.

ESMA 6600. PROBABILITY THEORY (I). Three credit hours. Three hours of lecture per week.

Sample spaces and events, conditional probability and independence, discrete and continuous random variables, moment generating functions, and limit theorems.

ESMA 6607. ADVANCED SAMPLING THEORY (II) (Even numbered years). Three credit hours. Three hours of lecture per week.

Advanced theory and techniques of statistical sampling, including simple, stratified, systematic, and conglomerate sampling; comparison among these and corresponding problems of estimation; allocation problems.

ESMA 6616. LINEAR MODELS (I) (Odd numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Multivariate normal distribution; distribution of quadratic forms; theory of least squares; estimation

and hypothesis testing in the general linear model, analysis of multiple classifications; components of variance models.

ESMA 6660. BIOSTATISTICAL ANALYSIS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Descriptive and inferential statistical techniques, design of experiments, construction of biomathematical models, bio-essays and probit analysis.

ESMA 6661. THEORY OF STATISTICS I (II). Three credit hours. Three hours of lecture per week.

Sampling distributions, point and interval estimation, optimal properties of estimators, tests of simple and composite hypotheses, likelihood ratio tests, tests of goodness of fit, and analysis of contingency tables.

ESMA 6662. THEORY OF STATISTICS II (I). Three credit hours. Three hours of lecture per week. Prerequisite: ESMA 6661.

Nonparametric tests, multivariate distributions, introduction to linear models, estimation and hypothesis testing in linear models, Bayesian methods, and statistical decision theory.

ESMA 6665. STATISTICAL COMPUTING (II) (Odd numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: ESMA 6205 or authorization of the Director of the Department.

Exploratory data analysis techniques; probability approximation; matrix computation applied to linear regression; computational methods for optimization, nonlinear regression, and multivariate analysis.

ESMA 6787. EXPERIMENTAL DESIGN (I) (Even numbered years). Three credit hours. Three hours of lecture per week.

Principles of experimental design and hypothesis testing: randomized blocks, latin squares, 2^n , 3^n , and other factorial experiments; confounding, fractional factorials, response surface methodology, split plot and incomplete block designs.

ESMA 6788. ADVANCED PROBABILITY THEORY (On demand). Three credit hours. Three hours of lecture per week.

Fundamentals of integration and measure theory; basic concepts of probability in the context of

measure theory; conditional probability and conditional expectation; strong law of large numbers; theory of martingales and central limit theorem.

ESMA 6789. STOCHASTIC PROCESSES (II) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Probability spaces and convergence concepts; random walk; Markov chains; Poisson processes and purely discontinuous Markov processes; stationary processes; martingales; Brownian motion and diffusion stochastic processes.

ESMA 6835. TOPICS IN STATISTICS (II) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Selected topics in theoretical and applied statistics. The content will vary according to the interests of students and professors.

ESMA 6836. TOPICS IN STATISTICS (On demand). Three credit hours. Three hours of lecture per week.

Selected topics in theoretical and applied statistics. The content will vary according to the interests of students and professors.

TEACHING MATHEMATICS AT SECONDARY LEVEL

Graduate Courses

EDMA 6005. GEOMETRY. Three credit hours. Three hours of lecture per week.

Discussion of topics in plane, analytical, and transformational geometry using a constructivist approach with emphasis on the development of problem-solving abilities. Discussion of methodologies for the teaching of these topics in the classroom will be included.

EDMA 6015. SET THEORY AND LOGIC. Three credit hours. Three hours of lecture per week.

Study of set theory and logic including propositional calculus, algebra of finite, infinite and countable sets, well-ordered sets, and number systems. Emphasis on the development of abilities to do mathematical proofs.

EDMA 6025. CALCULUS THEORY. Three credit hours. Three hours of lecture per week.

Detailed study of the fundamental concepts of the theory of calculus of functions of one variable. Discussion of limits, continuity, derivatives and its applications, and integrals and their applications. The theory and its relevance to the teaching of mathematics at the high school level will be emphasized.

EDMA 6105. PROBLEM-SOLVING. Three credit hours. Three hours of lecture per week.

Formulation and comparison of strategies and techniques for problem-solving in diverse areas of mathematics. Problems will be selected in order to introduce important mathematical concepts and motivate high school students.

EDMA 6205. STATISTICS. Three credit hours. Three hours of lecture per week.

Study of the fundamental concepts of probability, random variables, sampling distributions, inferential statistics, and simple and multiple linear regression. The statistical principles that guide the planning, design, and analysis of an experiment will be discussed. The design of an experiment in the area of mathematics education is required.

**EDMA 6215. TECHNOLOGY IN
MATHEMATICS TEACHING.** Three credit hours. Three hours of lecture per week.

Study of the use of technology in the mathematics curriculum at the high school level and its impact in the classroom. The relation between the integration of technology and the student's mathematical achievement will be analyzed.

EDMA 6225. MODERN ALGEBRA. Three credit hours. Three hours of lecture per week.

Rigorous study of the algebraic structure of number systems and algebras of polynomials. Generalization of numerical systems to structure to structure of groups, rings and fields. Emphasis on the application and relevance of algebraic structures in the teaching of mathematics at the high school level.

**EDMA 6991. TOPICS IN MATHEMATICS
EDUCATION.** One to three credit hours. One to three hours of lecture per week.

Selected topics in mathematics education and related areas in the mathematics curriculum at the high school level.

EDMA 6992. TOPICS IN NUMBER THEORY. Three credit hours. Three hours of lecture per week.

Special topics oriented toward the exploration of problems and techniques of number theory that will be used for projects of high school students.

EDMA 6993. PROJECT IN MATHEMATICS EDUCATION. One to three credit hours. One to three hours of research per week.

Development of a project in mathematics education. Oral and written presentation of a report is required.

MATHEMATICAL SCIENCES FACULTY

A list of professors who engage in graduate activities in the Department follows including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

ROBERT ACAR, *Associate Professor*, Ph.D., 1987, University of Wisconsin-Madison. Research and Teaching interests: Numerical Analysis, Partial Differential Equations, Inverse Problems.

EDGAR ACUÑA-FERNÁNDEZ, *Professor*, Ph.D., 1989, University of Rochester. Research and Teaching interests: Linear Models, Data Analysis, and Computational Statistics.

LUIS F. CÁCERES-DUQUE, *Professor*, Ph.D., 1998, University of Iowa, Iowa City, Iowa. Research and Teaching interests: geometry, problem solving, mathematics Olympiads.

GABRIELE CASTELLINI, *Professor*, Ph.D., 1986, Kansas State University. Research and Teaching interests: Category Theory, Categorical Topology and Commutative Algebra.

PAUL CASTILLO, *Professor*, Ph.D., 2001, University of Minnesota. Research and Teaching interests: Finite Element and Numerical Analysis, Scientific computation and applications.

OMAR COLÓN-REYES, *Professor*, Ph.D., 2005, Virginia Polytechnic Institute and State University. Research and Teaching interests: Discrete Dynamical Systems, Algebra, Field theory and applications.

ÁNGEL CRUZ-DELGADO, *Professor*, Ph.D. 2000, Louisiana State University. Research and Teaching interests: Pure Mathematics, Differential Equations.

STAN M. DZIOBIAK, *Assistant Professor*, Ph.D., 2011, Louisiana State University. Research and Teaching interests: Graph Theory, Graph Minors, Combinatorics. Teaching interests: Discrete

Mathematics, Number Theory, Abstract Algebra, Foundations of Mathematics, Algorithms, Calculus.

WIESLAW DZIOBIAK, *Professor*, Ph.D., 1982, Wroclaw University, Poland. Research and Teaching interests: Algebraic Logic.

MARGGIE D. GONZÁLEZ-TOLEDO, *Assistant Professor*, Ph.D., 2016, NC State University. Research and Teaching interests: Her research interests are in the areas of helping teachers develop new teaching practices in the secondary mathematics classroom. She is focused on designing new approaches to professional development that are more centered in teaching day-by-day practices. Her teaching interests are to teach future teachers of mathematics how to integrate technology into their teaching in ways that is meaningful to their student's learning.

DARRELL W. HAJEK, *Professor*, Ph.D., 1971, University of Florida. Research and Teaching interests: General Topology; Topological Extensions, Compactifications; Evaluation of Teaching Effectiveness; Numerical Analysis.

EDGARDO LORENZO, *Professor*, Ph.D., 2002, Wichita State University. Research and Teaching interest: Applied Statistics, Nonparametric Statistics, Survival Analysis.

FLOR E. NARCISO FARIAS, *Assistant Professor*, Ph.D., 1999, University of South Florida. Research interests: Human-Computer Interaction.

VICTOR A. OCASIO GONZALEZ, *Assistant Professor*, Ph.D., 2014, Notre Dame University. Research interests: Logic and Computability, Computable Structure Theory. Teaching interests: Model Theory, Computability, Set Theory, Abstract Algebra.

REYES M. ORTIZ-ALBINO, *Professor*, Ph.D., 2008, The University of Iowa. Research and Teaching interests: Mathematics, Ideal Theory, Generalized Factorization.

JUAN A. ORTIZ-NAVARRO, *Associate Professor*, Ph.D., 2007, University of Iowa. Research and Teaching interests: Quantum Topology, Knot Theory and 3 manifold invariants, Khovanov Homology, Reidemeister Torsion, Long Knots, Pure Mathematics, Computer Science.

ARTURO PORTNOY, *Professor*, Ph.D., 1997, Rensselaer Polytechnic Institute, Troy, NY. Research and Teaching interests: Analysis, Differential Equations, Applied Mathematics.

WILFREDO QUIÑONES, *Professor*, Ph.D., 1986, University of Massachusetts. Research and Teaching interests: Applied Mathematics and Analysis.

KAREN RÍOS-SOTO, *Associate Professor*, Ph.D., 2008, Cornell University. Research and Teaching interests: Bio-mathematics, Mathematical Epidemiology and Ecology, Population and Social Dynamics; Mathematical Biology, Mathematical Modeling, Differential Equations, Linear Algebra, Stochastic Processes, Dynamical Systems and Calculus.

OLGAMARY RIVERA-MARRERO, *Professor*, Ph.D., 2007, Virginia Tech Polytechnic Institute. Research and Teaching interests: Mathematics Education and Technology.

WOLFGANG ROLKE, *Professor*, Ph.D., 1992, University of Southern California. Research and Teaching interests: Mathematical Statistics, Probability Theory.

JUAN ROMERO-OLIVERAS, *Professor*, Ph.D., 2005, University of Maryland. Research and Teaching interests: Harmonic Analysis and Wavelet Theory and Applications to Biomedical Imaging, Calculus.

KRZYSZTOF ROZGA, *Professor*, Ph.D., 1976, University of Warsaw, Poland. Research and Teaching interests: Mathematical Physics, Differential Geometry.

HÉCTOR SALAS, *Professor*, Ph.D., 1983, University of Iowa. Research and Teaching interests: Analysis, Functional Analysis and Operator Theory; Calculus, Differential Equations, Linear Algebra, Real and Complex Analysis, Topology and Numerical Analysis.

DÁMARIS SANTANA, *Professor*, Ph.D., 2005, University of Florida. Research and Teaching interests: Applied Statistics.

FREDDIE SANTIAGO-HERNÁNDEZ, *Professor*, Ph.D., 1988, State University of New York at Stony Brook. Research and Teaching interests: Differential Geometry.

MARKO SCHÜTZ-SCHMUCK, *Professor*, Ph.D., 2001, J.W. Goethe University, Frankfurt. Research and Teaching interests: Software Engineering, Operating Systems, Open Source Software, Programming, Programming Languages.

LEV G. STEINBERG, *Professor*, Ph.D., 1988, Institute for Mathematics and Mechanics of Academy of Science, Alma-Ata, USSR. Research interests: Inverse Problems, Mathematical Modeling, Nonlinear Mechanics. Teaching interests: Differential Equations and Numerical Analysis.

PEDRO A. TORRES-SAAVEDRA, *Associate Professor*, Ph.D., 2013, North Carolina State University, Raleigh, North Carolina. Research and Teaching interests: Longitudinal data, mixed models, functional data, epidemiology and statistics education;

undergraduate statistics, sampling, mixed models and consulting.

ALEXANDER SHRAMCHENKO, *Associate Professor*, Ph.D., 1980, USSR Academy of Sciences. Research and Teaching interests: Fluid Dynamics, Stability, Symbolic Computation and Applied Mathematics.

PEDRO VÁSQUEZ-URBANO, *Professor*, D.Sc., 1997, George Washington University, Washington D.C. Research and Teaching interests: Linear and Non-linear Programming, Scheduling, Neural Networks.

ALEJANDRO VÉLEZ SANTIAGO, *Assistant Professor*, Ph. D., 2010, University of Puerto Rico at Río Piedras. Research and Teaching interests: Elliptic and parabolic boundary value problems on non-smooth domains, Generation of operator semigroups, Potential theory, Analysis on fractals, Operator theory. Differential Equations, Real & Complex Analysis, Functional Analysis, Operator Theory.

JULIO VIDAURAZAGA, *Professor*, Ph.D., 1982, State University of New York at Stony Brook. Research and Teaching interests: Riemannian Geometry, Positive Curvature, Analysis, Linear Algebra, Geometry.

UROYOÁN R. WALKER, *Professor*, Ph.D., 2001, Louisiana State University. Research and Teaching interests: Linear Algebraic Group, Galois Cohomology, Algebraic Number Theory, Quadratic Forms.

KEITH WAYLAND, *Professor*, Ph.D., 1979, Louisiana State University. Research and Teaching interests: Math Education, Number Theory, Combinatorics, Graph Theory.

XUERONG YONG, *Associate Professor*, Ph.D., 2002, Hong Kong University of Science and Technology. Research and Teaching interests: Special Matrices and Graph theory with applications.

DEPARTMENT OF KINESIOLOGY

The Kinesiology Department offers a Master's in Art in Kinesiology (MAK), with two options thesis (31 credits) or project (34 credits) in one of three areas: Teaching in Physical Education, Sports Training, and Exercise Physiology. Kinesiology is the study of movement or physical activity in which the main objectives are to study: a) the physiological, psychological responses and mechanical qualities of movement; b) the cultural, social and historical perspectives physical activity and sports; c) the motor skill learning and performance processes to change behaviors towards healthy lifestyles. Our graduates can work efficiently in the academic, governmental, and industrial endeavors or pursue doctoral studies.

Admission to the MAK Program is guided by the general regulations and requisites established by the Office of Graduate Studies. In addition to these requirements, only applicants with a minimum of an overall 2.50 GPA, a GPA in the area of specialization 3.00 or more in a bachelor's degree. Applicants must also have approved credit hours in the following areas: Exercise Physiology (3 crs.), Motor Learning (3 crs.), and Evaluation in Physical Education (3 crs.) or their equivalent, have obtained a score of 500 or more in the Admission to Graduate Studies (EXADEP), and submit two letters of recommendation. **Having complied with all the above requisites does not guarantee an automatic admission to the program.** Candidates will be competitively selected from within all who have met the requirements, after the consideration of faculty and/or budgetary dispositions. An interview with the MAK Admissions Committee is required if necessary or if an assistantship is solicited.

Departmental facilities include laboratories in exercise physiology, which houses a modern Bod Pod capsule for body composition measures among other lab equipment. The biomechanics laboratory that includes technical equipment, such as high speed cameras and software for human movement analysis. Also, the anthropometry, sport development, and the motor learning laboratories all located in the Rafael Mangual Coliseum.

Advanced Undergraduate Course

EDFI 5005. HEALTH ASSESSMENT. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: (BIOL 3715 and BIOL 3716) or authorization of the Director of the Department.

The application of the laws of mechanics to the analysis of sport techniques. A research project will be required.

Graduate Courses

EDFI 6005. ANALYSIS OF TEACHING PHYSICAL EDUCATION. Three credit hours. Three hours of lecture per week.

Analysis of teacher behavior, decisions and actions as the director of the teaching and learning process. Experiences in the performance and analysis of teaching skills through demonstrative classes are included. The student is expected to identify and apply the teacher behavior, decisions and actions that have proven to be effective, in their own teaching. Conferences, discussion, group work, observations and practice are included. A research project is required.

EDFI 6046. SAFETY IN PHYSICAL EDUCATION. Three credit hours. Three hours of lecture per week.

Risk management and prevention of accidents in physical education and sport programs; safety considerations and legal aspects. At the end of the course students must be able to recognize inherent risks and elaborate solutions for the prevention of accidents in different activities and in facilities for recreation and sport. Conferences, discussions, critical analysis of articles, and a research project are included.

EDFI 6105. LEARNING AND CONTROL OF MOTOR SKILLS. Three credit hours. Three hours of lecture per week.

Research methods and study of the factors influencing learning and control of motor skills such of memory systems, information processing, attention and performance, motor programming, individual differences and capabilities, practice conditions, feedback and knowledge of results, and motor memory. Students are expected to do research to determine how different variables influence motor learning and/or performance. Students are also expected to apply the learning and motor control concepts in the teaching and performance of motor skills. Conference, discussion and critical analysis of articles, and a research project are included.

EDFI 6107. CURRICULAR DESIGN IN PHYSICAL EDUCATION. Three credit hours. Three hours of lecture per week.

Analysis of traditional and innovative curricular designs in Physical Education, including the present curricular framework and the Physical Education Program Standards of Puerto Rico. The adaptation of the curricular design in accordance with school context is discussed. The student is expected to identify, select and design the implementation of a curricular design that best attends to the needs of the student population in becoming physically educated. Conferences, discussion and demonstrative classes are included. A research project is required.

EDFI 6209. EVALUATION AND PRESCRIPTION OF EXERCISE. Three credit hours. Three hours of lecture per week.

Scientific principles applied to the evaluation of physical fitness and health with emphasis on the interpretation and application of results. A combination of conferences and practical experiences to teach the skills related to the evaluation of physical components and health used in the preparation of the prescription of exercise regimes, are included. Communication skills for interview, and the performance and interpretation of physical fitness test will be discussed. The student is expected to evaluate physical fitness groups in the population and apply it in the preparation of exercise programs. A research project is required.

KINE 6015. THEORIES OF SPORTS TRAINING. Three credit hours. Three hours of lecture per week.

Study of the sports training theories and its application. Emphasis on the physiological, technical, and psychological aspects of the athlete and the training planning. The student is expected to plan the design and supervision of the training cycle of an athlete in any sport. Conference and critical review of related literature will be used. A project is included.

KINE 6105. CURRENT TOPICS IN KINESIOLOGY. Three credit hours. Three hours of lecture per week.

Trends and research of current topics in kinesiology, physical education, and sports. The student is expected to critically analyze, prepare reports and develop a research project related to a contemporary topic. Conferences, discussion, critical analysis of articles and oral presentations are included. A research project is required.

KINE 6107. ANTHROPOMETRY. Three credit hours. Three hours of lecture per week.

Measurements of the structure of the human body with emphasis in the athlete's performance in different sports. The student is expected to measure, evaluate, analyze and interpret anthropometric data in relation to the athlete's performance in sports. Conference, practice, reports, laboratories, discussion, and research report are included.

KINE 6109. PHYSIOLOGY OF THE ATHLETE IN SPORTS. Three credit hours. Three hours of lecture per week.

Study of the physiological changes in the athlete during performance of different sports and in the training requirements. Emphasis on the activities used for improving the performance of the cardio-respiratory and muscular-skeletal systems and the metabolism of the athletes who practice individual group sports. The student is expected to apply in the design of the athlete training the adequate activities that will attain the adaptations necessary for the different sports. Conference, group discussion and critical analysis of literature in the field of sport physiology will be used. A research project is required.

KINE 6115. SPORTS FACILITIES MANAGEMENT. Three credit hours. Three hours of lecture per week.

Planning, design, and operation of facilities for instruction, recreation and sport activities. Field trips required.

KINE 6125. LEGAL ASPECTS IN THE ADMINISTRATION OF KINESIOLOGY, SPORTS AND RECREATION. Three credit hours. Three hours of lecture per week.

Legal considerations in the administration of Kinesiology, athletics, and Recreation. The students will discuss legal aspects and responsibilities as they relate to the administration of programs in these areas. It includes lectures, critical analysis of articles, and an individual research project.

KINE 6155. PHYSICAL ACTIVITY FOR SENIOR CITIZENS. Three credit hours. Three hours of lecture per week.

The role of physical activity in the maintenance of the physical, mental, and social health of senior citizens. The student is expected to design and develop programs in physical activity directed to improve and maintain the health of senior citizens. Conference, discussion and critical analysis of articles, reports, and research project are included. Field trips are required.

KINE 6205. ANALYSIS OF HUMAN MOVEMENT. Three credit hours. Three hours of lecture per week.

The analysis of human movement using video images in two dimensions and the quantitative methods of kinematics. The student is expected to acquire a video of the execution of a sport or exercise skill and analyze quantitative aspects of the kinematics of it. Conference, discussion, some laboratories, and a movement analysis project are included.

KINE 6500. GRADUATE SEMINAR. One credit hour. One hour of seminar per week.

Discussion, oral presentations, and written reports performed by the student in topics of kinesiology and physical education. The student is expected to create a written report in topics of kinesiology and physical education and present it to an audience for its discussion.

KINE 6905. PROJECT. Three credit hours. Nine hours of research per week.

Comprehensive study of a concrete and practical problem in kinesiology or physical education with the purpose of integrating the acquired knowledge in the graduate program. It includes the formulation of a problem, the review of literature, collection of data, analysis, conclusion, the presentation of a defense of the project. It is expected that the student be capable of presenting a project to solve a problem in one of the subareas of kinesiology or physical education and of approving an oral exam before the Examiner Committee.

KINE 6985. RESEARCH METHODS IN KINESIOLOGY. Three credit hours. Three hours of lecture per week.

Research methodology in human movement and sports.

KINE 6991. INDEPENDENT STUDY. One to three credit hours. Three to nine hours of research per week.

Elaboration of a supervised pilot investigative project on a Kinesiology, Physical Education or sports topic. The formulation of the problem, review of literature, data collection, analysis and conclusion may be included. The student is expected to make a presentation and a written report of the investigation.

KINE 6992. SPECIAL TOPIC. One to three credit hours. One to three hours of lecture per week.

Special topic in kinesiology, not offered in courses in the university catalogue. Discussion of a

specialized topic of interest for students or offered by a visiting professor. The student is expected to discuss and present reports related to the special topic. Conferences, discussion, presentations and laboratory are included. A research project is required.

KINE 6999. RESEARCH AND THESIS. Three to six credit hours. Nine to eighteen hours of research per week.

Supervised research in kinesiology (includes teaching or physical education). Review of literature, data collection, analysis, presentation, and defense of a master's thesis are included. Students are expected to complete a research in kinesiology (includes teaching or physical education) and defend it in front of a graduate committee.

Physical Education Faculty

A list of professors who engage in graduate activities in the Department follows including their highest earned degree, date, institution granting the degree.

RAMON L. ALVAREZ-FELICIANO, *Assistant Professor*, E.Ed., 2015, University of Puerto Rico-Rio Piedras.

IBRAHIM M. CORDERO-MORALES, *Professor*, Ph.D., 2002, Florida State University.

LUIS O. DEL RÍO-PÉREZ, *Professor*, Ph.D., 1989, University of Pittsburgh.

MARGARITA FERNÁNDEZ-VIVÓ, *Professor*, Ph.D., 2002, Florida State University.

HECTOR HEREDIA-VARGAS, *Assistant Professor*, Ph.D.; 2015, University of Miami.

EFRANK MENDOZA-MARTÍNEZ, *Professor*, Ph.D., 1990, The University of New Mexico.

CARLOS E. QUIÑONES-PADOVANI, *Associate Professor*, Ph.D., 2009, Florida State University.

ENID A. RODRÍGUEZ-NOGUERAS, *Assistant Professor*, Ph.D., 2010, University of North Carolina at Greensboro.

MANUEL SILVA, *Assistant Professor*, Ph.D., 2014, Claremont Graduate University.

EDUARDO SOLTERO-FLORES, *Professor*, Ed.D., 1988, University of Houston.

DIANA RODRÍGUEZ-VEGA, *Professor*, Ed.D., 1996, Teachers College Columbia University, N.Y.

IRIS FIGUEROA-ROBLES, *Associate Professor*, Ph.D., 2012, Florida State University.

PHYSICS

The Department of Physics offers a graduate program leading to a Master of Science degree. Applicants for admission should have a Bachelor's degree in Physics or related subject, and must meet the requirements of the Graduate Studies Office. Students not meeting these requirements may be admitted on a provisional basis until leveling courses are completed.

At the present, the Master of Science Degree of the Department of Physics follows Plan I. With Thesis Requirement. All students need to complete all courses in The Plan of Graduate Studies with a GPA of at least 3.00. The courses in the Plan of Graduate Studies are the following:

FISI 6090 Introduction to Theoretical Physics I	3 crds.
FISI 6190 Introduction to Theoretical Physics II	3 crds.
FISI 6431 Theory of Electricity and Magnetism	3 crds.
FISI 6451 Introduction to Quantum Mechanics	3 crds.
FISI 6280 Graduate Seminar I	1 crds.
FISI 6380 Graduate Seminar II	1 crds.
Electives in specialization	6 crds.
Electives outside of specialization	6 crds.
FISI 6991 Physics Research	6 crds.

All students are required to carry out a research project, as specified in the Plan of Graduate Studies, prepare a thesis, and pass an oral exam.

There are current research projects in the Department of Physics in fields such as Condensed Matter/Materials Science, Laser Spectroscopy, High Energy Physics, Astrophysics and Radioastronomy, Statistical Physics and Mathematical Modeling for Biological Applications, and Atmospheric Physics. Department facilities for research include well-developed laboratories for experimental research in laser spectroscopy and condensed matter/materials science, and facilities for computational work. For laser spectroscopy and nonlinear-optical studies, the Department of Physics research laboratories are equipped with a wide variety of laser sources producing beams from continuous wave to femtosecond pulses, and advanced spectroscopic equipment including double spectrometers and photon counting systems. Thin film and crystal growth facilities include systems for pulsed laser deposition, DC and RF sputtering, metal-organic chemical vapor deposition, and sol-gel techniques, high temperature furnaces and other sample preparation equipment. Materials characterization facilities include a high-resolution x-ray

diffractometer specially equipped for thin film studies, atomic force/scanning tunneling microscope, systems for low-temperature electronic, optical, and magneto-optical studies of solids, multiple wavelength ellipsometer, and an electron spin resonance spectrometer. Additional facilities are available to researchers through other UPRM facilities and the UPR Materials Characterization Center.

Experimental research in high energy Physics is conducted in close collaboration with Fermilab, in Illinois, and advanced data analysis and transmission facilities to aid this effort are located in the Department of Physics. Research in Radioastronomy is performed with the Arecibo Radiotelescope. Distributed computational resources sustaining research are available through several laboratories, and the computer room for use by students and faculty, and through communication connections to campus and external facilities. The Department also has a precision machine shop supporting research activities. Additional facilities include an automated 16-inch reflector telescope, and a planetarium with capacity for 60 occupants.

PROGRAM OF STUDY

MASTER OF SCIENCE IN PHYSICS CURRICULUM

FIRST YEAR

First Semester

Number	Credits	Course
FISI 6090	3	Introduction to Theoretical Physics I
FISI 6431	3	Theory of Electricity and Magnetism
ELECTIVE*	<u>3</u>	Elective in specialization or outside of specialization
	9	

Second Semester

Number	Credits	Course
FISI 6190	3	Introduction to Theoretical Physics II
FISI 6451	3	Introduction to Quantum Mechanics
ELECTIVE*	<u>3</u>	Elective in specialization or outside of specialization
	9	

SECOND YEAR

First Semester

Number	Credits	Course
ELECTIVE*	3	Elective in specialization or outside of specialization
FISI 6280	1	Graduate Seminar I
FISI 6991	<u>3</u>	Physics Research
	7	

Second Semester

Number	Credits	Course
ELECTIVE*	3	Elective in specialization or outside of specialization
FISI 6380	1	Graduate Seminar II
FISI 6991	<u>3</u>	Physics Research
	7	

* Only 6 credits in electives in specialization and 6 credits in electives outside specialization are required.

Advanced Undergraduate Courses

FISI 5025. INTRODUCTION TO SOLID STATE PHYSICS. Three credit hours per semester. Three hours of lecture per week each semester. Prerequisites: FISI 5037 or authorization of the Director of the Department.

An introduction to X-ray diffraction, crystal structures, elastic constant of crystals, lattice energy and vibrations; thermal properties of solids, dielectric properties, ferroelectric crystals; diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism; free electron model of metals, superconductivity, excitons, photoconductivity and luminescence.

FISI 5037. INTRODUCTION TO SOLID STATE PHYSICS (On demand). Three credit hours per semester. Three hours of lecture per week each semester.

An introduction to X-ray diffraction, crystal structures, elastic constant of crystals, lattice energy and vibrations; thermal properties of solids, dielectric properties, ferroelectric crystals; diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism; free electron model of metals, superconductivity, excitons, photoconductivity and luminescence.

FISI 5045. PHYSICS OF FLUIDS. Three credit hours. Three hours of lecture per week. Prerequisites: MATE 4009, FISI 3152 and authorization of the Director of the Department.

Hydrostatics, mathematical models of fluid dynamics, dimensional analysis and similitude, boundary layer flow in pipes and ducts, incompressible potential flow.

FISI 5047. LASER PHYSICS. Three credit hours. Three hours of lecture per week. Prerequisites: (FISI 4105 and FISI 4068) or authorization of the Director of the Department.

Semiclassical theory of laser operation. Analysis of laser light characteristics, interaction of radiation with matter, optical resonators, pumping schemes, common laser systems, and non-linear optics.

METE 5065. ADVANCED DYNAMIC METEOROLOGY. Three credit hours. Three hours of lecture. Prerequisites: (METE 4061 and MATE 4009) or authorization of the Director of the Department.

Discussion of the quasi-geostrophic approximation, linear perturbation theory, and baroclinic instability to describe atmospheric motion in middle latitudes. Mesoscale phenomena and the general circulation of the atmosphere, variability over tropical latitudes, and principles of numerical modeling for atmospheric motion will be studied.

Graduate Courses

FISI 6051-6052. MATHEMATICAL PHYSICS (On demand). Three credit hours. Three hours of lecture per week each semester.

Calculus of variations, Lagrange's equations of motion, Hamilton's equations, contact transformation, introduction to quantum theory and special theory of relativity; mathematical theory of vibrations, statistical mechanics, introduction to theory of elasticity, electrodynamics and other related topics.

FISI 6060. NUCLEAR PHYSICS (On demand). Four credit hours. Four hours of lecture per week.

Fundamentals of quantum theory of the nucleus; mathematical theory of scattering, neutron-proton scattering; theory of nuclear reactions, theory of beta decay, and other related topics.

FISI 6090. INTRODUCTION TO THEORETICAL PHYSICS. Three credit hours per semester. Three lectures per week each semester.

Introduction to the problems and methods of theoretical physics; dynamics, electrodynamics, statistical mechanics, quantum mechanics, hydrodynamics and elasticity.

FISI 6190. INTRODUCTION TO THEORETICAL PHYSICS II. Three credit hours. Three hours of lecture per week. Prerequisites: authorization of the Director of the Department.

Introduction to the problems and methods of theoretical physics, dynamics, electrodynamics, statistical mechanics, quantum mechanics, hydrodynamics and elasticity.

FISI 6280-6380. GRADUATE SEMINAR (I)-(II). One credit hour per semester. Two hours of lecture per week each semester.

Discussions and reports on special topics in physics.

FISI 6431-6432. THEORY OF ELECTRICITY AND MAGNETISM (I)-(On demand). Three credit hours per semester. Three hours of lecture per week each semester.

Discussion of problems in electrostatics, magnetostatics and stationary currents; formulation of Maxwell's equations, electromagnetic wave theory, and radiation from moving charges, etc.

FISI 6451-6452. INTRODUCTION TO QUANTUM THEORY (II)-(On demand). Three credit hours per semester. Three hours of lecture per week each semester.

Introductory background to Quantum Theory; wave mechanical method and some of its applications to one-particle problem; linear oscillators and spatial oscillators; radiation and fields; approximate methods; perturbation theory; introductory general formulation of Quantum Theory.

FISI 6477. ELEMENTARY PARTICLES. Three credit hours. Three hours of lecture per week.

The physics of elementary particles and their interactions.

FISI 6510. SPECIAL TOPICS IN PHYSICS (I, II). One to nine credit hours. One to nine hours of lecture per week. Prerequisite: authorization of Director of Department.

Specialized topics in physics such as high-energy physics, nuclear reaction physics, plasma physics, low temperature physics, cosmology and others.

FISI 6991. PHYSICS RESEARCH (I, II, S). One to six credit hours.

The student will choose a member of the faculty as his adviser. Presentation of a thesis is required for credit.

Astronomy (ASTR)

ASTR 5005. FORMATION AND EVOLUTION OF GALAXIES. Three credit hours. Three hours of lecture per week.

Formation, types, structures, evolution, and interaction of galaxies.

ASTR 5007. PLANETARY ASTRONOMY. Three credit hours. Three hours of lecture per week. Prerequisite: ASTR 4005 or authorization of the Director of the Department.

The study of the properties, physical formation, and evolution of the planets and the solar system.

ASTR 6001-6002. INTRODUCTION TO CELESTIAL MECHANICS (On demand). Three credit hours per semester. Three hours of lecture per week each semester.

Fundamental principles of astronomy and dynamics, with emphasis on the theoretical aspect: general equations of motions for bodies in an isolated system; integrals of motion, orbits, planetary equations, perturbations, canonic equations, contact transformations, lunar theory and the satellite problems.

ASTR 6991. SPECIAL TOPICS IN ASTRONOMY AND ASTROPHYSICS. One to six credit hours. One to six hours of lecture per week.

Selected topics in astronomy and astrophysics.

PHYSICS FACULTY

A list of professors who engage in graduate activities in the Department follows including their highest earned degree, date, institution granting the degree, and research interests.

LUIS BEJARANO-AVEDAÑO, *Associate Professor*, Ph.D. 2006, Florida State University. Research Interest: Geophysical Fluid Dynamics.

FÉLIX E. FERNÁNDEZ, *Professor*, Ph.D., 1987, University of Arizona. Research interests: Thin Film Physics, Materials Characterization.

ÁNGEL A. GAUD, *Professor*, M.S., 1968, University of Puerto Rico, Juris Doctor, 1980, Pontifical Catholic University of Puerto Rico.

HÉCTOR JIMÉNEZ-GONZÁLEZ, *Professor*, Ph.D., 1992, Massachusetts Institute of Technology. Research interests: Experimental Solid State Physics, Magneto-optics.

YONG-JIHN KIM, *Professor*, Ph.D., 1989, Seoul National University. Research interests: Theoretical Solid State Physics, Superconductivity.

MARK JURY, *Professor*, Ph.D., 1984, University of Cape Town. Research interest: Meteorology.

JOSÉ R. LÓPEZ, *Professor*, Ph.D., 1983, Michigan State University. Research interests: Physics Education, Biophysics.

SERGIY LYSENKO, *Professor*, Ph.D. 2001, Institute of Semiconductor Physics, NAS, Kiev, Ukraine. Research Interests: Solid State, Ultrafast Spectroscopy.

JUNQIANG LU, *Associate Professor*, 2003, Tsinghua University, Beijing, China. Research interests: Nanoscale Solid State Theory.

SUDHIR MALIK, *Associate Professor*, Ph.D., 1997, University of Delhi, India. Research Interests: Experimental High Energy Physics.

PABLO J. MARRERO-SOTO, *Professor*, Ph.D., 2001, University of Massachusetts at Amherst. Research interests: Thin Film Physics, Quantum Theory.

HÉCTOR MÉNDEZ-MELLA, *Professor*, Ph.D., 1990, Centro de Investigación y Estudios Avanzados, Mexico City. Research interests: Experimental High Energy Physics.

LESZEK NOWAKOWSKI, *Professor*, Ph.D., 1983 N. Copernicus University, Torun, Poland. Research interests: Radioastronomy, Astrophysics of Pulsars.

MOISÉS ORENGO-AVILÉS, *Professor*, Ph.D., 1996, Brown University. Research interests: Physics Education, Nuclear Magnetic Resonance.

CARLOS U. PABÓN, *Professor*, Ph.D., 1994, City College of New York. Research interests: Atmospheric Physics.

RAÚL PORTUONDO, *Professor*, Ph.D., University of La Habana -UH-. Research interest: Pedagogy.

HENRI A. RADOVAN, *Professor*, Ph.D., 1998, University of Ulm, Germany. Research interests: Experimental Solid State Physics, Superconductivity.

JUAN E. RAMÍREZ, *Professor*, Ph.D., 2002, University of Colorado at Boulder. Research interests: Experimental High Energy Physics.

RAFAEL A. RAMOS, *Professor*, Ph.D., 1994, Boston University. Research interests: Computational Materials Science, Statistical Physics.

ERICK ROURA-DÁVILA, *Professor*, Ph.D., 2001, University of Massachusetts at Amherst. Research interests: Quantum Theory.

ARMANDO RÚA, *Assistant Professor*, Ph.D., 2014, City University of New York. Research Interest: Condensed Matter Physics.

SAMUEL SANTANA-COLÓN, *Associate Professor*, Ph.D., 2008, Indiana University.

COLLEGE OF BUSINESS ADMINISTRATION

Mission

Prepare qualified graduates for the business world through excellence in education and the advancement of locally and internationally recognized research.

Vision

To be Puerto Rico's best option in Business Administration with the best students, professors and recruiters.

Culture

With the purpose of creating a culture that supports our vision and mission, the College of Business Administration:

- Promotes pedagogical approaches that facilitate teaching and learning.
- Maintains undergraduate and graduate curricula that encourage practical experience and are up-to-date with technological and global changes, allowing for competitive differentiation.
- Sponsors active student organizations that encourage leadership and participative citizenship.
- Develops a learning community with common goals, willing to support and serve other faculties within the UPR system and the Caribbean.
- Encourages processes that promote effective communication with our stakeholders.
- Values honesty, service and quality
- Encourages an organizational culture that procures excellence through a responsive administration with minimum bureaucratic processes, with an environmental conscience for business.
- Supports teamwork.
- Encourages the continuous improvement of our faculty.

Educational Objectives

LEARNING OBJECTIVES

1. Differentiate and match appropriate leadership styles within a given business situation.
2. Identify and analyze ethical issues embodied in realistic scenarios or cases.
3. Develop and write a consistent and well organized research project by accessing, analyzing and synthesizing data to make recommendations.
4. Apply appropriate quantitative models to make business decisions.
5. Demonstrate business knowledge by implementing in a simulation, business levels strategies that improve overall performance.
6. Identify and explain business opportunities

Academic Programs

The College of Business Administration offers a program leading to both, a Master of Business Administration degree and an MBA with specialization in Human Resources, Industrial Management or Finance.

Applicants for admission should have a Bachelor's degree from an accredited university and must meet the general requirements of the Graduate Studies Office (Certification #09-09).

All candidates should also

- Have approved the following courses at the undergraduate level:
 - CONT 3011 & CONT 3012, or 6-8 equivalent credits in basic accounting
 - ESTA 3001 & ESTA 3002, or 6-8 equivalent credits in business statistics.
- Foreign Applicants whose native language is
 - Other than English
 - Must also take TOEFL and achieve a minimum of 500 (written) and 173 (computerized) in their score
 - Other than Spanish
 - Submit evidence of Spanish proficiency (Spanish courses, standardized test results)

Students admitted to the program are required to meet all requisites of the Graduate Studies Office and to approve 48 credit hours divided as follows:

Core courses (21 credit hours)

- Managerial Accounting
- Managerial Economics
- Managerial Statistics
- Financial Management
- Organizational Behavior
- Managerial Quantitative Methods
- Marketing Management

A maximum of twelve credits may be approved by examination from the core courses described above.

Elective Courses

Twenty-one credits must be approved in elective courses. Courses vary according to the specialization areas.

Capstone Courses (6 credit hours)

- Development of Medium and Small Business
- Business Policy

COURSES OFFERED

(I): Normally offered during the First Semester

(II): Normally offered during the Second Semester

(S): Normally offered during the Summer Session

(OD): Based on demand

ACCOUNTING (CONT)

CONT 5006. TAX LIABILITIES FOR BUSINESSES IN PUERTO RICO (II) (OD). Three credit hours. Three hours of lecture per week.

A comprehensive study of business tax liabilities in Puerto Rico under local or federal laws. Includes topics such as property, municipal, labor-related and excise taxes as well as tax exemptions under the Industrial Incentives Act.

CONT 6005. MANAGERIAL ACCOUNTING (I). Three credit hours. Three hours of lecture per week.

Fundamental accounting concepts and techniques and their application to all types and functions of organizations. Study of the relationships between accounting techniques and business operations control through the case solution approach. Financial statement analysis and their relevance in the decision making process. Tax effects on business decisions. Emphasis on planning and control.

ADMINISTRATION (ADMI)

ADMI 6005. SPECIAL TOPICS (OD). Three to six credit hours. Three to six hours of lecture per week.

Selected topics in Business Administration.

ADMI 6006. COOP PLAN PRACTICE (I)(II)(S). One to three credit hours. Prerequisite: 18 credits approved in the graduate program.

Supervised work experience in a government agency, a private enterprise or foundation, in accordance with the student's academic background and the job requirements.

ADMI 6008. DEVELOPMENT OF MEDIUM AND SMALL BUSINESS (II). Three credit hours. Three hours of lecture per week. Prerequisites: CONT 6005, ESTA 6005, GERE 6025, ECON 6027, FINA 6015, MERC 6055, and GEIN 6035.

Study and analysis of the development of small and medium size business in manufacturing, service and retailing sectors. Study of legal aspects in the establishment of a business, development of appropriate record keeping and accounting systems, identification and servicing of appropriate markets, financing and uses of funds and concepts of human resources management needed for an efficient business operation.

ADMI 6097. PROJECT (I), (II). Zero to three credit hours. Zero to three hours of lecture per week.

Comprehensive study of a business problem with the purpose of integrating the knowledge acquired in the graduate program.

ADMI 6996. THESIS (I), (II). Zero to six credit hours.

Research in Business Administration. Presentation and approval of a thesis is required.

COMPUTERIZED INFORMATION SYSTEMS (SICI)

INEL/ICOM/SICI/COMP 5318.

INTERMEDIATE ROUTING, SWITCHING AND WIDE AREA NETWORKS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL/ICOM/SICI/COMP 4308 or authorization of the Director of the Department.

Study and configuration of link state protocols. Study of intermediate level concepts such as

switching, wide area network or WAN standards, virtual local area networks or VLAN, network design, and redundancy. Presentation and study of strategies for managing and saving address space such as variable length subnet masks and network address translation.

SICI 6065. MANAGEMENT INFORMATION SYSTEMS (II, OD). Three credit hours. Three hours of lecture per week.

This course provides a general understanding of information systems and information technology (IS/IT), planning and development, information resources management and social impacts of informatics. It discusses how information is used for decision support in organizations and how information systems enable competitive advantage.

ECONOMICS (ECON)

ECON 6027. MANAGERIAL ECONOMICS (I). Three credit hours. Three hours of lecture per week.

Study of several economic concepts and their applications to managerial problems in different markets. Analysis of the economic system in the aggregate level and of production cost; price setting under different market structures, demand and supply, elasticity and capital cost.

FINANCE (FINA)

FINA 5015. PRINCIPLES OF FINANCIAL ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisites: (ESTA 3002 and MATE 3049) or authorization of the Director of the Department.

Introduction to the development of financial strategies and financial instruments according to the efficient market hypothesis.

FINA 6015. FINANCIAL MANAGEMENT (II). Three credit hours. Three hours of lecture per week.

Management decisions concerning the acquisition, distribution and control of funds; role of money and capital markets in decision making; short-term financing policies and the various considerations taken in developing financial strategies. Cases are used to demonstrate the process of financial decision-making.

FINA 6016. PUBLIC FINANCE (I) (OD). Three credit hours. Three hours of lecture per week. Prerequisites: FINA 6015.

Theoretical and applied aspects of the allocation of resources and economic stabilization policies in modern states. Theory on public expenditures, tax collection and its outcomes; effect of public debt financing.

FINA 6017. INVESTMENT ANALYSIS AND PORTFOLIO THEORY (I) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: FINA 6015.

Analysis of an investment opportunity within the context of the most recent theories on risk diversification and balance on investment portfolios; investment strategy on portfolio management.

FINA 6018. CORPORATE FINANCIAL STRATEGIES AND POLICIES (II) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: FINA 6015.

Problems related to management of assets, liabilities and capital. Emphasis on financial decisions and the formulation of financial policies in two basic areas: working capital management and capital budgeting decisions.

FINA 6019. INTERNATIONAL FINANCE (II), (OD). Three credit hours. Three hours of lecture per week. Prerequisite: FINA 6015.

Theoretical and empirical aspects of the financial management of enterprises that operate in an international business environment, emphasizing multinational enterprises (MNE's). Development of knowledge, attitudes, and skills needed to make financial decisions for organizations such as multinational enterprises.

FINA 6025. ADMINISTRATION OF FINANCIAL INSTITUTIONS (I), (OD). Three credit hours. Three hours of lecture per week.

A study of the economic, legal and tax environment in which financial institutions operate. Assets and liabilities management for depositary and non-depositary institutions. Risk management on changes in interest rate, credit risk and planning the liquidity of long and short term investment.

HUMAN RESOURCES MANAGEMENT (GERH)

GERH 6027. LEGAL ASPECTS OF BUSINESS ORGANIZATION (II, OD). Three credit hours. Three hours of lecture per week.

Social and philosophical aspects of the law; its systems, functions, processes and limits, applied to business organization in its internal and external issues.

GERH 6028. INNOVATION AND ORGANIZATIONAL CHANGE (II) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: GERE 6025.

Different approaches for planned change in organizations from long-range viewpoint. Structural, technological, and behavioral changes; models of change; methods of intervention; behavior of the change agent; measurement of change. Innovation processes, theories of creativity, technological innovations, and organizational change are explored in terms of their implications for managerial action.

GERH 6029. LEADERSHIP IN FORMAL ORGANIZATIONS (II, OD). Three credit hours. Three hours of lecture per week. Prerequisite: GERE 6025.

Identification of effective managerial styles within a contingency perspective. Present orientation in leadership theories, the nature of managerial work, and major roles performed by leaders in different types of organizations. Measurement instruments, simulations and analysis of vocational interest of manager, and their applications to managerial functions.

GERH 6030. SUPERVISORY MANAGEMENT (I) (OD). Three credit hours. Three hours of lecture per week.

Supervision as a managerial function, emphasizing those personal, administrative, and human relation skills needed for an effective supervision. Legal aspects, at the state and federal levels, which supervisors face on a daily basis.

GERH 6037. WAGE AND SALARY ADMINISTRATION (II, OD). Three credit hours. Three hours of lecture per week.

Development and maintenance of internally equitable and externally competitive compensation programs. The role of compensation in the recruitment, retention, and motivation of employees.

Topics include: compensation as an exchange process, compensation and behavioral concepts, job analysis and evaluation, salary structures, incentive plans, employee benefits, legal aspects and executive compensation.

GERH 6040. FOUNDATIONS OF HUMAN RESOURCES MANAGEMENT (I) (OD). Three credit hours. Three hours of lecture per week.

An in-depth study of the major functions of human resources administration. Emphasis is given to recruitment, performance appraisal and fringe benefits. Consideration is given to the impact of current legislation on these areas.

INDUSTRIAL MANAGEMENT (GEIN)

GEIN 6005. PHYSICAL DISTRIBUTION AND LOGISTICS (II) (OD). Three credit hours. Three hours of lecture per week.

Study of physical distribution systems; an examination of the costs involved in physically moving and storing the product from its production point to the point it is purchased; an analysis of the efforts to coordinate physical distribution and materials management in order to reduce costs and improve services.

GEIN 6035. MANAGERIAL QUANTITATIVE METHODS (II). Three credit hours. Three hours of lecture per week. Prerequisite: ESTA 6005.

Mathematical approach to analysis and solution of complex business problems with special emphasis on their formulation and solution procedures in areas such as: inventory control, linear programming, integer programming, queuing, and decision theories.

GEIN 6036. DECISION ANALYSIS (I, OD). Three credit hours. Three hours of lecture per week. Prerequisite: GEIN 6035 or MECU 6035 or authorization of the Director of the Department.

Strategies used in the decision making process and their applications in long range planning. Use of decision trees and probabilistic analysis in decision making.

GEIN 6038. QUALITY CONTROL (II) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: ESTA 6005.

Assumptions and technical postulates that support quality control: sampling, control charts, estimation of the characteristics of industrial processes,

hypothesis testing and analysis of variance. Emphasis on the integration of the quality control function to the decision making process.

GEIN 6039. FORECASTING MODELS FOR THE FIRM (I) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: ESTA 6005.

Forecasting methods, their essential characteristics, and their application. Forecasting within the firm, acquisition of data, planning of the forecasting process, maintenance of systems in use and identification and implementation of new developments.

GEIN 6045. PRODUCTION CONTROL (I), (OD). Three credit hours. Three hours of lecture per week. Prerequisite: GEIN 6035 or MECU 6035.

New developments in the area of production control. Analysis of techniques and models in recent literature in areas such as: inventory control, production planning, scheduling, forecasting and control models. Application of these techniques to current problems.

GEIN 6047. MATERIALS MANAGEMENT AND PURCHASING (I) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: GEIN 6035 or MECU 6035.

Functions and contributions of purchasing and materials management in the organization. Management of transportation, traffic and purchasing activities. Analysis and control techniques in purchasing and materials management.

GEIN 6048. MANUFACTURING STRATEGIES (I) (OD). Three credit hours. Three hours of lecture per week.

Basic links between manufacturing processes and the corporate infrastructure. Study of the contribution of the manufacturing function to the development of corporate strategies.

GEIN 6065. PROJECT MANAGEMENT (II) (OD). Three credit hours. Three hours of lecture per week.

Study of the concepts and applications of project management, its evolution, importance, and the managerial implications for contemporary organizations. The planning, management and control of projects including the different phases in its life cycle will be studied in detail.

MANAGEMENT (GERE)

GERE 6025. ORGANIZATIONAL BEHAVIOR (I). Three credit hours. Three hours of lecture per week.

Study of the social and psychological aspects needed to understand the behavior of individuals within an organization. Management strategies for organizational effectiveness. Topics such as individual and small group behavior, goal definition, organizational structure, and leadership will be considered.

GERE 6026. ORGANIZATIONAL DESIGN (I, OD). Three credit hours. Three hours of lecture per week. Prerequisite: GERE 6025.

Evaluation of organizational design structures, measurements of system performance, and problems in the design of adaptive systems. Job specialization, behavior formalization, units grouping, unit size, lateral relationships, and vertical and horizontal decentralization are some of the parameters of design to be considered.

GERE 6035. BUSINESS RESEARCH METHODS (II), (OD). Three credit hours. Three hours of lecture per week. Prerequisite: ESTA 6005.

Management research formats; study design; study sampling and reliability; techniques on how to report and register behavior.

GERE 6036. INTERNATIONAL MANAGEMENT (I, OD). Three credit hours. Three hours of lecture per week.

The multinational enterprise, its activities, environment and limitations, including external aspects like the legal area, cultural environment and social responsibility and control. Internal aspects such as strategies aimed at attaining the enterprise's objectives, information systems, cost transfer, management performance evaluation, and risk management in foreign investment projects.

GERE 6055. BUSINESS, GOVERNMENT AND SOCIETY (II) (OD). Three credit hours. Three hours of lecture per week.

Study of the interrelationships between profit or non-profit organizations and their external environments; consideration of the public policy process.

GERE 6056. ENVIRONMENTAL DECISION MANAGEMENT (I, OD). Three credit hours. Three hours of lecture per week.

Study of environmental issues and programs from the managerial decision-making perspective with emphasis on the design and implementation of environmental management systems; the industrial ecology approach as an alternative to the traditional approach to environmental management.

GERE 6096. BUSINESS POLICY (I). Three credit hours. Three hours of lecture per week. Prerequisites: CONT 6005, ESTA 6005, GERE 6025, FINA 6015, (GEIN 6035 or MECU 6035), MERC 6055, and ECON 6027.

Analysis and interpretation of the formulation and implementation of policies that integrate different functional areas of a business. The study of managerial complex cases will be emphasized.

MARKETING (MERC)

MERC 6055. MARKETING MANAGEMENT (II). Three credit hours. Three hours of lecture per week.

Fundamental elements and the decision making process in management and planning of marketing activities.

MERC 6056. MARKETING COMMUNICATION STRATEGY (I) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: MERC 6055.

Communication as an integral part of marketing strategy. The essential role of the various components of communication in the total marketing strategy examined under different marketing conditions. Design and implementation of a marketing communication strategy.

MERC 6057. CONSUMER ANALYSIS (II) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: MERC 6055.

Behavior of the final consumer and the processes directly related to the acquisition and consumption of goods and services. Use of models of behavior to illustrate the decisional process, and the concepts involved in establishing strategies for new products, distribution systems and pricing decisions.

MERC 6065. MARKETING RESEARCH (I) (OD). Three credit hours. Three hours of lecture per week. Prerequisites: MERC 6055.

Applied research in the area of marketing: identification and solution of marketing problems; research design, measurement, data collection and

analysis in consumer behavior, product, advertising and sales estimates; analytical methods commonly used in these areas; development of solutions and action recommendations.

STATISTICS (ESTA)

ESTA 6005. MANAGERIAL STATISTICS (I). Three credit hours. Three hours of lecture per week.

Probability theory, statistical inference, and decision theory applied to managerial decision problems. Basic theoretical concepts that support the statistical methods. Analysis and discussion of cases with statistical background.

ESTA 6006. EXPERIMENTAL DESIGN AND ANALYSIS (II) (OD). Three credit hours. Three hours of lecture per week. Prerequisite: ESTA 6005.

Fundamental concepts in the design of experiments: principles of inferential statistics, statistical linear models, block models, factorial models, and analysis of variance. Use of computer software for the solution of statistical problems related to business.

BUSINESS ADMINISTRATION FACULTY

A list of professors who engage in graduate activities in the Department follows including the highest earned degree, date obtained, and institution granting the degree. Research and teaching interests are also included.

MARÍA AMADOR-DUMOIS, Professor, Ph.D., 2005, George Washington University. Research and Teaching interest: International Business, Entrepreneurship, Project Management and Strategic Management.

MARIO CÓRDOVA-CLAUDIO, Professor, Ph.D., 1998, Rutgers - The State University of New Jersey. Research and Teaching interest: Operations Management, Operations Research.

EVALUZ COTTO-QUIJANO, Associate Professor, L.L.M., 1996, Georgetown University, Ph.D, 2011, University of London. Research and Teaching interests: Financial Services Law.

JOSÉ A. CRUZ-CRUZ, Professor, Ph.D., 1997, University of Pittsburgh. Research and Teaching interests: Intelligent Business Systems, Management Information Systems and Ethic Across the Curriculum.

DARIK Y. CRUZ-MARTÍNEZ, *Assistant Professor*, LL.M., 2007, Boston University. Research and Teaching interests: Corporate Finance, Public Finance, Financial Institutions Management, Business Law, International Finance and Corporate Governance.

AURY CURBELO-RUIZ, *Professor*, Ph.D., 2002, The Ohio State University. Research and Teaching interests: Information Security, computer and mobile forensic analysis, risk management, malwares and cyber security.

MORAIMA DE HOYOS-RUPERTO, *Associate Professor*, Ph.D., 2012, Case Western Reserve University. Research and Teaching interests: Entrepreneurial Ecosystem, Entrepreneurial Education, Entrepreneurial Metrics

CARMEN FIGUEROA MEDINA, *Assistant Professor*, Ph.D., 2011, Inter American University of Puerto Rico. Research and Teaching interests: Human Resources Management, Organization Behavior, Compensation and Benefits.

WILLIAM J. FREY, *Professor*, Ph.D., 1986, Southern Illinois University at Carbondale. Research and Teaching interests: Business Ethics, Practical and Professional Ethics and Moral Psychology.

DAVID GONZÁLEZ-LÓPEZ, *Professor*, D.B.A., 2012, Pontifical Catholic University, CPA. Research and Teaching interests: Accounting

LUZ GRACIA-MORALES, *Associate Professor*, D.B.A., 2012, Pontifical Catholic University, CPA. Research and Teaching interests: Accountability and transparency in non profit organizations, Disclosure of functional expenses in the 990 Form (IRS return for non-profit organizations).

JOSE G. MARTINEZ-MARTINEZ, *Professor*, D.B.A., 2001, University of Sarasota. Research and Teaching interests: Information Technologies, Operations Management and Human Resources.

ROSARIO DE LOS A. ORTIZ-RODRÍGUEZ, *Associate Professor*, Ph.D. (2008), University of Illinois at Chicago. Research and Teaching interests: Statistics and Quantitative Methods.

LUZ E. QUIÑONES-GONZÁLEZ, *Assistant Professor*, Ph.D. (2014), Inter American University of Puerto Rico. Research and Teaching interests: Human Resources, Organizational Behavior, Organizational Leadership and Organizational Change.

ROBERTO RIVERA-SANTIAGO, *Associate Professor*, Ph.D., 2009, University of California-Santa Barbara. Research and Teaching Interests: Applied Statistics, Spatio-temporal Models, Statistics, Mathematical Finance.

YOLANDA RUIZ-VARGAS, *Professor*, Ph.D., 2000, University of Texas-Pan American. Research and Teaching interests: Capital Structure, Economic Development, Financial Planning, Corporate Finance and Financial Education.

ROBERTO SELJO-VIDAL, *Associate Professor*, Ph.D., 2009, Texas A&M University. Research and Teaching Interests: Supply Chain Management, Operations and Project Management.

JAIME E. SEPÚLVEDA-RIVERA, *Professor*, LL.M., 1994, Georgetown University Law Center; CPA. Research and Teaching interests: Business Law and Taxation.

MARITZA SOTO-GARCIA, *Professor*, Ph.D., 2015, Interamerican University of Puerto Rico. Research and Teaching interests: Human Resources Management.

EDGAR SOTO-RODRÍGUEZ, *Assistant Professor*, D.B.A., 2007, Argosy University at Sarasota, Florida.

PATRICIA VALENTIN-CASTILLO, *Assistant Professor*, Ph.D., 2015, Interamerican University of Puerto Rico. Research and Teaching interests: Human Resources, Social Entrepreneurial, Community Economic Development.

JOSÉ VEGA-TORRES, *Associate Professor*, Ph.D., 2008, University of the Basque Country, Spain. Research and Teaching interests: Marketing Management in small and medium sized enterprises and Entrepreneurial Development and Innovation.

MARI LUZ ZAPATA-RAMOS, *Associate Professor*, Ph.D., 2012, University of Florida. Research and Teaching interests: Marketing and Media.

COLLEGE OF ENGINEERING

The graduate program of the College of Engineering is the key contributor to Research and Development (R&D) activities at the University of Puerto Rico, Mayagüez campus (UPRM). It provides graduate students with experiences in state-of-the-art developments. During the last two decades, the College of Engineering has evolved from a College with emphasis on traditional teaching and community service, to one with a balanced portfolio which also includes a strong research component. One of the most important components in the research structure at the College of Engineering is represented by the several centers which foster an interdisciplinary research culture between professors, students, and research support staff. These research hubs include the NSF-Center for Research and Excellence in Science and Technology (CREST): Nanotechnology Center for Biomedical and Energy-Driven Systems and Applications, the Program in Research in Computing and Information Sciences and Engineering (PRECISE), the Center for Subsurface Sensing and Imaging Systems (CenSSIS), the Center for Structured Organic Composites (CSOC), the Puerto Rico Water Resources and Environmental Research Institute (PRWRERI), the Civil Infrastructure Research Center (CIRC), the Center for Collaborative Adaptive Sensing of the Atmosphere (CASA), the Wisconsin-Puerto Rico Partnership for Research and Education on Materials (PREM), the Wireless Integrated Microsystems Center (WIMS), the Mid America Earthquake Center (MAEC), the Environmentally Benign Semiconductor Manufacturing Center and the Transportation Technology Transfer Center. Most of these centers have also consolidated strong interactions with the industrial sector. Our Research Centers play an essential role in scientific and technological advance while enhancing the growth in high-quality research at the College of Engineering.

The College of Engineering offers Master of Science degrees in:

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

The College of Engineering also offers Master of Engineering degrees in:

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

Doctor of Philosophy degrees (Ph.D.) are offered in the following disciplines:

- Chemical Engineering
- Computer and Information Sciences and Engineering
- Civil Engineering, Infrastructure and Environmental options
- Bioengineering
- Mechanical Engineering

CHEMICAL ENGINEERING

The Department of Chemical Engineering offers programs leading to the Master of Sciences (MS), Master of Engineering, (ME), and Doctor of Philosophy (Ph. D.) degrees.

In addition to the admission requirements of the Graduate Studies Office, a Bachelor of Science degree in Chemical Engineering or its equivalent is required.

Academic graduation requirements for Master of Science and Master of Engineering Programs above those established by the Graduate Studies Office include taking the following four courses: Advanced Thermodynamics, Transport Phenomena, Reactor Design, and Mathematical Methods in Chemical Engineering.

Research in the Department of Chemical Engineering spans the spectrum from fundamental work on chemical engineering science to applications development. Research projects broadly falls in four categories:

- Bioprocess and Biomedical Engineering
- Environmental Engineering and renewable Energy
- Nanostructured Materials Synthesis and Applications
- Pharmaceutical Engineering

Other research in traditional chemical engineering disciplines is also represented in the department.

ADVANCED UNDERGRADUATE AND GRADUATE COURSES

INQU 5006. STATISTICAL METHODS FOR CHEMICAL ENGINEERS. Three credit hours. Three hours of lecture per week. Prerequisites: (INQU 4005 and (MATE 4009 or MATE 3048)) or authorization of the Director of the Department.

Statistical analysis of experimental data, curve fitting, and sampling theory; nomography; problem solving with digital computers. Emphasis is given to chemical engineering applications.

INQU 5015. FUNDAMENTALS OF AIR POLLUTION (I). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4008 or authorization of the Director of the Department. Corequisite: INQU 4002.

Classification and extent of air pollution problems; meteorology and air pollution; dispersion from effluents; the effect of air pollution on plants and animals; visibility problems; socioeconomic impact of pollution problems; analytical and experimental sampling methods; equipment and process for abating air pollution; governmental regulations for air pollution control.

INQU 5018. AIR POLLUTION CONTROL (II). Three credit hours. Three hours of lecture per week. Prerequisite: INQU 4010 or INCI 4008 or authorization of the Director of the Department.

A discussion of the theory, principles, and practices related to engineering control of particulate and gaseous emissions from natural, industrial, agricultural, commercial, and municipal sources of atmospheric pollution.

INQU 5019. INDUSTRIAL WASTE CONTROL (I). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4008 or authorization of the Director of the Department. Corequisite: INQU 4002.

The minimization of industrial wastes through the proper design and operation of manufacturing plants; treatment and disposal of industrial wastes, with emphasis on the chemical industries in Puerto Rico.

INQU 5020. CHEMICAL PROCESS SAFETY AND ECONOMICS. Three credit hours. Three hours of lecture per week. Prerequisite: INQU 4001 or authorization of the Director of the Department.

Process safety and economic engineering analysis of chemical engineering unit operations and processes. Estimation of capital and manufacturing costs for engineering economic analysis and profitability analysis of chemical processes. Evaluation of the impact of chemical processing on the health and safety of people, and damage to the environment. Understanding of potential hazards and risk assessment associated with chemical processes and equipment. Analysis of process design and optimization.

INQU 5021. CHEMICAL ENGINEERING PROCESS DESIGN I. Three credit hours. Three hours of lecture per week. Corequisites: INQU 4002 and INQU 4017.

Analysis and design of chemical and biochemical process units, in particular, chemical reactors,

mixers, separation units, heat exchangers, and transport of fluids.

INQU 5022. CHEMICAL ENGINEERING PROCESS DESIGN II. Three credit hours. Three hours of lecture per week. Prerequisites: (INQU 4017 and INQU 4002 and INQU 5021) or authorization of the Director of the Department.

Integration of chemical engineering concepts, economics, safety, ethics, and environmental considerations to plant and/or chemical process design.

INQU 5025. ANALYSIS AND CONTROL OF PROCESSES. Three credit hours. Three hours of lecture per week. Prerequisites: (INQU 4017 and INQU 4002) or authorization of the Director of the Department.

Mathematical simulation of chemical and physical processes. Analysis of first and second order systems; control modes; control hardware; roots locus and frequency response analysis; optimum control settings; applications to the design of control systems.

INQU 5026. MICROCLIMATE AND DISPERSION OF AIR POLLUTANTS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INQU 4002 or INCI 4008 or authorization of the Director of the Department.

Discussion of the elements of microclimate in urban, rural, and valley environments. Dispersion of air pollutants in these environments.

INQU 5029. BIOPROCESS ENGINEERING LABORATORY. Two credit hours. One hour of lecture and three hours of laboratory per week. Prerequisites: INQU 4207 or INQU 4003 or authorization of the Director of the Department.

Hands-on experiences in upstream and downstream bioprocess unit operations. Experiments in the areas of bioreactor cultures, cell and protein separation, as well as application of bioanalytical methods.

INQU 5030. CHEMICAL ENGINEERING LABORATORY II (I, II). Two credit hours. Two threehour laboratory periods per week. Prerequisite: (INQU 4002 and INQU 4017) or authorization of the Director of the Department. Corequisite: INQU 5025.

Experimental studies on mass transfer, process control, fermentation, kinetics and catalysis using pilot plant equipment at the Unit Operations Laboratory.

INQU 5035. BIOREACTOR ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisite: INQU 4005 or authorization of the Director of the Department.

Fundamentals of biochemistry. Kinetics of enzyme reactors; growth kinetics of suspended cell cultures; consideration of transport phenomena in bioreactors; operation and control strategies of bioreactors; culture of genetically engineered cells to produce recombinant proteins of therapeutic value.

INQU 5036. PARTICULATE SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: INQU 4002 or authorization of the Director of the Department.

Creation, characterization, separation and agglomeration of particles. Sizing fractionation of powders, surface area and pore size determinations. Pulverization, crystallization, agglomeration, tableting and granulation.

INQU 5050. HAZARDOUS WASTE TREATMENT. Three credit hours. Three hours of lecture per week. Prerequisite: INQU 4012 or INCI 4008 or authorization of the Director of the Department.

Introduction to the application of traditional and innovative technologies for the treatment of hazardous wastes in water and soil. Discussion of aspects such as: environmental regulations, design and operating parameters, and cost analysis. Use of computer software for the simulation and design of the different technologies.

INQU 5075. POLYMER ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisites: ((QUIM 3042 or QUIM 3132) and (INQU 4010 or INGE4010 or INGE4015)) or authorization of the Director of the Department.

Application of the principles of fluid mechanics, and heat and mass transfer to describe the production and processing of polymeric materials. Application of engineering principles to the analysis of polymer processes such as extrusion, molding and other industrially relevant unit operations. Emphasis on the effects of processing on structure and physical properties of polymers, and vice versa.

INQU 5076. POLYMER SCIENCE. Three credit hours. Three hours of lecture per week. Prerequisites: QUIM 3042 or QUIM 3132 or authorization of the Director of the Department.

Analysis of the fundamental physical and chemical properties of polymers and their relevance in the

synthesis, production and characterization of polymer-based materials. Discussion of polymerization and reaction kinetics of polymers and copolymers, structure and morphology in solution, melt, and solid phases, thermodynamics of polymers, solutions and blends, and molecular weight characterization.

INQU 5995. SPECIAL PROBLEMS (I, II, S). One to three credit hours. One to three laboratory, library or independent work periods per week. Prerequisite: authorization of the Director of the Department.

Undergraduate research problems in chemical engineering or related field. Topics vary with interest of student and instructor. Open only to outstanding chemical engineering students.

Graduate Courses

INQU 6001. MATHEMATICAL METHODS IN CHEMICAL ENGINEERING (I). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of Department Director.

Mathematical formulation and analysis of chemical engineering problems: application of linear algebra, vector analysis, and advanced ordinary differential equations.

INQU 6002. NUMERICAL METHODS IN CHEMICAL ENGINEERING (II). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Formulation and numerical analysis of chemical engineering problems: application of partial differential equations, boundary value problems, orthogonal functions, and error analysis.

INQU 6005. REACTOR DESIGN (I). Three credit hours. Three hours of lecture per week.

Analysis and design of batch and continuous chemical reactors for homogeneous, heterogeneous, catalytic and non-catalytic reactions; residence time distribution; influence of mass and heat transport on yield and product distributions; stability and optimization of reactors.

INQU 6009. COLLOIDS AND INTERFACES. Three credit hours. Three hours of lecture per week.

Study of the principles of colloid science and interphases and their applications. Development of the fundamental understanding of how various

properties of colloids and their interactions at a microstructural level lead to the observed bulk behavior of the material under study.

INQU 6010. APPLIED MOLECULAR BIOLOGY FOR ENGINEERS. Three credit hours. Three hours of lecture per week.

Study of the fundamentals of cell composition, structure, and function, cellular signal transduction, and the relationship of defects in these areas to human diseases. Discussion of commonly used molecular biology techniques and the primary literature in which these techniques are applied to the solution of biomedical engineering problems.

INQU 6016. ADVANCED TRANSPORT PHENOMENA (II). Three credit hours. Three hours of lecture per week.

Advanced analysis of momentum, energy and mass transport of continuous media. Analytical and numerical solutions to the equations of change, transport coefficients, boundary layer theory, relationship between microscopic and macroscopic balances, and dimensional analysis.

INQU 6019. ADVANCED THERMODYNAMICS (I). Three credit hours. Three hours of lecture per week.

A study of thermodynamics, emphasizing thermodynamic potential functions, fugacities in gas and liquid mixtures, thermodynamic properties, and phase equilibria.

INQU 6020. RHEOLOGY OF COMPLEX FLUIDS. Three credit hours. Three hours of lecture per week.

Study of the mechanical and flow properties of complex fluids, and the relationship with their microstructure. Discussion of fundamentals of rheological measurements, including flow kinematics, material functions, rheometry, and structural probes. Overview of rheological properties of colloids, liquid crystals, and polymer solutions and melts, amongst others.

INQU 6025. CATALYSIS (II). Three credit hours. Three hours of lecture per week.

A study of heterogeneous reactions, reaction rate, catalysis, activity and selectivity of catalytic agents, and surface chemistry; an analysis of industrial catalysts.

INQU 6028. INSTRUMENTATION AND CONTROL PROCESS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INQU 5025.

Application of advanced control techniques to chemical engineering processes. Emphasis on feedback/feedforward control, ratio control, multi-variable process control, interacting control loops, and sampled-data systems.

INQU 6029. GRADUATE SEMINAR (I,II). From zero to one credit hour. From zero to one one-hour session per week.

Research presentation by graduate students and faculty members.

INQU 6035. SELECTED TOPICS IN BIOCHEMICAL ENGINEERING (On demand). Three credit hours. Three hours of lecture per week.

Advanced topics in biochemical engineering: kinetics of enzymatic reactions, transport phenomena in microbial systems, deviation from ideal flow patterns, design and analysis of biological reactors.

INQU 6036. ENGINEERING PROJECT (I, II, S). Three to six credit hours.

Comprehensive study of a specified chemical engineering problem selected so as to integrate the knowledge acquired in the graduate program of study. This project fulfills one of the terminal requirements of the Master of Engineering program, and will be governed by the norms established for this purpose.

INQU 6037. MASTER'S THESIS (I, II, S). Six credit hours.

Research in chemical engineering, and presentation of a thesis.

INQU 6038. X-RAY CHARACTERIZATION OF MATERIALS. Three credit hours. Three hours of lecture per week.

Study of the use of X-rays for the characterization of materials. Study of the fundamentals of space groups and the theory, applications, and experimental considerations of diverse techniques such as: single crystal and powder X-ray diffraction, small angle scattering, amorphous scattering, X-ray fluorescence, and X-ray absorption. Discussion of the relation between these techniques and other materials characterization techniques.

INQU 6995. SPECIAL PROBLEMS (On demand). One to three credit hours. One to three hours of lecture per week.

Investigations and special problems in chemical engineering.

INQU 8007. TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisites: Authorization of the Director of the Department.

Integrated study of momentum, heat, and mass transfer, thermodynamics, and reaction kinetics to provide a mechanistic understanding of such processes as the physiological and cellular level in the human body. Formulation and solution of mathematical expressions to describe artificial organs, analyze biological systems characteristics, and evaluate their implication in biological transport.

INQU 8010. SPECIAL TOPICS IN TRANSPORT PHENOMENA. Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Special topics in transport phenomena and related areas.

INQU 8016. SPECIAL TOPICS IN HETEROGENEOUS CATALYSIS. Three credit hours. Three hours of lecture per week.

Selected topics in heterogeneous catalysis. Includes a catalyst design project or a seminar on recent research.

INQU 8025. FOOD FERMENTATION AND BIOTECHNOLOGY. Three credit hours. Three hours of lecture per week.

A study of the chemistry, microbiology and technology in fermentation processes in the food industry. Includes topics such as: kinetics of biological processes, optimal conditions for the design of fermentors, thermodynamic and stoichiometric limitations, and production of industrial microorganisms by genetic engineering processes.

INQU 8027. CHEMICAL ENGINEERING PRINCIPLES APPLIED TO DRUG THERAPY. Three credit hours. Three hours of lecture per week. Prerequisites: Authorization of the Director of the Department.

Application of chemical engineering principles to drug therapy. Topics include: pharmacokinetic and

pharmacodynamic concepts, design of therapeutic regimens, and the application of transport phenomena in the design and modeling of drug delivery devices.

INQU 8036. ADSORPTION IN NANOSTRUCTURED MATERIALS. Three credit hours. Three hours of lecture per week.

Study of the principles and phenomena of surface adsorption of molecular scale materials. Design of nano-scale materials, including potential energy calculations considering the composition and surface geometry. Methods of adsorbent synthesis, adsorption techniques and methods for performance analysis, and simulation of molecular dynamics will also be included.

INQU 8103. NANOPARTICLE SCIENCE AND ENGINEERING. Three credit hours. Three hours of lecture per week.

Study of the theory, fabrication techniques, and applications of metallic and magnetic nanoparticles. Topics include: synthesis and derivatization methods, physical and chemical properties, and particle-particle and particle-surface interactions.

INQU 8995. SPECIAL PROBLEMS. One to six credit hours.

Research and special problems in Chemical Engineering.

INQU 8996. DOCTORAL SEMINAR. Cero to one credit hour.

Oral presentations and discussions in areas of interest.

INQU 8997. SPECIAL TOPICS IN COMPLEX FLUIDS. One to six credit hours. One to six hours of lecture per week.

Special topics in rheology, structure, characterization, modeling, and processing of complex fluids. Application of engineering concepts to novel and classical research areas of complex fluids.

INQU 8999. DOCTORAL DISSERTATION. Eighteen credit hours.

Development, preparation and defense of a thesis or dissertation based on an original research project in Chemical Engineering, which represents a significant contribution to the state of knowledge of this discipline.

CHEMICAL ENGINEERING FACULTY

A list of professors who are engaged in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

ALDO ACEVEDO RULLAN, *Professor*, Ph.D., 2006, University of Delaware. Research interests: complex fluids; rheology. Teaching interests: Rheology, Transport Phenomena, Fluid Mechanics.

CLARIBEL ACEVEDO VELEZ, *Assistant Professor*, Ph.D., 2011, University of Wisconsin, Madison. Research interest: Colloidal and Interfacial Phenomena, Surfactant Science, Nanoscale Science. Teaching interests: Momentum Transfer Operations, Chemical Engineering Seminar, Graduate Seminar, Doctoral Seminar.

JORGE L. ALMODOVAR-MONTAÑEZ, *Assistant Professor*, Ph.D., 2011, Colorado State University. Research interests: Biomaterials, Layer-by-Layer, Growth Factors, Biopolymers, Mammalian Cell Culture, Tissue Engineering. Teaching interests: Momentum and Mass Transfer, Thermodynamics.

MOSES N. BOGERE, *Professor*, Ph.D., 1993, University of Akron. Research interests: Multiphase Transport Phenomena in Dispersed Multiphase Systems, Control and Optimization, Applied Mathematics. Teaching interests: Multiphase Transport Phenomena, Process Control, Modeling and Instrumentation, Process Design.

NELSON CARDONA-MARTÍNEZ, *Professor*, Ph.D., 1989, University of Wisconsin-Madison. Research interests: Heterogeneous Catalysis and Chemical Reaction Kinetics, Surface Thermodynamics and Surface Science. Teaching interests: Kinetics and Catalysis, Thermodynamics.

UBALDO M. CÓRDOVA-FIGUEROA, *Professor*, Ph.D., 2008, California Institute of Technology. Research interests: Transport Phenomena, Physicochemical Hydrodynamics, Brownian Dynamics Simulations, Colloidal Dispersions, Microrheology, Synthesis of Selfpropelled Janus Particles. Teaching interests: Transport Phenomena, Colloidal Physics.

MARÍA C. CURET ARANA, *Associate Professor*, Ph.D., 2006, Northwestern University, Northwestern University, Evanston, IL. Research interests: Kinetic modeling, Catalysis, First-principle calculations. Teaching interests: Undergraduate and Graduate Chemical Reaction Kinetics, Catalysis, Applied Molecular Modeling, Environmental Chemical Engineering.

MARIBELLA DOMENECH GARCIA, *Assistant Professor*, Ph.D., 2010, University of Wisconsin, Madison. Biomedical Engineering. Research interests: Microfluidics, Tumor Microenvironment, Stemcells, Breast Cancer, Nano-systems for Cell-targeted Drug Delivery. Teaching interests: Biomedical Engineering, Biotechnology, Quantitative Computational Biology, Biomaterials, Tissue Engineering, Chemical Engineering-Unit Operations.

L. ANTONIO ESTÉVEZ-DE VIDTS, *Professor*, Ph.D., 1983, University of California-Davis. Research interests: Supercritical Fluids Fundamentals and Applications; Bubble Columns Hydrodynamics and Applications; Distillation Tray Efficiency. Teaching interests: Thermodynamics, Momentum, Heat and Mass Transfer, Separation Processes, Reactor Design, and Applied Mathematics.

ARTURO J. HERNÁNDEZ-MALDONADO, *Professor*, Ph.D., 2004, University of Michigan. Research interests: Synthesis and Characterization of Microporous and Mesoporous Materials, Zeolites, Zeolitic Crystallography, Adsorption. Teaching interests: Mass Transfer, Transport Phenomena, Adsorption Engineering.

MAGDA LATORRE-ESTEVEZ, *Associate Researcher*, Ph.D., 2006, Harvard Medical School. Research interests: Nanomaterials for Biomedical Applications, Molecular Mechanisms of Disease, Tissue Engineering. Teaching interests: Molecular Biology and Genetics, Nanomedicine Science and Technology, Quantitative Biology, Bioengineering.

MARIA M. MARTINEZ IÑESTA, *Professor*, Ph.D., 2005, University of Delaware. Research Interests: synthesis of metal nanostructures (nanowires and nanogrids), study of porous materials as templates, structural characterization of disordered materials, structural characterization of nanostructures, characterization of the properties of nanostructures and of the composite nanostructure + template for electronic and catalytic applications. Teaching Interests: Undergraduate and Graduate Kinetics, Diffraction, and Materials Characterization

RAFAEL MENDEZ ROMAN, *Associate Professor*, Ph.D., 2005, University of Puerto Rico-Mayagüez. Research interests: Pharmaceutical Powder Properties, Continuous Mixing, Tablet Compaction. Teaching interests: Pharmaceutical Operations, Thermodynamics, Kinetics and Statistical Methods for Chemical Engineers.

PATRICIA ORTIZ BERMUDEZ, *Professor*, PhD, 2005, UW-Madison, Microbiology. Research interests: Discovery and characterization of novel biocatalysts for lignocellulose degradation, and synthesis of antimicrobial nanoparticles and their interaction with microbial cell walls. Teaching interests: Bioengineering, Food Fermentation and Biotechnology, Biorefineries and Bioproducts.

YOMAIRA J. PAGAN-TORRES, *Assistant Professor*, PhD, 2011, UW-Madison, Chemical Engineering. Research interests: Heterogeneous Catalysis, Kinetic and Reaction Engineering, Catalytic Nanomaterial Synthesis and Characterization, Renewable Energy and Sustainability. Teaching interests: Chemical Engineering Kinetics and Catalysis, Chemical Process Safety and Economics, Chemical Engineering Seminar.

LORENZO SALICETI-PIAZZA, *Professor*, Ph.D., 1996, Purdue University. Research interests: Biochemical Engineering, Utilization of Renewable Resources. Teaching interests: Biochemical Engineering, Process Control and Applied Statistics.

LAKSHMI N. SRIDHAR, *Professor*, Ph.D., 1991, Clarkson University. Research interests: Analysis and Separation Processes, Process Optimization and Control Design, Synthesis and Control. Teaching interests: Applied Mathematics, Separation Processes, Reactions Engineering, and Transport Phenomena.

DAVID SULEIMAN-ROSADO, *Professor*, Ph.D., 1994, Georgia Institute of Technology. Research interests: Specialty Separations and Advanced Materials. Teaching interests: Material & Energy Balances, Thermodynamics, Kinetics and Transport Phenomena.

MADELINE TORRES-LUGO, *Professor*, Ph.D., 2001, Purdue University. Research interests: Biochemical Engineering, Biomedical Engineering, Materials, and Polymers. Teaching interests: Polymers, Thermodynamics.

CARLOS VELÁZQUEZ-FIGUEROA, *Professor*, Ph.D., 1997, University of Connecticut, Storrs, Connecticut. Research interests: Process Control, Application of Control Theory to Pharmaceutical Operations and Biotechnology, Supercritical Fluid for Pharmaceutical Applications, and Parameter Estimation. Teaching interests: Process Control, Instrumentation, Material and Energy Balances, Pharmaceutical Technologies.

CIVIL ENGINEERING AND SURVEYING

The Department of Civil Engineering and Surveying offers programs leading to the degrees of Master of Science, Master of Engineering, and Doctor of Philosophy. There are no formal options, but students are able to specialize in structural, construction engineering, environmental/water resources, geotechnical or transportation engineering.

Students should comply with the admission requirements of the Graduate Studies Office. Students in the Master of Science (Plan I) program are required to approve at least 24 course credits, to carry out a research project and write a thesis. Students in the Master of Engineering (Plan II) program must approve at least 27 course credits, work on a design or development project and write an engineering report. Students in the Master of Engineering (Plan III) program must approve at least 36 credits in courses and pass a comprehensive exam. Students in the Doctor of Philosophy program are required to approve 42 course credits and pass a qualifying exam which includes a written and oral component, pass a comprehensive exam which includes a written and oral component, and prepare and defend an 18 credit doctoral dissertation. The doctoral dissertation must be an original contribution to the state of the art in the field of study.

The Department has over 52,000 square feet of facilities space for teaching and research activities. There are laboratory facilities for engineering materials, structures and structural models, soil mechanics, highway engineering, environmental engineering, traffic engineering, and surveying and topography. A wind tunnel facility is available for modeling and simulation of wind effect on constructions. A strong floor facility for testing full-scale structures is also available. Each laboratory has a faculty in charge and a trained laboratory technician.

The Department has in its premises a computer laboratory equipped with microcomputers and their accessories, and a LAN running at 100 mbps. Computer facilities are available to faculty and students around the clock, seven days a week. A new systematic computer network infrastructure provides access to Internet to every classroom, computer center, laboratory, and every employee. An optic fiber network provides rapid external

communication. In addition, there are two computer laboratories: the Civil Engineering Infrastructure Research Center is equipped with microcomputers and work stations to assist students and professors in the development of their research projects; CAIREL (Computer Aided Instruction and Research Laboratory) facility is equipped with microcomputers and visual aids equipment.

MISSION

We provide society with people serving, problem solving professionals in civil engineering and surveying. We provide citizens who have a strong technical and professional education in civil engineering and surveying, with rich cultural background, ethical values, and social sensitivity; with capacity for critical thinking and the managerial and entrepreneurial skills needed to solve civil infrastructure problems facing society.

VISION

Provide our society high quality professionals with a strong education in civil engineering and/or land surveying: with rich cultural, ethical, environmental, and social sensitivities; capacity for critical thinking; and the entrepreneurial skills to solve civil infrastructure problems. Search for and disseminate new knowledge. Provide services to solve engineering problems as members of interdisciplinary teams.

SLOGAN

$CES = (PS)^2 \rightarrow$ (Civil Engineers and Surveyors
= People-Serving, Problem-Solvers)

HIGHLIGHTS:

Strong research component in hazard mitigation, resilient civil infrastructure, environmental and transportation engineering with significant external support from local and federal government, industry and others.

Our faculty in Civil Engineering and Surveying submitted research proposals for external funding ranking among the top Departments in proposals submitted at UPRM.

OBJECTIVES:

Our Civil Engineering graduates will address the challenges that they will face in their careers, pursue life-long learning and continue to develop their problem-solving skills. They will also exhibit leadership and team-building skills in a bilingual setting, provide quality service to the profession, to our government, and to our society, and function as effective members of interdisciplinary teams.

COURSES OFFERED

(I)= courses normally offered during the First Semester

(II)= courses normally offered during the Second Semester

(S)= courses normally offered during the Summer Session

(BD)= based on demand

CIVIL ENGINEERING (INCI)

Advanced Undergraduate Courses

INCI 5006. APPLIED HYDRAULICS (I). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4138 or authorization of the Director of the Department.

Dimensional analysis and modeling; hydraulic machinery and structures; steady conduit and open channel flow; pipe network system.

INCI 5007. SOLID WASTE MANAGEMENT. Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4008 or authorization of the Director of the Department.

The solid waste problem: volume reduction and storage of solid wastes, design and optimization of collection systems, recycling, integrated treatment and disposal systems.

INCI 5008. INTRODUCTION TO HYDROLOGY. Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4138 or authorization of the Director of the Department.

The elements of the hydrologic cycle; probability theory and commonly used probability distributions in hydrology: hydrologic and hydraulic flood routing analysis; use of hydrologic concepts in design.

INCI 5009. FUNDAMENTALS OF AIR POLLUTION (II). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4008 or authorization of the Director of the Department.

Classification and extent of air pollution problems, its effects on plants, animals, visibility, and its socio-economic impact; dispersion of effluents; analytical and experimental sampling methods.

INCI 5010. SUSTAINABLE CONSTRUCTION. Three credit hours. Three hours of lecture per week. Prerequisite: Fifth year student or graduate student or authorization of the Director of the Department.

Study of sustainable development and the application of sustainability to engineering design and construction. Discussion of the principles needed to support green design and construction, including the relationship between professional ethics and sustainability. In addition, topics such as the process to deliver and assess green buildings, the building system for resource optimization, the reduction on environmental impact, and the use of the integrated building design will be considered.

INCI 5012. APPLIED SANITARY ENGINEERING CHEMISTRY (II). Four credit hours. Three hours of lecture and one three-hour laboratory per week. Prerequisite: INCI 4008 or authorization of the Director of the Department.

The application of chemical principles to the sanitary engineering field. Physical, chemical, and biochemical analysis of water and wastewater. Interpretation of analytical data. Integration of experimental data into the design process. The preparation of laboratory reports in the form of engineering reports is emphasized.

INCI 5015. WATER TREATMENT AND POLLUTION CONTROL. Three credit hours. Two lectures and one three-hour laboratory per week. Prerequisite: INCI 4008 or authorization of the Director of the Department.

Study of water and wastewater treatment processes in terms of the underlying physical, chemical, and biological principles; the application of the principles to the study of unit treatment processes and to the design, operation, and analysis of performance of integrated treatment plants; the influence of the self-purification of natural bodies of water and of the planned use of the resources on the type and degree of treatment of waste and its disposal; wastewater reclamation.

INCI 5017. PRESTRESSED CONCRETE STRUCTURES (I). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4012 or authorization of the Director of the Department. Corequisite: INCI 4022.

Prestressing systems and materials; stress losses, design of beams of flexure, bond, shear and bearing; specifications and economics of design.

INCI 5018. MATRIX ANALYSIS OF STRUCTURES I (I). Three credit hours. Three hours of lecture per week. Prerequisites: INCI 4022 and authorization of the Director of the Department.

Use of matrix methods in the analysis of structures; flexibility and stiffness methods.

INCI 5021. INTRODUCTION TO DYNAMICS OF STRUCTURES. Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4022 or authorization of the Director of the Department.

Study of the modeling of structures as systems of single and multiple degrees of freedom. Explanation of the calculation of natural frequencies and vibration modes. Use of computer programs for the dynamic analysis of structures. Introduction of the concept of response and design spectra along with their use for the calculation of the response to earthquake loads.

INCI 5026. BRIDGE DESIGN (II). Three credit hours. Three hours of lecture per week. Prerequisites: (INCI 4012 and INCI 4022) or authorization of the Director of the Department.

Bridge analysis and design; bridge types, characteristics; design problems.

INCI 5027. MODEL ANALYSIS OF STRUCTURE (BD). Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: INCI 4022 or authorization of the Director of the Department.

Model analysis in structural engineering; similarity of structures; theory of models of trussed and framed structures and shells; direct and indirect model analysis of structures.

INCI 5029. PRINCIPLES OF CITY PLANNING. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

The scope of and legislative bases for planning, organization of planning agencies, basic studies for studies for planning, public utilities and related

service facilities, transit and transportation systems, recreation and related service facilities, transit and transportation systems, recreation and public spaces, land use planning, zoning, land subdivision regulations, economic and social aspects of planning, local, regional and national levels of planning.

INCI 5047. INTRODUCTION TO ROCK MECHANICS (BD). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4139 or INCI 4031 or authorization of the Director of the Department.

Fundamentals of rock mechanics: properties of rocks; strength and deformation characteristics of intact and *in-situ* rocks, computation of internal stresses in a rock mass; methods of rock exploration; application of rock mechanics.

INCI 5049. GEOSYNTHETICS IN CIVIL ENGINEERING (II). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4139 or authorization of the Director of the Department.

Manufacture, properties and test methods of the different products that comprise the geosynthetics. Applications in: drainage and filtration, design of pavements, earth retaining structures, systems of pollution control, sanitary landfills and other environmental projects.

INCI 5055. DESIGN OF TIMBER STRUCTURES (II). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4021 or authorization of the Director of the Department.

Physical and mechanical properties of solid and laminated wood; design and behavior of flexural, tension, and compression members; design of timber connections and mechanical fasteners; special problems in the design of wood trusses, shear walls, diaphragms and plywood composite beams.

INCI 5056. STRUCTURAL ANALYSIS III. Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4022 or authorization of the Director of the Department.

Application of methods for analysis of statically indeterminate structures. Moment distribution. Slope deflection and energy theorems.

INCI 5057. DESIGN OF REINFORCED CONCRETE STRUCTURES. Three credit hours. Two hours of conference and one hour of computation per week. Prerequisites: (INCI 4012 and INCI 4022) or authorization of the Director of the Department.

Design of concrete buildings, review of the design of slabs, beams and columns applied to buildings using the new seismic design codes, design of two-way slab systems, shear walls, typical foundations, retaining walls and design for torsion. Discussion of examples related to a complete structural design of a multistory building including the preparation of construction drawings.

INCI 5065. PRODUCTION OF BITUMINOUS MATERIALS. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: INGE 4001 or authorization of the Director of the Department.

Study of the production of bituminous materials, the distillation process, and products applicable to the construction and rehabilitation of flexible pavements. Laboratory tests and trials for the characterization of such materials according to current standards. Design of bituminous mixtures for different types of pavement construction.

INCI 5146. INTRODUCTION TO TRAFFIC ENGINEERING (I). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 4137 or authorization of the Director of the Department.

Operation and geometric analysis and design of intersections. Interrupted traffic flow theory, queuing theory, capacity and level of service, traffic studies, service models for signalized intersections and traffic simulation models.

INCI 5995. SPECIAL TOPICS (II). One to six credit hours. The contact will vary according to the topic to be presented. Prerequisite: authorization of the Director of the Department.

The topics will be presented by visiting professors and members of the department who are specialists in the field to be covered. The selection and scope of the topics shall be in accordance with the interests and needs of the students.

INCI 5996. SPECIAL PROBLEMS (BD). One to six credit hours. The contact will vary according to the topic to be presented. Prerequisite: authorization of the Director of the Department.

Research and special problems in Civil Engineering and related fields. Open to outstanding students in the field of Civil Engineering.

Graduate Courses

INCI 6005. WATER AND WASTEWATER TREATMENT (II). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of Department Director.

The process of treating water and wastewater; design of facilities for treatment of water for municipal and industrial use; principles for treatment of municipal and industrial wastewater; application of unitary processes in the design of treatment plants to meet industrial effluents guidelines.

INCI 6006. GROUNDWATER HYDROLOGY (II). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of Department Director.

Fundamentals of groundwater hydrology: well hydraulics, groundwater quality, surface and subsurface factors affecting groundwater, and seawater intrusion.

INCI 6008. WATER RESOURCES SYSTEMS (II). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of Department Director.

Systems theory and operation research for solving typical water resources problems quantitatively and qualitatively; aspects of engineering economics, the concepts of the discount rate, methods of project evaluation, stochastic and deterministic simulation.

INCI 6009. WATER AND WASTEWATER TREATMENT LABORATORY (II). Three credit hours. One hour of lecture and six hours of laboratory per week.

Physical, chemical and biological processes in the treatment of water and waste water. Waste analysis, biodegradation, and waste water characterization.

INCI 6015. SANITARY ENGINEERING MICROBIOLOGY (BD). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Biochemical reactions induced by microorganisms, emphasizing microbiological processes related to water and wastewater treatment and to environmental pollution control.

INCI 6016. STOCHASTIC HYDROLOGY (BD). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of Department Director.

Probability theory applied to hydrology; extreme value distribution; recurrence and frequency analysis; stochastic simulation of the hydrological process; hydrological models.

INCI 6017. STRUCTURAL MECHANICS (I). Three credit hours. Three hours of lecture per week.

Advanced theories of mechanics of materials are discussed with emphasis on topics most relevant to the civil engineering structures. The selection includes thin-walled cross sections subject to unsymmetrical bending and torsion, Mohr's circle for second moments of area, shear center of monosymmetric and unsymmetric sections, beams on elastic foundation, curved beams, thin shells of revolution subject to axisymmetric loading, and the limit states associated with fatigue, fracture and creep. Case studies on metal roof systems, long span beams, and liquid storage tanks are used to augment the theory.

INCI 6018. FINITE ELEMENT ANALYSIS OF STRUCTURES (II). Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

The finite element method and its application in the analysis of structures with elastic and non-linear behavior and in the determination of buckling loads, element development for the solution of unitary stress and strain problems in flexion of plates, thin and thick shells, axisymmetric shells, and solids.

INCI 6019. DESIGN OF STEEL STRUCTURES (I). Three credit hours. Three hours of lecture per week.

Evaluation of current specifications for the design of structural members under axial, flexure, torsional, and combined axial and flexural loadings; design of plate girders and rigid frames; plastic design of gable and multistory frames; design of connections for fatigue loading.

INCI 6020. OPTIMIZATION IN STRUCTURAL DESIGN (II). Three credit hours. Three hours of lecture per week.

Application of linear programming to the optimization of the design of steel and reinforced concrete frames subject to gravitational and lateral loads.

INCI 6021. THEORY OF ELASTICITY. Three credit hours. Three hours of lecture per week. Prerequisites: INCI 6017 or authorization of the Director of the Department.

Presentation of the theory to analyze stresses and strains in three-dimensional elastic solids presuming constitutive elastic equations. Formulation of models based on differential equations for the explicit solution of simple problems in the classic literature. Study of alternate formulations of virtual work and its changes due to variations in displacements and forces, small and large deformations, and fundamentals of thermoelasticity.

INCI 6022. DESIGN OF EARTHQUAKE RESISTANT STRUCTURES. Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Study of the parameters used for the selection of a Design Earthquake, development of ground spectra, elastic and inelastic design spectra. Design of structures using the capacity method. Introduction to base isolation systems.

INCI 6023. ANALYSIS OF STRUCTURES OF COMPOSITE MATERIALS. Three credit hours. Three hours of lecture per week.

Analysis of the mechanical and physical properties of composite materials from the micromechanical to the macromechanical level. Laminate analysis including failure theories. Analysis, design, and optimization of structural elements and of concrete reinforced with composite materials. Study of the manufacture of components and analysis of connections between elements.

INCI 6025. PLAIN AND REINFORCED CONCRETE (II). Three credit hours. Three hours of lecture per week.

Brief review of the theories used in the design of concrete and the factors affecting the properties and behavior of the material and of the test specimen; behavior of plain concrete under different types of environment and of loading; critical review of ultimate strength; behavior of reinforced concrete members and relation between results of research and current specifications for design.

INCI 6026. REINFORCED CONCRETE STRUCTURES (I). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 6025.

Continuation of INCI 6025. Ultimate strength and behavior of statically indeterminate reinforced concrete structures; floors, slabs; specifications.

INCI 6027. ADVANCED STRUCTURAL PROBLEMS (BD). Three credit hours. Three hours of lecture per week.

Advanced design of complex structural projects.

INCI 6029. DESIGN OF STRUCTURES FOR DYNAMIC LOADS (II). Three credit hours. Three hours of lecture per week.

Free vibrations; forced vibrations and transient response of structures having one or more degrees of freedom; damping and inelastic action; nature of dynamic loading from earthquakes and bomb blasts; methods of analysis and criteria for designing earthquake-resistant and blast-resistant structures.

INCI 6030. ANALYSIS OF STRUCTURAL SYSTEMS IN THE NON-LINEAR REGIME (BD). Three credit hours. Three hours of lecture per week.

Nature of the problem of non-linear behavior. Tangent stiffness method. Structures on elastic foundations. Soil and structure interaction.

INCI 6031. ADVANCED SOIL MECHANICS I (II). Three credit hours. Three hours of lecture per week.

One-dimensional consolidation; advances in consolidation theories; secondary consolidation; precompression; three-dimensional consolidation; sand drains; distribution of stresses in a soil mass; computation of settlements.

INCI 6032. MEASUREMENT OF SOIL PROPERTIES. Two hours of lecture and one three-hour laboratory per week.

Study and practice of the measurement of stress-strain and consolidation properties of soils including tests such as one-dimensional consolidation, direct shear, and triaxial tests. Practice in sample preparation, testing details, sources of error, analysis and interpretation of results, and report preparation is included.

INCI 6037. APPLIED SOIL MECHANICS (BD). Three credit hours. Three lectures per week.

Application of soil mechanics to earth pressure and retaining walls; foundations of buildings; stability of earth slopes; braced cuts; settlement and contact pressure; seepage.

INCI 6038. FOUNDATION ENGINEERING (I). Three credit hours. Three hours of lecture per week.

Case histories of projects in foundation engineering; design and construction procedures for foundations, embankments and other civil engineering earthworks.

INCI 6045. PAVEMENT DESIGN (I). Three credit hours. Three lectures per week. Prerequisite: INCI 4031.

Traffic loads, climatic effects, stresses in pavements, flexible pavement design, rigid pavement design, skid resistance, construction practices and maintenance.

INCI 6046. URBAN TRANSPORTATION PLANNING (II). Three credit hours. Three hours of lecture per week.

Urban travel characteristics and trends; basic urban transportation studies, including origin, destination surveys, inventory, use studies, parking studies, and transit surveys; application of transportation, economic, land use data in estimating future travel; planning arterial street and expressway systems, off street parking, and transit systems; coordination of city planning and transportation engineering; metropolitan transportation administration and finance.

INCI 6047. TRAFFIC ENGINEERING (I). Three credit hours. Two hours of lecture and one two-hour discussion, computation or field period per week.

City and highway traffic surveys and designs; accidents, congestion, delay, speed, volume density, parking, channelization, lighting, traffic control and routing, signs, signals and markings, urban traffic consideration in city planning; driver reactions and habit patterns.

INCI 6048. TRANSPORTATION SYSTEMS ANALYSIS (II). Three credit hours. Three hours of lecture per week.

Principles and techniques of systems analysis and mathematical programming are presented and applied to economic, physical planning, and the evaluation and operation of transportation facilities. Mathematical models are used to examine problems related to optimum efficiency of transportation systems and modes. Operations research methods of linear programming, non-linear programming, network analysis, queueing theory, and simulation are studied.

INCI 6049. TRANSPORTATION SYSTEMS EVALUATION (II). Three credit hours. Three hours of conference per week.

The course is designed to provide graduate students with knowledge of evaluation studies and methods employed in planning the proper function and character of transportation facilities, and of the broad administrative policies such as transportation needs, finance, and economics that affect the planning, design, and programming of transportation systems. The course contents give attention to the application of basic techniques in engineering economic evaluation and the assessment of user and non-user impacts of transportation improvements.

INCI 6050. ADVANCED TRANSPORTATION SYSTEMS ANALYSIS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INCI 6048.

Advanced topics in transportation and demand analysis; transportation economy; resource models; techniques for the design and generation of alternatives in transportation systems.

INCI 6051. MASS TRANSPORTATION SYSTEMS. Three credit hours. Three hours of lecture per week.

Study of concepts related to the planning and operation of mass transportation systems in urban areas. Discussion and comparison of diverse modes of mass transport. Detailed study of urban rail systems.

INCI 6055. CONSTRUCTION COSTS ESTIMATES. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of construction cost-estimating techniques during the different phases of the construction process. Development and application of knowledge and skills necessary to estimate costs in a construction project.

INCI 6057. THEORY OF ELASTIC STABILITY (II). Three credit hours. Three hours of lecture per week.

Bending of prismatic bars subjected to axial and lateral loads; buckling of compression members on the elastic and inelastic ranges; lateral buckling of beams, and torsional buckling.

INCI 6059. MODELING OF URBAN STORM DRAINAGE (I). Three credit hours. Three hours of lecture per week.

Application of hydrologic and hydraulic principles to the analysis, design, and management of urban drainage and small watersheds; computer modeling

and simulation; effects of spatial and temporal rainfall variabilities; overland flow; runoff from highways; stormsewers, culverts, and other related drainage structures.

INCI 6060. POLLUTANT TRANSPORT (I). Three credit hours. Three hours of lecture per week.

Point and non-point source pollutants; the Streeter-Phelps equation; analysis of the transport problem in streams and estuaries; finite element approach to system analysis; ocean outfalls; pollutographs and loadgraphs; universal equation of soil conservation, mathematical model for pollutants handling.

INCI 6061. SEDIMENT TRANSPORT I. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Introduction to sediment transport. Hydrodynamics of fluid-particle systems. Initiation of particle motion. Relation of bedforms to flow regime. Design of stable channels and live bed stable channels. Bedload and suspended sediment transport. Local scour in channels measurement of sediment transport.

INCI 6063. COMPUTER HYDROLOGIC MODELING (II). Three credit hours. Three hours of lecture per week.

Emphasis on computer hydrologic modeling. Application of the Hydrologic Cycle's components to the development of precipitation-runoff models. Individual watershed processes are analyzed and their integration to computer models studied. Model selection and calibration techniques, with special attention to error analysis, are also studied. Students are exposed to actual problems of using Hydrologic Models. Class projects include applications to real cases.

INCI 6064. ADVANCED CONCRETE TECHNOLOGY (BD). Three credit hours. Three hours of lecture per week.

Microstructure, physical and mechanical properties of concrete; strength-porosity relation, failure modes, and behavior of concrete under various stress states; fiber reinforced cementitious composites: types, mechanical properties, applications, and mixture proportions; fiber-reinforced shotcrete: applications and field performance; fiber reinforced plastics (FRPs): applications for repair, rehabilitation, and reinforcement.

INCI 6065. ENGINEERING PROJECT (I, II). Three to six credit hours.

Comprehensive study of a specific civil engineering problem selected so as to integrate the knowledge acquired in the graduate program of study. This project fulfills one of the terminal requirements of the Master of Engineering Program and will be governed by the norms established for this purpose.

INCI 6066. RESEARCH THESIS (I, II). One to six credit hours.

Research in the field of civil engineering and presentation of a thesis.

INCI 6068. PAVEMENT MANAGEMENT. Three credit hours. Three hours of lecture per week.

Development of systematic methods to evaluate and administer existing pavements for highways and airports. Analysis of existing pavement defects, structural capacity, safety, and geometry. Development and application of statistical models, optimization techniques, and analysis of rehabilitation techniques for existing pavements. Field project required.

INCI 6069. SOIL DYNAMICS (BD). Three credit hours. Three hours of lecture per week.

Introduction to the terminology and notation used in the analysis of dynamic systems. Discussion of dynamic soil properties and wave propagation theories in soils. Design of foundations in seismic regions, theory of machine vibrations, and the problem of soil liquefaction in granular soils. Description of laboratory dynamic tests and analysis of the data obtained from them.

INCI 6070. CONSTRUCTION ADMINISTRATION AND INSPECTION. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the concepts and processes related to the administration and inspection of construction projects. Discussion of the organization and scheduling of a project, applicable laws and regulations, specifications, quality control, safety, and other administrative aspects.

INCI 6076. PHYSICO-CHEMICAL TREATMENT OF WATER (I). Three credit hours. Three hours of lecture per week.

Theory and applications of physico-chemical unit processes for the removal of pollutants from water

and wastewater; substitution of biological treatment by physico-chemical processes; problems and technology of wastewater reuse for drinking purposes.

INCI 6077. PLANNING AND SCHEDULING CONSTRUCTION PROJECTS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the concepts of planning and scheduling construction projects. Emphasis on division of the project into activities and the estimation of their duration; bar charts; development of networks by CPM and PM and their analysis using PERT. Scheduling with limited resources and resource leveling and the use of the schedule as a project control mechanism.

INCI 6078. SHEAR STRENGTH OF SOILS. Three credit hour. Three hours of lecture per week.

Studies of the physic-chemical properties of soils and the mechanisms of shearing resistance. Discussion of residual shear strength, Hvorslev's parameters, drained and undrained shear strength, and long-term shear strength.

INCI 6080. ANALYSIS AND DESIGN OF DEEP FOUNDATIONS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analysis and design of single and grouped piles subjected to axial and lateral forces, drivability analysis, and practical recommendations for pile driving. Design and interpretation of load test considering negative skin friction effects, and design of drilled shafts.

INCI 6085. ADVANCED MATHEMATICAL METHODS IN CIVIL ENGINEERING. (BD). Three credit hour. Three hours of lecture per week.

Advanced calculus; optimization methods, estimation theory; sampling theory; queuing theory; application of spread sheet and data base programs in microcomputers.

INCI 6086. STATISTICAL METHODS IN WATER RESOURCES. Three credit hours. Three hours of lecture per week.

Application of probabilistic methods to problems in water resources. Study of the probability distributions of rainfall and runoff processes. Analysis of random variables and hypothesis testing; frequency analysis of extreme events; correlation

and regression analysis in water resources; fundamentals of uncertainty and risk analysis.

INCI 6087. CONSTRUCTION COST ENGINEERING AND FINANCIAL MANAGEMENT. Three credit hours. Three hours of lecture per week.

Study of techniques and technologies required to achieve success in construction projects through improved cost control. Fundamental concepts related to cost control, financial management, advanced engineering economics, accounting, project control systems, and cash flow analysis applied to construction. The use of computer software for cost control and accounting will be explained.

INCI 6088. ENGINEERING GROUND IMPROVEMENT. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the methods of ground and site improvement to mitigate construction problems under poor engineering conditions. Description of design techniques for dewatering systems and ground improvement techniques applied to diverse systems including: compaction, preloading, vertical drains, admixtures, grouting, reinforced earth, in-situ densification, stone columns, slurry trenches, and relevant uses of geotextiles.

INCI 6089. ADVANCED STRUCTURAL DYNAMICS. Three credit hours. Three hours of lecture per week. Prerequisite: INCI 6029 or authorization of the Director of the Department.

Variational formulation of the equations of motion and of the equations of motion in state space, including the use of complex eigenvalues and eigenvectors. Study of free and forced vibrations of continuous systems using the frequency response method. Introduction to nonlinear vibrations and to wave propagation in unidimensional finite, semi-infinite, and infinite media.

INCI 6090. GEOMETRIC DESIGN OF HIGHWAYS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of geometric design concepts and policies used to design highways and streets, at-grade intersections, grade separations, interchanges, and other ground transportation facilities. Application of design control and criteria and consideration of the safety and operational effects of the roadway and roadside elements, the sight distance, the horizontal

and vertical alignment, and other elements of the design of roads of different functional classification.

INCI 6098. REHABILITATION OF REINFORCED CONCRETE STRUCTURES (BD). Three credit hours. Three hours of lecture per week.

Discussion of the available techniques to compute the maximum load capacity of a structure, estimates of expected gravity and lateral loads, and determination of the actual safety factor of the structure under the imposed load. Reinforced concrete pathology and prognosis of the problems caused by materials' defects, construction problems, and inadequate design. Techniques for strengthening structural elements. Presentation and discussion of typical cases.

INCI 6099. CONSTRUCTION METHODS AND EQUIPMENT. Three credit hours. Three hours of lecture per week.

Study of construction methods and equipment for civil engineering projects. Selection, layout, and organization of construction installations, equipment, and resources. Analysis of cost, operation, and productivity of equipment and construction methods. Field trips are required.

INCI 6100. STRUCTURAL COMPONENTS IN GEOTECHNICAL ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analysis and design of individual and combined foundations, mat foundations, cantilever retaining walls, and pile caps. Rigid and flexible method of analysis of combined and mat foundations will also be studied.

INCI 6105. EARTH PRESSURES AND SHALLOW FOUNDATIONS. Three credit hours. Three hours of lecture per week.

Application of soil mechanics concepts to earth pressure and retaining structures, foundations of buildings, sheet piles, braced cuts, settlement, and contact pressures. Analysis and design of shallow foundations, retaining structures, sheet piles, and braced cuts.

INCI 6106. TEMPORARY STRUCTURES IN CONSTRUCTION. Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Study of the fundamental concepts related to the selection, design, and layout of temporary structures

needed in construction. Safety issues, prefabricated and customized structures, use of pumps during construction, ramps, runways, and scaffolding, and design and analysis of frameworks for concrete structures will also be discussed.

INCI 6107. DURABILITY OF CONSTRUCTION MATERIALS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Development of the analysis and design skills necessary to build public work in challenging environments. Study of the construction materials' lifecycle to provide a high level of expertise in areas such as: cement chemistry, aggregate science, binder technology, microstructure, and transportation mechanisms in concrete, concrete durability, alternative materials, durability of non-cement based materials, and material's performance.

INCI 6108. ROAD SAFETY ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the analytical methods used to estimate and analyze the safety effects and the relationships between different elements and characteristics of drivers, vehicles, traffic flow, and highway design. Analysis of crash, traffic and roadway inventory databases, the consideration of human factors and driver responses to risk perception. Application of conventional safety modeling techniques and methods for identifying hazardous locations, and recognize causes for different crash types.

INCI 6109. PRODUCTIVITY ANALYSIS AND SIMULATION IN CONSTRUCTION. Three credit hours. Three hours of lecture per week.

Study of the techniques and technologies used to manage productivity and methods of improvement in construction. Study of productivity measurement including work sampling, crew balance charts, process charts, and flow diagrams. Application of simulation to construction to illustrate how discrete event simulation can be used for productivity studies and for the design of complex and dynamic operations.

INCI 6115. PROGRAMMING METHODS IN CIVIL ENGINEERING (BD). Three credit hours. Three hours of lecture per week.

Implementation of numerical methods and algorithms for the solution of linear and non-linear systems of equations. Development and implementation of design systems and computer

graphics (CAE/CAD). A comprehensive programming project will be required.

INCI 6116. HYDROLOGICAL AND HYDRAULIC MEASUREMENT METHODS. Three credit hours. One hour of lecture and one six-hour workshop per week.

Utilization of field equipment, sampling techniques, and data analysis for hydrological and hydraulic applications. Field work is required.

INCI 6118. BIOREMEDIATION: PRINCIPLES AND APPLICATIONS. Three credit hours. Three hours of lecture per week.

Design and management of bioremediation projects. Topics in bioremediation include: site characterization, project management, subsoil microbial systems, biotransformation pathways of hazardous contaminants, and bioremediation technologies to solve environmental problems. The relationship among the physiological traits of microorganisms, the physicochemical properties of the contaminants, and the nature of the remediation environment will be emphasized.

INCI 6119. DATA ANALYSIS AND MODELING OF TRANSPORTATION SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the variety of analytical tools that are regularly applied to data collected for transportation research studies. Emphasis on the use of model estimation methods as well as software packages helpful in the analysis of data for improving research in transportation engineering.

INCI 6125. UNSTEADY FLOW IN CLOSED CONDUITS. Three credit hours. Three hours of lecture per week.

Study of the principles of unsteady flow in closed-conduits, wave propagation and its causes. Derivation of the equations that describe unsteady flow and its limitations. Discussion of the numerical methods for computer solution of unsteady flow problems. Consideration of boundary conditions and methods for controlling unsteady flow. Development of computer programs for transient unsteady flow simulation.

INCI 6127. UNSTEADY FLOW IN OPEN CHANNELS. Three credit hours. Three hours of lecture per week.

Detailed study of the St. Venant equations for unsteady open channel flow. Derivation of the

differential of shallow-water equations. Modern methodologies to solve unsteady open-channel flow problems using computers. Applications to surge problems and dam breaks and introduction to methods of flow routing. Development of computer programs and use of well-known software to solve real life applications.

INCI 6130. PEDESTRIAN AND BICYCLE TRANSPORTATION. Three credit hours. Three hours of lecture per week.

Study and analysis of current practices related to the planning, design, operation, and maintenance of pedestrian and bicycle facilities. Identification of access and mobility needs and challenges of pedestrians and cyclists and their integration in the development of safe and sustainable transportation infrastructure systems.

INCI 6150. SLOPE STABILITY. Three credit hours. Three hours of lecture per week.

Study and analysis of soil and rock slope stability including the aspects of design and stabilization within a geotechnical framework.

INCI 6205. CONSTRUCTION CONTRACTING FOR ENGINEERS AND CONSTRUCTION PROFESSIONALS. Three credit hours. Three hours of lecture per week.

Study of the fundamental principles for contracting in the construction industry including topics such as: legal obligations for the parties, formation principles, contracts for architectural and design services, construction contracts, subcontractor agreements, description of commercial terms.

INCI 6206. PRECAST CONCRETE CONSTRUCTION. Three credit hours. Three hours of lecture per week.

Study of precast concrete, the benefits of prefabrication and its applications. Emphasis of the use of precast concrete for innovative and modern designs. Development of expertise in precast construction philosophy, principles, and systems. Study of precast detailing, stability, and key issues such as fire resistance and sustainability.

INCI 6207. PROCUREMENT OF INFRASTRUCTURES. Three credit hours. Three hours of lecture per week.

Study of the engineering, technical and organizational issues related to the procurement of infrastructure. Analysis of the scientific principles, practical information, decision-making, pecuniary

as well as socio-economic aspects of civil engineering infrastructures. Discussion of sector profiles and developments, issues and options, planning principles, as well as practices, funding and cost recovery of public works.

INCI 6208. BUILDING CONSTRUCTION SYSTEMS. Three credit hours. Three hours of lecture per week.

Study of the general characteristics of building materials, codes and standards, and construction methods pertaining to soils, foundations, wood, masonry, concrete, steel, and cladding and roofing systems. Discussion of the fundamental aspects of mechanical and electrical systems for buildings.

INCI 6209. ENVIRONMENTAL IMPACT ANALYSIS. Three credit hours. Three hours of lecture per week.

Description of environmental assessment fundamentals. Planning of the environmental assessment process including impact identification, environmental assessment indicators, prediction and assessment of impacts on environmental, social, economic, and cultural settings. Evaluation of alternatives including methods of decision making and preparation of environmental documents.

INCI 6306. SEEPAGE AND CONSOLIDATION. Three credit hours. Three hours of lecture per week. Prerequisites: Authorization of the Director of the Department.

Principles of steady state and transient seepage flow in soils, governing differential equations for unconfined and confined seepage flow problems. Graphical, analytical, and numerical solutions of seepage flow in homogeneous and layered soils with both isotropic and anisotropic permeability. Classical one-dimensional consolidation theory; the use of consolidation theory to analyze and interpret laboratory and field tests; analysis and design considerations. Extended theories of consolidation, nonlinear finite strain, Biot's consolidation theory, and generalized consolidation theory.

INCI 6335. GRADUATE SEMINAR (BD). One credit hour. One hour of seminar per week.

Presentations and discussions in the areas of graduate studies and research. Faculty members, graduate students, and visiting lecturers will participate in this course.

INCI 6555. STORMWATER RUNOFF MANAGEMENT. Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Study of the hydrologic, environmental, and economic aspects of stormwater runoff management systems design. Volume determination for the design, study of quality and pollutant loading, and treatment of this stormwater runoff. Design of swales and detention ponds, financial planning of stormwater management systems, and rural area storm water management.

INCI 6995. SPECIAL PROBLEMS (I, II). One to six credit hours.

Research and special problems in Civil Engineering.

INCI 6996. PRACTICE IN CIVIL ENGINEERING. Zero to three credit hours. Zero to three hours of internship per week.

Practical experience in civil engineering jointly planned between the department and the collaborating organization.

INCI 6997. SPECIAL TOPICS. One to six credit hours. One to six hours of lecture per week.

Special topics in Civil Engineering and related areas.

INCI 8024. STRUCTURAL RELIABILITY. Three credit hours. Three hours of lecture per week.

Study of reliability theory and its applications in structural design, risk and sensibility analysis, and code revision. Detailed presentation of level I and level II reliability analysis and an introduction to level III analysis. Discussion of the fundamentals of stochastic processes and load modeling.

INCI 8080. ADVANCED ANALYSIS OF STEEL STRUCTURES. Three credit hours. Three hours of lecture per week.

Study of advanced design theories for steel structures. Analysis of current design specifications for structural members and connections in rigid and semi-rigid frames.

INCI 8999. DOCTORAL RESEARCH AND THESIS. Nine to eighteen credit hours.

Research and presentation of a thesis which constitutes a significant contribution to the field of specialization of the student.

CIVIL ENGINEERING FACULTY

A list of professors who engage in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

FELIPE J. ACOSTA-COSTA, Professor, Ph.D., 1999, Georgia Institute of Technology. Research interests: Experimental Material Characterization, Construction and Rehabilitation of Structures of Composite Materials. Teaching interest: Finite Element Analysis, Mechanics of Composite Materials, Construction Materials.

LUIS D. APONTE-BERMÚDEZ, Professor, Ph.D., 2006, University of Florida. Research interest: Wind Engineering. Teaching interests: Wind Engineering, Probabilistic Methods.

JUAN B. BERNAL-VERA, Professor, Ph.D., 1984, The University of Texas at Austin. Research interests: Foundations. Teaching interests: Soil Mechanics.

ARSENIO CÁCERES-FERNÁNDEZ, Associate Professor, Ph.D., 1998, West Virginia University. Research interest: Materials for Civil Engineering, Composite Materials Applications and Civil Engineering Infrastructure, Damage Mechanics, Construction Materials made from Recycled Products, Concrete Technology. Teaching interest: Civil Engineering Materials, Composite Materials, and Reinforced Concrete Design.

BEATRIZ I. CAMACHO-PADRÓN, Associate Professor, Ph.D., 2006, University of Texas at Austin. Research interests: Experimental Geotechnics, Geoenvironmental Engineering, Foundation Engineering. Teaching interests: Geoenvironmental Engineering, Foundation Engineering, Environmental Geotechnics, Structural Components in Construction.

BENJAMIN COLUCCI-RIOS, Professor, Ph.D., 1984, Purdue University. Research interests: Pavement Evaluation, Bituminous Materials. Teaching interests: Highway Engineering, Transportation.

IVETTE CRUZADO-VELEZ, Associate Professor, Ph.D., 2009, Pennsylvania State University. Research interests: Transportation Systems Analysis, Public Transportation System, Urban Transportation Planning. Teaching interest: Transportation and Highway Engineering.

ALBERTO M. FIGUEROA-MEDINA, Professor, Ph.D., 2005, Purdue University, Indiana. Research interests: Highway Safety, Urban Transit Systems, Public Transportation System. Teaching interest: Highway Geometric Design, Highway Safety, Highway Engineering, Urban Transit Systems.

HIRAM GONZÁLEZ-HERNÁNDEZ, *Professor*, MSCE, 1984, University of Puerto Rico at Mayagüez. Research interests: Engineering professional accreditation issues. Teaching interest: Soil and Rock mechanics.

JOSÉ O. GUEVARA, *Professor*, Ph.D., 1990, University of Florida. Research interests: Behavior of Reinforced Concrete Structures, Structural Design, Rehabilitation of Structures. Teaching interests: Reinforced Concrete Structures, Structural Design.

SANGCHUL HWANG, *Professor*, Ph.D., 2002, University of Akron. Research interests: Biological treatment, Bioremediation and Environmental Biotechnology. Teaching interests: Environmental Engineering.

CARLA LÓPEZ DEL PUERTO, *Associate Professor*, Ph.D., 2009, Saint Louis University. Research interests: Construction Management, Design-Build Construction, Cost Estimation. Teaching interests: Construction Management, Design-Build Construction, Project Management, Construction Administration and Inspection.

RICARDO LÓPEZ-RODRÍGUEZ, *Professor*, Ph.D., 1988, University of Illinois, Urbana-Champaign. Research interests: Behavior of Reinforced Concrete Structures, Earthquake Engineering and Wind Engineering. Teaching interests: Reinforced Concrete, Structural Analysis, Wind Engineering, Dynamic Analysis.

FRANCISCO MALDONADO-FORTUNET, *Professor*, Ph.D., 2002, Georgia Institute of Technology. Research interests: Sustainable Construction, Construction Management. Teaching interests: Construction Management, Construction Projects Planning and Scheduling.

JOSÉ A. MARTÍNEZ-CRUZADO, *Professor*, Ph.D., 1993, University of California at Berkeley. Research interests: Earthquake Resistance Engineering, Concrete Behavior. Teaching interests: Reinforced Concrete, Structural Steel Design, Earthquake Resistance of Structures.

OMAR I. MOLINA-BAS, *Professor*, Ph.D., 2008, “Universidad Politécnica de Madrid”. Research interests: Durability of Construction Materials, Precast Concrete Construction, Procurement of Infrastructure. Teaching interest: Construction Engineering and Management, Concrete Life Cycle, Public-Private Partnerships, Industrialized Construction.

ALESANDRA C. MORALES-VELEZ, *Assistant Professor*, Ph.D., 2015, University of Rhode Island. Research Interests: Liquefaction of Non Plastic Soils, Shear Wave Velocity, Soil Behavior, Experimental Soil Characterization, Geotechnical Characterization of Calcareous Sands. Teaching Interests: Theory of 1D-

Consolidation, Geotechnical Earthquake Engineering, Soil Behavior, Soil Mechanics and Foundations.

JONATHAN MUÑOZ-BARRETO, *Assistant Professor*, Ph.D., 2014, City College of New York. Research interests: Remote Sensing, Geographic Information Systems. Teaching interests: Geodesy, Surveying, Geographic Information System.

INGRID Y. PADILLA, *Professor*, Ph.D., 1998, University of Arizona. Research interests: Subsurface Hydrology and Contaminant Transport, Soil and Ground-Water Remediation, Water Chemistry, Ground- Water/Surface-Water Interactions, and Ground- Water Flow and Contaminant Transport Modeling. Teaching interests: Groundwater Hydrology, Contaminant Transport, Water Chemistry.

ISMAEL PAGÁN-TRINIDAD, *Professor*, M.S.C.E. 1977, University of Puerto Rico at Mayagüez. Research interests: Urban Drainage, Tropical Hydrology, Flash Floods, Natural Disasters, Water Infrastructure. Teaching interests: General Hydrology and Hydraulics, Applied Hydraulics, Groundwater Hydrology and Hydraulics, Water Resources Systems, Stochastic Hydrology, Flood Control, Disaster Mitigation.

JOSÉ L. PERDOMO-RIVERA, *Professor*, Ph.D., 2004, Virginia Polytechnic Institute. Research interests: Materials Management in Construction, Information Technology for Construction, Handheld Devices Applied to Construction, Wireless Data Transmission, Business Practices Applies to Construction, Means and Methods for Building and Heavy Construction, Temporary Structures for Construction, Simulation and Modeling, Heavy Equipment Performance. Teaching interests: Construction Engineering.

RICARDO RAMOS-CABEZA, *Professor*, Ph.D., 1999, Rensselaer Polytechnic Institute. Research interest: Soil Dynamics, Soil-Structures Interaction, Earthquake Engineering. Teaching interest: Foundation Engineering, Steel Structures Design, Concrete Structures.

JORGE RIVERA-SANTOS, *Professor*, Ph.D., 1988, University of Colorado-Boulder. Research interest: Water Resources Engineering. Teaching interests: Water Resources Systems, Hydrologic Simulation, Computer Graphics.

DANIEL RODRÍGUEZ ROMÁN, *Assistant Professor*, Ph.D., 2015, University of California at Irvine. Research interests: Transportation Planning, Travel Demand Management, Metaheuristic Optimization. Teaching interests: Urban Transportation Planning, Discrete Choice Analysis, Public Transportation.

ALI SAFFAR, *Professor*, Ph.D., 1986, Worcester Polytechnic Institute. Research interests: Structural Fire Resistance, Stress Analysis, Gaussian Closure Techniques, Plastic Fire Design of Steel Structures. Teaching interests: Reinforced Concrete Structures, Building Design, Structural Analysis, and Design of Steel Structures.

RAFAEL SEGARRA-GARCÍA, *Professor*, Ph.D., 1988, Virginia Polytechnic Institute and State University. Research interests: Hydrology, Stochastic Processes, Water Resources Planning and Management. Teaching interests: Hydrology and Water Resources Engineering.

LUIS E. SUÁREZ-COLCHE, *Professor*, Ph.D., 1986, Virginia Polytechnic Institute and State University. Research interests: Structural Dynamics, Computational Methods, Earthquake Engineering, Active and Passive Control. Teaching interests: Structural Dynamics, Structural Analysis, Structural Mechanics, Soil Dynamics.

PEDRO J. TARAFA-VÉLEZ, *Associate Professor*, Ph.D., 2010, University of South Carolina. Research interests: Bio-molecular Engineering, Chemical Processes, Air Pollution, Water and Wastewater Treatment, Waste Disposal. Teaching interests: Water Treatment, Water and Wastewater Treatment, and Environmental Engineering.

DIDIER M. VALDÉS-DÍAZ, *Professor*, Ph.D., 1999, Texas at Austin. Research interests: Transportation Systems Modeling and Analysis, Intelligent Transportation Systems Applications, Network Modeling, Public Transportation System, Urban Transportation Planning, Geometric Design Applied to Urban and Rural Setting. Teaching interest: Transportation and Highway Engineering.

DANIEL A. WENDICHANSKY, *Professor*, Ph.D., 1996, State University of New York at Buffalo. Research interests: Bridge Design, Earthquake Analysis and Design Prestressed Structures, Energy Dissipation System, Experimental Analysis. Teaching interests: Bridge Design, Reinforced Concrete Structures.

RAÚL E. ZAPATA-LÓPEZ, *Professor*, Ph.D., 1987, University of Florida at Gainesville. Research interests: Climatological Data, Water Resources Engineering, Wind Engineering, Groundwater, Hydraulics, Sediment Transport, Fluid Mechanics. Teaching interests: Sediment Transport, Water Resources, Aqueduct and Sewerage Design, Hydraulics, Groundwater, Wind Engineering.

ELECTRICAL AND COMPUTER ENGINEERING

General Information

The Department of Electrical and Computer Engineering offers graduate degrees (masters and doctorate) in electrical and computer engineering, with emphasis in the areas of Power and Energy Engineering, Digital Signal Processing, Control Systems, RF Systems and Microwave Remote Sensing, Electronics, Hardware and Embedded Systems, and Computing Systems. In addition, the Department is involved in the multidisciplinary doctoral program in Computing and Information Sciences and Engineering (CISE) offered jointly by the School of Engineering, and the School of Arts and Sciences.

The ECE graduate program involves 38 faculty and 14 research laboratories, group and centers, with grants from NSF, DoD, NOAA, and NIH, and collaborative projects with industry, that provide support to qualified graduate students. Detailed information on the ECE graduate programs can be found at <https://ece.uprm.edu/graduates-programs/>.

Degrees offered:

1. Master of Engineering (ME) – The master of engineering is a professional degree that comprises advanced coursework in electrical and computer engineering. The ME program has two options, Plan II, where students take 24 to 27 credits in courses, and work on an engineering project (3-6 credits), and Plan III, where students take 30 credits in courses. The department offers ME programs in Electrical Engineering (MEEE) and in Computer Engineering (MECpE).

2. Master of Science (MS) – The master of science degree comprises advanced coursework in electrical and computer engineering (24 credits) and requires the preparation of an original thesis (6 credits). The department offers MS programs in Electrical Engineering (MSEE) and in Computer Engineering (MSCpE)

3. Doctor of Philosophy (PhD) – This is the terminal degree for those seeking a technical or research career in electrical engineering. The PhD program in Electrical Engineering requires the completion of 37 course credits above the BS, the preparation of an original dissertation (12 credits),

passing the qualifying and comprehensive examinations, and a successful dissertation defense.

Master of Science and Master of Engineering in Electrical Engineering

Admission Requirements:

1. A bachelor's degree in Electrical Engineering, Computer Engineering or their equivalents from an accredited institution of higher learning is required for the ECE graduate programs. Applicants with a degree in other engineering fields, science, mathematics, or in related areas, may be considered for admission.
2. A general grade point average of 3.0/4.0. Admission is possible for applicants with lower GPAs, but that have previous industrial or research experience.
3. A minimum mastery of both English and Spanish skills to understand technical literature and to write technical documents.
4. Three letters of recommendation from qualified referees.
5. A statement of purpose describing the applicant's goals and interests.

Graduation Requirements:

Students pursuing the degree of Master of Science (Plan I) or Master of Engineering (Plan II or III) in Electrical Engineering may specialize in the areas of (i) electronics, (ii) power and energy systems, (iii) control systems, (iv) systems and microwave remote sensing, and (v) digital signal processing.

For students enrolled in M.S. (Plan I) the program requires a minimum of 30 credits distributed as follows:

- 18 credits in core courses and technical electives in the selected area of specialization.
- 6 credits in electives outside the area of specialization.
- 6 credits of graduate thesis.

The Master of Engineering with project option (Plan II) requires a minimum of 30 credits distributed as follows:

- 18-21 credits in core courses and technical electives in the selected area of specialization.
- 6 credits in electives outside the area of specialization.
- 3-6 credits of graduate project.

The Master of Engineering with courses option (Plan III) requires a minimum of 30 credits distributed as follows:

- 24 credits in core courses and technical electives in the selected area of specialization.
- 6 credits in electives outside the area of specialization.

No more than 9 credits in advanced undergraduate level (5000 level) courses can be used to meet the degree requirements for any of the three plans.

Master of Science and Master of Engineering in Computer Engineering

Admission Requirements:

6. A bachelor's degree in Electrical Engineering, Computer Engineering or their equivalents from an accredited institution of higher learning is required for the ECE graduate programs. Applicants with a degree in other engineering fields, science, mathematics, or in related areas, may be considered for admission.
7. A general grade point average of 3.0/4.0. Admission is possible for applicants with lower GPAs, but that have previous industrial or research experience.
8. A minimum mastery of both English and Spanish skills to understand technical literature and to write technical documents.
9. Three letters of recommendation from qualified referees.
10. A statement of purpose describing the applicant's goals and interests.

Graduation Requirements:

Students pursuing the degree of Master of Science (Plan I) or Master of Engineering (Plan II or III) in Computer Engineering may specialize in the areas of (i) hardware and embedded systems, (ii) computing systems, and (iii) digital signal processing.

For students enrolled in M.S. (Plan I) the program requires a minimum of 30 credits distributed as follows:

- 18 credits in core courses and technical electives in computer engineering (at least 12 credits at 6000 level or above).
- 6 credits in electives outside the computer engineering areas of emphasis.
- 6 credits of graduate thesis.

The Master of Engineering with project option (Plan II) requires a minimum of 30 credits distributed as follows:

- 18-21 credits in core courses and technical electives in computer engineering (at least 12 credits at 6000 level or above).
- 6 credits in electives outside the computer engineering areas of emphasis.
- 3-6 credits of graduate project.

The Master of Engineering with courses option (Plan III) requires a minimum of 30 credits distributed as follows:

- 24 credits in core courses and technical electives computer engineering (at least 12 credits at 6000 level or above).
- 6 credits in electives outside the computer engineering areas of emphasis.

In addition, for all options, the core courses and technical electives are distributed as follows:

- a minimum of 6 credits in computing systems (CS) (at least 3 credits at 6000 level or above)
- a minimum of 3 credits at 6000 level in hardware and embedded systems (HES), or digital signal processing (DSP)
- a minimum of 6 credits at 6000 level in the selected area of emphasis

No more than 9 credits in advanced undergraduate level (5000 level) courses can be used to meet the degree requirements for any of the three plans.

Doctoral Program in Electrical Engineering

Admission Requirements:

1. A bachelor's or master's degree in Electrical Engineering, Computer Engineering or their equivalents from an accredited institution of higher learning. Applicants with a bachelor degree or a master's degree in other engineering fields, science, mathematics, or in

- related areas, may be considered for admission. Depending on the applicant's academic background, admission may be granted with deficiency courses, or a master degree in Electrical or Computer Engineering may be recommended before admission into the doctoral program.
2. A general grade point average of 3.3/4.0 if the applicant holds a BS degree, or 3.5/4.0 if the applicant holds an MS or higher degree. Admission is possible for applicants with lower GPAs, but that have previous industrial or research experience.
 3. A minimum mastery of both English and Spanish skills to understand technical literature and to write technical documents.
 4. Three letters of recommendation from qualified referees.
 5. A statement of purpose describing the applicant's goals and interests.

Graduation Requirements:

Students pursuing the degree of Doctor of Philosophy in Electrical Engineering may specialize in the areas of (i) electronics, (ii) power and energy systems, (iii) rf systems and microwave remote sensing, and (iv) signals and systems.

The program requires a minimum of 49 credits, above a bachelor's degree, distributed as follows:

- 24 credits in core courses and technical electives in the selected area of emphasis (at least 6 credits at 8000 level).
- 6 credits in electives outside the area of emphasis.
- 6 credits in advanced math courses (5000 level or above, at least 3 credits at 6000 level or above)
- 1 credit of doctoral seminar
- 12 credits of graduate thesis.

In addition, the student must pass the qualifying and comprehensive examinations, and have a successful dissertation defense.

Doctoral Program in Computing and Information Sciences and Engineering

The Department of Electrical and Computer Engineering participates in the interdisciplinary doctoral program in Computing and Information

Sciences and Engineering. Refer to the *Interdisciplinary Programs* section of this bulletin for information. Detailed program information is available at <http://phd.cise.uprm.edu>.

Research Infrastructure

The ECE Department has over 8600 square foot of research laboratories. There are 6 shared use laboratories (graduate and undergraduate) and 11 research laboratories. The laboratories include state of the art computer network, instrumentation, and development and prototyping facilities. ECE facilities are located in the Stefani Building and at the UPRM Research and Development Center.

Detailed information about the department laboratories can be obtained at the departmental web site, <https://ece.uprm.edu/laboratories/>.

ELECTRICAL ENGINEERING (INEL)

Advanced Undergraduate Courses

INEL 5046. PATTERN RECOGNITION. Three credit hours. Three hours of lecture per week. Prerequisites: (INEL 4095 or INEL 4301) and (ININ 4010 or ININ 4011) or authorization of the Director of the Department.

Introduction to the field of pattern recognition, including statistical decision making, nonparametric decision making, nonparametric decision making, clustering techniques, artificial neural networks, learning techniques, evaluation of classification rules, and image analysis.

INEL 5195. DESIGN PROJECT IN ELECTRICAL ENGINEERING. Three credit hours. One hour of lecture and four hours of laboratory per week. Prerequisite: authorization of the Director of the Department.

Capstone design course in which students apply the fundamental knowledge in electrical engineering to solve engineering problems considering engineering standards and realistic design constraints.

INEL 5205. INSTRUMENTATION (I). Three credit hours. Three hours of lecture per week. Prerequisites: (INEL 4201 and INEL 4206) or authorization of the Director of the Department.

Signals from transducers; signal conditioning, data conversion and transmission; effects of noise. Data storage and display; use of microprocessors in instrumentation.

INEL 5206. DIGITAL SYSTEMS DESIGN. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4207 or authorization of the Director of the Department.

Design methods in combinational and sequential systems. Use of programmable logic devices in digital systems design. Analysis and design of system controllers.

INEL 5207. ANALOG SYSTEMS DESIGN. Three credit hours. Three hours of lecture per week. Prerequisite: (INEL 4201 and INEL 4205) or authorization of the Director of the Department.

This course covers the design of applications using analog integrated circuits. A discussion on the characteristics of operational amplifiers is followed with a detailed overview of applications.

INEL 5208. PRINCIPLES OF BIOMEDICAL INSTRUMENTS. Four credit hours. Three hours of lecture and two hours of laboratory per week. Prerequisite: INEL 4202 or authorization of the Director of the Department.

Theoretical and practical aspects of the methods used to measure physiological events with emphasis in the cardiovascular, pulmonary, and nervous systems.

INEL 5209. INTRODUCTION TO SOLID STATE ELECTRONICS. Three credit hours. Three hours of conference per week. Prerequisite: authorization of the Director of the Department.

Basic operation principles of solid state electronic devices, physical phenomena and properties of solid materials involved in the analysis and design of such devices, detailed treatment of the most common elements used as diodes, transistor and controlled rectifiers.

INEL 5218. INTRODUCTION TO MIXED-SIGNAL TESTING. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4201 or authorization of the Director of the Department.

Description and analysis of tester hardware, sampling theory for Digital Signal Processing (DSP), analog channels and sample channel testing, including testing for mixed signal circuits focused on A/D and D/A converters, focused calibration and test economics.

INEL 5265. ANALOG INTEGRATED CIRCUIT DESIGN. Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4201 or authorization of the Director of the Department.

Analysis and design of analog and mixed-technology (analog-digital) circuits through the use of advanced computer-assisted design (CAD) techniques. Discussion of functional tests of analog integrated circuits.

INEL 5295. DESIGN PROJECT IN ELECTRONIC SYSTEMS AND EMBEDDED HARDWARE. Three credit hours. One hour of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Capstone design course in which students apply the fundamentals of electronic systems and embedded hardware to solve electrical engineering problems considering engineering standards and realistic design constraints.

INEL 5307. OPTICAL COMMUNICATIONS (I). Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4301 or authorization of the Director of the Department.

Optical communication principles; transmitter and receiver design; fiber optic channels.

INEL 5309. DIGITAL SIGNAL PROCESSING. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4095 or authorization of the Director of the Department.

Signal classification, Z-Transform and discrete Fourier transform; matrix representation of digital filters and digital systems; digital filter design; discrete Fourier transform algorithms.

INEL 5315. THEORY OF COMMUNICATIONS II. Three credit hours. Three hours of lecture per week. Prerequisite: (INEL 4301 and (ININ 4011 or ININ 4010)) or authorization of the Director of the Department.

Information theory; coding theory; signal design; noise and probability of error.

INEL/ICOM/SICI/COMP 5318. INTERMEDIATE ROUTING, SWITCHING AND WIDE AREA NETWORKS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL/ICOM/SICI/COMP 4308 or authorization of the Director of the Department.

Study and configuration of link state protocols. Study of intermediate level concepts such as switching, wide area network or WAN standards, virtual local area networks or VLAN, network design, and redundancy. Presentation and study of strategies for managing and saving address space such as variable length subnet masks and network address translation.

INEL 5326. COMMUNICATION SYSTEM DESIGN: SIGNAL PROCESSING (II). Three credit hours. One hour of lecture and two two-hour laboratories per week. Prerequisite: INEL 5309 or authorization of the Director of the Department.

Block diagram design and simulation of communication systems. Design projects including: specification, evaluation and selection of alternatives, and implementation. Computer and laboratory work and written reports required.

INEL 5327. IMAGE PROCESSING. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4095 or INEL 5309 or ICOM 4045 or authorization of the Director of the Department.

Mathematical representation of two dimensional digital signals. Two-dimensional filter design, image coding, image filtering, enhancement, and compression.

INEL 5406. DESIGN OF TRANSMISSION AND DISTRIBUTION SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4415 or authorization of the Director of the Department.

Generation, transmission, and distribution of electric power. Reliability consumer services; overhead and underground lines.

INEL 5407. COMPUTER AIDED POWER SYSTEM DESIGN (II). Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4415 or authorization of the Director of the Department.

Design of power systems using digital computers; load flow, economic load dispatch, symmetrical and unsymmetrical faults. Selection of breakers.

INEL 5408. ELECTRICAL MOTORS CONTROL (I). Three credit hours. Three hours of lecture per week. Prerequisites: (INEL 4405 and INEL 4416 and INEL 4505) or authorization of the Director of the Department.

Characteristics and selection criteria of alternating current (A.C.) and direct current (D.C.) motors;

design and control of solid state drive systems; braking methods; heating and duty cycle calculations. Performance calculations and design of closed loop controllers.

INEL 5415. PROTECTION DESIGN FOR ELECTRICAL SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4415 or authorization of the Director of the Department.

Design and selection of protective devices used in electrical generation, transmission, and distribution systems such as: relays, fuses, breakers, reclosers, and arresters. Selection of other system components such as sectionalizers and throwovers. Protection and insulation coordination.

INEL 5417. POWER ELECTRONICS APPLIED TO RENEWABLE ENERGY SYSTEM. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4416 or authorization of the Director of the Department.

Design of interfaces using topologies based on power electronics for photovoltaic and wind applications. Use of algorithms for maximum power point tracking; control of photovoltaic and wind systems, and its applications.

INEL 5495. DESIGN PROJECT IN POWER SYSTEMS. Three credit hours. One hour of lecture and one-four hour laboratory per week. Prerequisite: Authorization of the Director of the Department.

Major design experience in electric power systems. Application of power system fundamental to the design of a system incorporating engineering standards and realistic constraints. Use of computational tools for the design and analysis of electric power systems.

INEL 5496. DESIGN PROJECTS IN POWER ELECTRONICS. Three credit hours. One hour of lecture and one-four hour laboratory per week. Prerequisite: INEL 4416 or authorization of the Director of the Department.

Application of power electronics fundamentals to the design of a system incorporating engineering standards and realistic constraints. Use of the computational tools for the design and analysis of power electronics systems.

INEL 5505. LINEAR SYSTEM ANALYSIS (II). Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4505 or authorization of the Director of the Department.

Linear spaces and matrices; state variables representations for linear continuous and discrete systems; the Z-transform and its application; controllability and observability; state estimators; stability.

INEL 5506. PROCESS INSTRUMENTATION AND CONTROL ENGINEERING (II). Three credit hours. Three hours of lecture per week. Prerequisite: (INEL 4505 and INEL 4206) or authorization of the Director of the Department.

Design of process instrumentation and control systems, based on analog and digital instruments and mini or microcomputers. Standards and practical considerations emphasized.

INEL 5508. DIGITAL CONTROL SYSTEMS (I). Three credit hours. Three hours of lecture per week. Prerequisites: INEL 4505 or authorization of the Director of the Department.

Analysis and design of digital control systems; stability, controllability and observability of discrete systems. Practical considerations when implementing a digital control system.

INEL 5516. AUTOMATION AND ROBOTICS (I). Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4206 or ININ 4057 or authorization of the Director of the Department.

Analysis and design of automated pneumatic systems using programmable controllers. Programming of industrial robots.

INEL 5595. DESIGN PROJECT IN CONTROL SYSTEMS. Three credit hours. One hour of lecture and one three-hour laboratory per week. Prerequisite: authorization of the Director of the Department.

Capstone design course in which students apply the fundamentals of control systems to solve engineering problems considering engineering standards and realistic design constraints.

INEL 5605. ANTENNA THEORY AND DESIGN. Three credit hours. Three hours of lecture per week. Prerequisites: ((INEL 4155 or INEL 4152) and (INEL 4095 or INEL 4301)) or authorization of the Director of the Department.

Radiation mechanism. Types of antennas; impedance; radiation patterns; antenna arrays. Antenna measurements.

INEL 5606. MICROWAVE ENGINEERING. Three credit hours. Three hours of lecture per week.

Prerequisites: ((INEL 4155 or INEL 4152) and (INEL 4095 or INEL 4301)) or authorization of the Director of the Department.

Rectangular and circular waveguides; passive components, tubes, and solid-state devices components, tubes, and solid-state devices used in microwave systems.

INEL 5608. RADIO FREQUENCIES (RF) SPECTRUM MANAGEMENT. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 4151 or authorization of the Director of the Department.

Analysis of the most relevant issues related to the RF spectrum management, including regulations at national and international levels, the geophysical fundamentals of wave propagation, the power budget equation, engineering aspects about antennas and active and passive sensors, introduction to the services that use the spectrum (satellite communications, radio astronomy, Earth exploration) and the agencies that regulate them.

INEL 5616. WIRELESS COMMUNICATION. Three credit hours. Three hours of lecture per week. Prerequisites: ((INEL 4155 or INEL 4152) and (INEL 4095 or INEL 4301)) or authorization of the Director of the Department.

Study of cellular radio and personal wireless communications, multiple access techniques for the efficient use of the radio spectrum, and wide-area wireless systems. Description of some wireless systems and their standards. Effects of EM radiation on health. Development of modulation and diversity methods to facilitate signal transmission and to improve quality of reception.

INEL 5625. COMMUNICATION SYSTEM DESIGN: CIRCUITS AND ANTENNAS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 5306 or INEL 5305 or authorization of the Director of the Department.

Design of communication circuits and antennas. Several design projects including: specification, evaluation and selection of alternatives and implementation. Written reports and computer use required.

INEL 5629. TELECOMMUNICATIONS ELECTRONICS. Three credit hours. Two hours of lecture and one two-hour laboratory per week. Prerequisites: (INEL 4152 and INEL 4301 and INEL 4201) or authorization of the Director of the Department.

Study of the theory of operation of radio frequency (RF) and microwave devices and components. Fundamentals of RF design to understand the operation of the diverse components of telecommunications systems.

INEL 5995. SPECIAL PROBLEMS (On demand). One to six credit hours. Prerequisite: Authorization of the Director of the Department.

Investigations and special problems in Electrical Engineering or related fields. Open to outstanding Electrical Engineering students.

Graduate Courses

INEL 6000. INTRODUCTION TO NONLINEAR CONTROL SYSTEMS (I). Three credit hours. Three hours of lecture per week.

Analysis and synthesis of nonlinear control systems; phase plane and describing function techniques; Lyapunov's second method and its application in the design and stability determination of nonlinear systems.

INEL 6001. FEEDBACK CONTROL SYSTEMS I (II). Three credit hours. Three hours of lecture per week.

The Z-transform and its application to sampled-data control systems; analysis of automatic control systems, using state variable concepts; stability criteria; introduction to parameter optimization techniques.

INEL 6002. FEEDBACK CONTROL SYSTEMS II. Three credit hours. Three lectures per week.

Selected topics in advanced control theory from such areas as adaptive control systems, optimal control theory, statistical design, and system identification.

INEL 6005. ANALYSIS, DESIGN AND PARASITIC EFFECT OF INTEGRATED CIRCUITS (On demand). Three credit hours. Three hours of lecture per week.

Analysis and design of integrated circuits. Study of linear and non-linear models, and parasitic effects. Analog and digital circuits.

INEL 6006. SPEECH AND IMAGE COMMUNICATION (I) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Digital coding of waveforms including pulse code modulation (PCM), differential pulse code

modulation (DPCM), tree/trellis coding, run-length coding, sub-band coding, transform coding; quadrature mirror filters; vector quantization; rate distortion theoretic performance bounds.

INEL 6007. INTRODUCTION TO REMOTE SENSING (I). Three credit hours. Three hours of lecture per week.

History, principles, and applications of remote sensing. Electromagnetic radiation; aerial photography; image interpretation; land observation satellite systems; image resolution; preprocessing and classification of images; geographic information systems.

INEL 6009. COMPUTER SYSTEM ARCHITECTURE. Three credit hours. Three hours of lecture per week.

Fundamentals of the architecture and organization of computers. Concepts of high-level languages. Architectural support to the compilation process and to operating systems.

INEL 6025. ADVANCED ENERGY CONVERSION (I) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Theory and design of processes for direct energy conversion. Thermoelectric, thermionic, and photovoltaic conversion. Fuel cells. Introduction to irreversible thermodynamics and its application to describe operations. MHD equations and generators. Conversion efficiency and electrical losses.

INEL 6026. COMPUTATIONAL METHODS FOR POWER SYSTEMS ANALYSIS II. Three credit hours. Three lectures per week. Prerequisite: INEL 5027.

Application of numerical techniques and computer methods to the solution of a variety of problems related to the planning, design and operation of large interconnected electric power systems.

INEL 6027. DYNAMICS AND CONTROL OF INTEGRATED POWER SYSTEMS (I). Three credit hours. Three hours of lecture per week.

Discussion of a variety of transient and control problems associated with interconnected power systems, and techniques for their analysis and solution. Methods for dynamic analysis of large systems are stressed.

INEL 6028. OPTIMIZATION AND ECONOMIC OPERATION OF INTEGRATED POWER SYSTEMS (II). Three credit hours. Three hours of lecture per week.

Theory of optimization under equality and inequality constraints; computational methods and application to generation scheduling in integrated power systems.

INEL 6045. ENGINEERING PROJECT (I, II). Zero to six credit hours.

Comprehensive study of a specific electrical engineering problem selected so as to integrate the knowledge acquired in the graduate program of study. This project fulfills one of the terminal requirements of the Master of Engineering Program, and will be governed by the norms for this purpose.

INEL 6046. MASTER'S THESIS (I, II). Zero to six credit hours.

Research in the field of Electrical Engineering and presentation of a thesis.

INEL 6047. ADVANCED CONTROL SYSTEM THEORY (II). Three credit hours. Three hours of lecture per week.

Advanced problems in linear and non-linear control systems. The use of linear algebra for the analysis and design of linear systems is emphasized. The implementation of linear systems via analog and digital simulation diagrams is also studied.

INEL 6048. ADVANCED MICROPROCESSOR INTERFACING. Three credit hours. Three hours of lecture per week.

Architecture of 8, 16, and 32 bits microprocessors; bus, input/output and memory interfacing; parallel processing architecture; configuration and interfacing of multiprocessors; applications of the multiprocessor system.

INEL 6049. MULTIDIMENSIONAL DIGITAL SIGNAL PROCESSING (II) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Representation of multidimensional signals and systems; Fourier analysis of multidimensional signals; design and implementation of two-dimensional digital filters; applications of digital filtering techniques to beam forming and image analysis.

NEL 6050. ADVANCED DIGITAL SIGNAL PROCESSING ALGORITHMS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 5309.

Theoretical foundations, fast algorithms for the Discrete Fourier Transform. Fast convolution algorithms, multidimensional techniques, fast filtering computations, architecture of filters and transforms, fast algorithms in VLSI. Application studies in transmission error controlling codes, sonar, radar, speech, image processing, and other engineering areas. Study of software implementations on vector and parallel architectures. Algorithms and symbolic computation.

INEL 6055. SOLID STATE ELECTRONICS. Three credit hours. Three hours of lecture per week.

This course deals with solid state electronic devices that utilize the conductive, dielectric, magnetic and optical properties of materials. Some of the topics included are atomic structure, interatomic forces and crystal structures, conduction mechanisms, transport phenomena, and application of these theories to semiconductor devices.

INEL 6057. REGULATORY ISSUES IN ELECTRICAL ENGINEERING. Three credit hours. Three hours of lecture per week.

Study of the regulatory entities or agencies and their regulations related to areas relevant to electrical engineering. Emphasis on telecommunications, energy, biomedical and electronic applications.

INEL 6058. HIGH FREQUENCY POWER CONVERTERS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 6085.

Simulation, analysis, modeling, design, and control of high frequency power converters. Study of unidirectional and bidirectional soft-switching topologies for dc to dc and dc to single-phase or three-phase power converters. Discussion of applications such as traditional and uninterruptible power supplies, electronic ballasts for fluorescent lamps, inverters for motor drives, and rectifiers with power factor correction.

INEL 6059. INTELLIGENT SYSTEMS AND CONTROLS. Three credit hours. Three hours of lecture per week.

Engineered intelligent systems and their application to complex decision, modeling, and control processes.

INEL 6066. CONTROL OF ELECTRIC DRIVE SYSTEMS (I) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Theory and operation of phase and chopper controlled direct current (d.c.) drives, closed loop d.c. drives and their analysis, phase locked loop d.c. drives; design of controllers for optimal performance. Speed control and control schemes for induction and synchronous motors; inverters and cycloconverters; closed loop alternating current (a.c.) drives; stability and performance analysis.

INEL 6067. DISTRIBUTED PROCESSING AND ADVANCED COMPUTER ARCHITECTURES. Three credit hours. Three hours of lecture per week.

Advanced topics in computer architecture and distributed processing, including: vector processors, multi-processors, pipeline computers, data flow computers.

INEL 6070. ADVANCED INTEGRATED CIRCUIT DESIGN TECHNIQUES. Three credit hours. Three hours of lecture per week.

Study of contemporary circuit design optimization techniques with emphasis on power management and power reduction in both analog and digital integrated circuits. Analysis of problems related to performance optimization and noise reduction.

INEL 6075. INTEGRATED CIRCUITS FABRICATION. Three credit hours. Three hours of lecture per week.

Basic principles underlying the fabrication of circuits with emphasis in very large scale integrated systems (VLSI). Properties of materials like silicon and gallium arsenide; phase diagrams; solid solubility; crystal growth; doping; evaporation; sputtering epitaxy; diffusion; ion implantation; oxidation; lithographic process; device and circuit fabrication. Thin and thick film circuits, assembly, packaging processing, yield and reliability.

INEL 6076. ADAPTIVE AND OPTIMAL SIGNAL PROCESSING. Three credit hours. Three hours of lecture per week. Prerequisite: INEL 6078.

Signal and system modeling, power spectrum estimation, optimum linear filtering, and linear and nonlinear adaptive filtering.

INEL 6077. SURGE PHENOMENA IN POWER SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Power system analysis under transient conditions due to breaker operation, lighting strikes, or sudden changes in loads. Design of power systems with emphasis on surge protection equipment, insulation level selection, and effects of ground resistance.

INEL 6078. ESTIMATION, DETECTION, AND STOCHASTIC PROCESSES. Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Fundamentals of estimation, detection, and random process theory relevant to signal processing, communications, and control. Parameter estimation; signal detection and estimation from wave form observations.

INEL 6079. ADVANCED INTEGRATED CIRCUIT DESIGN TECHNIQUES. Three credit hours. Three hours of lecture per week. Prerequisite: Authorization of the Director of the Department.

Study of contemporary circuit design optimization techniques with emphasis on power management and power reduction in both analog and digital integrated circuits. Analysis of problems related to performance optimization and noise reduction.

INEL 6080. VLSI SYSTEMS DESIGN (II). Three credit hours. Three hours of lecture per week.

MOS (metal-oxide-semiconductor) devices and circuits. Design, implementation and fabrication of integrated systems at a very large scale (VLSI). System timing analysis. Physical implementation of several computational systems.

INEL 6085. ANALYSIS AND DESIGN OF POWER SEMICONDUCTOR CIRCUITS (II). Three credit hours. Three hours of lecture per week.

Analysis and design of single phase and three phase controlled rectifiers, dual converters, A.C. voltage controllers, PWM converters, for power supplies, four quadrant choppers, voltage and current source inverters with modulation techniques, A.C. to A.C. converters.

INEL 6086. INTRODUCTION TO MICRO-ELECTRO-MECHANICAL SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Discussion of the basic principles of MEMS design, fabrication, and testing. Includes topics such as: the theory behind microfabrication techniques, material deposition techniques, lumped modeling of MEMS

structures, static and dynamic behavior of MEMS, and MEMS integration into systems.

INEL 6088. COMPUTER VISION. Three credit hours. Three hours of lecture per week.

Introduction to computer vision. Computer vision systems. Biological vision system and biological signal processing; early image processing; boundary detection; region growing; texture and shape analysis.

INEL 6096. ELECTRIC POWER QUALITY. Three credit hours. Three hours of lecture per week.

Analysis, modeling, and mitigation of the difficulties related to the distortion of voltages and current on power systems. Special emphasis in harmonics and sources of power quality problems. Study of voltage sags and swells, impulses, and other transient events.

INEL 6207. HIGH PERFORMANCE COMPUTERS. Three credit hours. Three hours of lecture per week.

Study of architectural and organizational aspects of processors that result in high performance. Study of contemporary high performance computers. Discussion of future trends in computer design.

INEL 6209. DIGITAL IMAGE PROCESSING. Three credit hours. Three hours of lecture per week.

Image representation and compression. Image enhancement by filtering and removal of existing degradations. Image transformation; image models; image restoration.

INEL 6601. ADVANCED ELECTROMAGNETICS. Three credit hours. Three hours of lecture per week.

Advanced theory and techniques for the analysis of electromagnetic systems applied to electrical engineering problems. Advanced study of Maxwell's equations, electrical properties of matter, and wave propagation, polarization, reflection, and transmission in diverse media. Use of Green's functions for the solution of electromagnetism problems.

INEL 6605. RADAR THEORY AND PRACTICE. Three credit hours. Three hours of lecture per week.

Discussion of the theory underlying radar and lidar techniques. Topics include: wave propagation and polarization, cross section of targets, matched filters, ambiguity functions, coded radar signals, signal

processing and interpretation of radar and lidar returns, and their applications.

INEL 6606. INTRODUCTION TO RADAR SYSTEMS. Three credit hours. Three hours of lecture per week.

Study of the basic theory underlying radar systems and their construction. Use of the radar equation for diverse applications. Discussion of different types of radar such as FM, FM-CW and pulse, their strengths and weaknesses as well as their applications. Study of calibration and signal detection in noise as well as different types of transmitters and receivers.

INEL 6615. MICROWAVE ACTIVE CIRCUITS. Three credit hours. Three hours of lecture per week.

Study and design of microwave frequency amplifiers and oscillators taking into consideration parameters such as noise, bandwidth, gain, and output power. Discussion of transistor amplifiers and oscillation that use dielectric resonators.

INEL 6668. MICROWAVE ANTENNA ENGINEERING. Three credit hours. Three hours of lecture per week.

Analysis and design of microwave and millimeter-wave antennas.

INEL 6669. MICROWAVE REMOTE SENSING. Three credit hours. Three hours of lecture per week.

Study of the interaction of electromagnetic waves with natural and artificial objects. Introduction to radiometry theory and to the operational principles of active and passive instrumentation used in remote sensing.

INEL 6995. SPECIAL TOPICS IN ELECTRICAL ENGINEERING (I, II). One to six credit hours. One to six hours of lecture per week.

Study of selected topics in Electrical Engineering.

INEL 6997. INDEPENDENT STUDIES. One to three credit hours. Three hours per credit of independent study. Prerequisite: to be a graduate student and authorization of the Director of the Department.

Independent studies in electrical engineering or related areas under supervision of a member of the faculty.

INEL 6998. PREPARATION FOR COMPREHENSIVE EXAM. Zero credit hours. One to twelve hours of independent study. Prerequisite: to be an option III graduate student from the Master in Electrical Engineering Program and have completed at least 30 credits in his program or authorization of the Director of the Department.

Independent studies in preparation for the comprehensive exam.

INEL 8295. ADVANCED TOPICS IN ELECTRONICS. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in electronics or related fields.

INEL 8296. ADVANCED TOPICS IN COMPUTER ENGINEERING. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in computer engineering or related fields.

INEL 8395. ADVANCED TOPICS IN SIGNAL PROCESSING. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in signal processing or related fields.

INEL 8396. ADVANCED TOPICS IN COMMUNICATIONS SYSTEMS. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in communications systems or related fields.

INEL 8495. ADVANCED TOPICS IN ELECTRIC POWER ENGINEERING. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in electric power engineering or related fields.

INEL 8496. SELECTED TOPICS IN POWER ELECTRONICS. One to three credit hours per semester up to a maximum of six credit hours. Prerequisite: authorization of the Director of the Department.

Study of selected topics in power electronics or related fields.

INEL 8595. ADVANCED TOPICS IN CONTROL SYSTEMS. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in control systems or related fields.

INEL 8695. ADVANCED TOPICS IN APPLIED ELECTROMAGNETICS. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in applied electromagnetics or related fields.

INEL 8995. ADVANCED TOPICS. One to six credit hours. One to six hours of lecture per week.

Study of selected topics in electrical engineering or related fields.

INEL 8997. INDEPENDENT STUDY. One to three credit hours.

Individual student research in electrical engineering and related fields.

INEL 8998. DOCTORAL SEMINAR. Zero to one credit hour. One hour of seminar per week.

Oral presentations in research topics in electrical engineering.

INEL 8999. DOCTORAL DISSERTATION. Three to twelve credit hours.

Development, preparation, and defense of a dissertation based on an original research project in electrical engineering that represents a significant contribution in the area of specialization.

COURSE OFFERINGS

COMPUTER ENGINEERING (ICOM)

Undergraduate Courses

ICOM 5007. OPERATING SYSTEMS PROGRAMMING. Four credit hours. Three hours of lecture and one-three hour laboratory per week. Prerequisites: (ICOM 4035 and INEL 4206) or authorization of the Director of the Department.

Concepts of operating systems, multiprogramming, multiprocessing, batch, partitioned, and real time. Organizational and processing of file systems. Study of queuing theory and information flow control.

ICOM/COMP 5015. ARTIFICIAL INTELLIGENCE. Three credit hours. Three hours of conference per week. Prerequisite: ICOM 4035.

An introduction to the field of artificial intelligence: Lisp language, search techniques, games, vision, representation of knowledge, inference and process of proving theorems, natural language understanding.

ICOM 5016. DATABASE SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: ICOM 4035 or authorization of the Director of the Department.

Study of database system architectures; design and implementation of database applications; conceptual and representational models; SQL and the relational model; functional dependencies and normalization; transaction processing.

ICOM 5017. OPERATING SYSTEM AND NETWORK ADMINISTRATION AND SECURITY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: (INEL 4307 and ICOM 5007) or authorization of the Director of the Department.

Practical experience in the administration and security of operating systems and networks. Design and development of measures for the detection of and response to attacks on such systems.

ICOM 5018. CRYPTOGRAPHY AND NETWORK SECURITY. Three credit hours. Three hours of lecture per week. Prerequisite: ICOM 5007 or authorization of the Director of the Department.

Study of the theoretical and practical aspects of computer systems and network security. Threat models and vulnerabilities of computer systems and networks to attacks such as: hackers, malicious code, Trojan horses, viruses, and worms. Methods and techniques to defend against attacks and minimize their damage. Cryptographic techniques, physical and operational security policies, and management-related issues.

ICOM 5025. OBJECT-ORIENTED SOFTWARE DEVELOPMENT. Three credit hours. Three hours of lecture per week. Prerequisites: ICOM 4035 or authorization of the Director of the Department.

Discussion of the fundamental concepts of object-oriented programming. Analysis, design, and development of object-oriented software. Study of object-oriented languages.

ICOM 5026. COMPUTER NETWORKS. Three credit hours. Three hours of lecture per week. Prerequisite: ICOM 5007 or authorization of the Director of the Department.

Study of computer communication including the OSI and Internet layering models and networking protocols at subnetwork, network, transport, and application layers. Analysis of media and standards applied to computer networks as well as the software, hardware, and terminology associated with data communications.

ICOM 5035. COMPUTER GRAPHICS. Four credit hours. Three hours of lecture and two hours of laboratory per week. Prerequisites: ICOM 4035 or authorization of the Director of the Department.

The analysis, creation and rendering of 3D models and animations using computer graphics: geometric modeling and transformations, rendering algorithms, animation, illumination models, image formation, antialiasing, and ray tracing.

ICOM 5047. COMPUTER ENGINEERING DESIGN. Three credit hours. One hour of lecture and four hours of laboratory per week. Prerequisites: ((ICOM 4009 or ICOM 5016) and (ICOM 5217 or INEL 5206 or INEL 5265) and ICOM 4215 and ICOM 5007 and INEL 4301 and INEL 4207)) or authorization of the Director of the Department.

Capstone course in which student teams design a project to solve a complete computer engineering problem considering engineering standards and realistic constraints. The project should integrate both hardware and software concepts.

ICOM 5104. COMPUTATIONAL SYSTEMS BIOLOGY. Three credit hours. Three hours of lecture per week. Prerequisites: (ICOM 5016 and INGE 5036) or authorization of the Director of the Department.

Study of fundamental concepts, models and computational methods for the analysis of biological networks. Discussion of theoretical foundations of networks and their use in biology systems modeling and simulation. Construction of networks from data and qualitative methods for their dynamic simulations and systems analysis.

INEL/ICOM/SICI/COMP 5318. INTERMEDIATE ROUTING, SWITCHING AND WIDE AREA NETWORKS. Three credit hours. Three hours of lecture per week. Prerequisite: INEL/ICOM/SICI/COMP 4308 or authorization of the Director of the Department.

Study and configuration of link state protocols. Study of intermediate level concepts such as switching, wide area network or WAN standards, virtual local area networks or VLAN, network

design, and redundancy. Presentation and study of strategies for managing and saving address space such as variable length subnet masks and network address translation.

ICOM 5995. SPECIAL PROBLEMS. One to six credit hours. Two to four hours of research per week per credit. Prerequisite: authorization of the Director of the Department.

Research and problem-solving in computer engineering or related fields.

Graduate Courses

ICOM 6005. DATABASE SYSTEM DESIGN. Three credit hours. Three hours of lecture per week.

Issues on design and implementation of database systems. Database system architectures and conceptual models, including a comparative study of hierarchical systems, networks, relational and object-oriented systems. Storage, index, query processing and optimization, transaction processing, fault tolerance, and crash recovery techniques. Design and implementation of a prototype database management system.

ICOM 6006. DISTRIBUTED OPERATING SYSTEMS. Three credit hours. Three hours of lecture per week.

Advanced topics in operating systems, with emphasis in distributed systems. Operating system architectures, including conventional, network, distributed, and cooperative-autonomous systems. Issues in design, concurrent programming, client/server models, synchronization, distributed process communication, time and resource scheduling, distributed/shared files and memory, and security.

ICOM 6015. ARTIFICIAL NEURAL NETWORKS. Three credit hours. Three hours of lecture per week.

Artificial neural network architectures and their learning algorithms.

ICOM 6025. HIGH PERFORMANCE COMPUTING. Three credit hours. Three hours of lecture per week.

Study of topics in high-performance computing including interconnection topologies, memory access and programming models, shared memory and message-passing systems, clusters, latency tolerance, load balancing, fault tolerance,

commodity software technologies, and performance profiling.

ICOM 6087. ARTIFICIAL INTELLIGENCE: TECHNIQUES AND APPLICATIONS (I) (Odd numbered years). Three credit hours. Three hours of lecture per week.

Special-purpose programming languages and their support systems used by researchers in the area of artificial intelligence. Techniques used in constructing psychological models. Mathematical methods for robot design. Applications such as language processing, computer vision, robotics, text processing, planning, and expert systems.

ICOM 6089. OBJECT-ORIENTED SOFTWARE DESIGN. Three credit hours. Three hours of lecture per week.

Fundamental concepts of object-oriented programming and its use in the design and development of software. Study and implementation of object-oriented languages and architectures.

ICOM 6095. HUMAN-COMPUTER INTERACTION. Three credit hours. Three hours of lecture per week.

Software engineering and human factors for the design, implementation and evaluation of effective user interface for computing systems.

ICOM 6115. TOPICS IN COMPUTER ENGINEERING. Three credit hours. Three hours of lecture per week.

Development of advanced topics in computer engineering of academic and research interest.

ICOM 6117. USABILITY ENGINEERING. Three credit hours. Three hours of lecture per week.

Fundamental concepts of usability. Usability components and attributes: learning-ability, efficiency, memory-ability, error reduction, and satisfaction. Study of usability evaluation techniques and methods. Design and implementation of usability tests.

ICOM 6205. ADVANCED SOFTWARE ENGINEERING. Three credit hours. Three hours of lecture per week.

Software design practices and techniques. Study of design representations and comparison of design methods. CASE tools methodologies for software development.

ICOM 6215. EXPERT SYSTEMS. Three credit hours. Three hours of lecture per week.

The study of the history and foundation of Expert Systems; its use in the analysis and solution of problems.

ICOM 6505. WIRELESS NETWORKS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the theoretical issues related to wireless networking and practical systems for design and performance evaluation of both wireless data networks and cellular wireless telecommunication systems. Topics include: wireless access technologies, QoS, location management in mobile environments, and impact of mobility on performance.

ICOM 6506. NETWORK PERFORMANCE ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of the analytical modeling and simulations techniques needed to evaluate the performance of a computer network system. Topics include: probability review, Markov chains, queuing theory, network traffic modeling, QoS, traffic engineering and MPLS.

ICOM 6994. PREPARATION FOR COMPREHENSIVE EXAM. Zero credit hours. One to twelve hours of independent study. Prerequisite: to be an option III graduate student from the Master in Computer Engineering Program and have completed at least 30 credits in his program or authorization of the Director of the Department.

Study period to allow graduates students in option III of the Master of Engineering in Computer Engineering Program to maintain regular student status, while preparing to take the comprehensive exam.

ICOM 6995. INDEPENDENT STUDIES IN COMPUTER ENGINEERING. One to three credit hours. Three to nine hours of independent study per week.

Individual study of advanced topics in computer engineering of academic and research interest.

ICOM 6998. MASTER'S PROJECT. Zero to six credit hours. Three to eighteen hours of project per week.

Design and development project in computer engineering.

ICOM 6999. MASTER'S THESIS. Zero to six credit hours. Three to eighteen hours of thesis per week.

Research project in computer engineering.

COMPUTER SCIENCE AND ENGINEERING (CIIC)

Undergraduate Courses

CIIC 5015. ARTIFICIAL INTELLIGENCE. Three credit hours. Three hours of lecture per week. Prerequisites: ICOM 4035 or CIIC 4020.

An introduction to the field of artificial intelligence: Lisp language, search techniques, games, vision, representation of knowledge, inference and process of proving theorems, natural language understanding.

CIIC 5017. OPERATING SYSTEM AND NETWORK ADMINISTRATION AND SECURITY. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: CIIC 4070 or ICOM 5026.

Practical experience in the administration and security of operating systems and networks. Design and development of measures for the detection and response to attacks on such systems.

CIIC 5018. CRYPTOGRAPHY AND NETWORK SECURITY. Three credit hours. Three hours of lecture per week. Prerequisites: CIIC 4050 or ICOM 5007.

Theoretical and practical aspects of computing system and network security, threat models, system vulnerability to attacks such as: hackers, malicious code, Trojan horses, viruses, and worms, cryptographic techniques used to defend systems from such attacks.

CIIC 5029. COMPILERS DEVELOPMENT. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: CIIC 4082 or INEL 4206. Corequisites: CIIC 4030 or ICOM 4036.

Study and application of techniques associated with the analysis of source languages and the generation of efficient object codes with emphasis on the components of a compiler.

CIIC 5045. AUTOMATA AND FORMAL LANGUAGES. Three credit hours. Three hours of lecture per week. Prerequisites: CIIC 4025 o ICOM 4038.

Study of theoretical computational models, languages, and machines. Introduction to the theory of intractable and un-decidable problems. Topics include: finite automata, regular languages, context-free languages, pushdown automata, Turing machine, halting problem, undecidability, and intractable problems.

CIIC 5995. SELECTED TOPICS. One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in computer science and engineering.

ELECTRICAL AND COMPUTER ENGINEERING FACULTY

A list of professors who engage in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

FABIO ANDRADE-RENGIFO, *Assistant Professor*, PhD, 2013, Universitat Politècnica de Catalunya. Research and Teaching interests: Microgrids, Renewable Energy Sources, Power Electronics.

ERICK E. APONTE BEZARES, *Associate Professor*, Ph.D. 2005, Rensselaer Polytechnic Institute. Research and Teaching interests: Distributed Generation, Islanding, DG Systems Dynamics, Optimization Techniques.

EMMANUEL ARZUAGA, *Assistant Professor*, Ph.D., 2012, Northeastern University. Research and Teaching Interests: Cybersecurity, Cloud Computing.

GERSON BEAUCHAMP-BÁEZ, *Professor*, Ph.D., 1990, Georgia Institute of Technology. Research and Teaching interests: Automatic Control, Fuzzy Logic Based Control Systems.

MARCEL CASTRO-SITIRICHE, *Associate Professor*, Ph.D., 2007, Howard University. Research interests: Appropriate Technology, Electric Drive Systems, Power Electronics, Intelligent Control, Education, Philosophy of Technology.

JOSÉ R. CEDEÑO-MALDONADO, *Professor*, Ph.D., 2002, Ohio State University. Research and Teaching interest: Power System Operation and Control, Optimization, Evolutionary Computation Techniques.

JOSÉ COLÓM-USTÁRIZ, *Professor*, Ph.D., 1998, Pennsylvania State University. Research and Teaching interest: Microwave Circuits and Systems, Computational Electromagnetics, Wireless Communication.

ISIDORO COUVERTIER, *Professor*, Ph.D., 1996, Louisiana State University. Research and Teaching interests: Computer Networks, Programming Languages, Operating Systems, Application Development.

SANDRA CRUZ-POL, *Professor*, Ph.D., 1998, Pennsylvania State University. Research and Teaching interests: Microwave Remote Sensing, Atmospheric Absorption Modeling, Microwave Ocean Emissivity.

GLADYS O. DUCOUDRAY, *Professor*, Ph.D., 2003, New Mexico State University. Research and Teaching interests: Low-Voltage low-power analog circuit design, Built-in self-test schemes for mixed signal circuits, Analog filters.

DEJAN S. FILIPOVIC, *Adjunct Professor*, Ph.D., 2002, University of Michigan. Research and Teaching interests: antenna theory and design with emphasis on frequency independent and wideband antennas; development of passive millimeter-wave components, systems, and electronic warfare front-ends; and multi-physics, multi-scale, metamaterial and nano-scale modeling.

SHAWN D. HUNT, *Professor*, Ph.D., 1992, Michigan State University. Research and Teaching interests: Digital Signal Processing, Non-linear Dynamic Systems.

HENRICK M. IERKIC-VIDMAR, *Professor*, Ph.D., 1980, Cornell University. Research and Teaching interests: Communications, Information Theory, Computer Networks.

AGUSTÍN A. IRIZARRY-RIVERA, *Professor*, Ph.D., 1996, Iowa State University. Research and Teaching interests: Power Systems Dynamics, Control and Operation.

MANUEL JIMÉNEZ-CEDEÑO, *Professor*, Ph.D., 1999, Michigan State University. Research and Teaching interests: Low-Power VLSI Design, CAD Tools for VLSI Layout Design, Embedded Systems/Rapid.

LUIS O. JIMÉNEZ-RODRÍGUEZ, *Professor*, Ph.D., 1996, Purdue University. Research and Teaching interests: Remote Sensing, Pattern Recognition, Image Processing.

EDUARDO J. JUAN-GARCÍA, *Professor*, Ph.D., 2001, Purdue University. Research and Teaching interests: Biomedical Acoustics, Medical Instrumentation.

LEYDA LEÓN-COLÓN, *Associate Professor*, Ph.D., 2010, Colorado State University. Research and Teaching interests: Radar Meteorology, Attenuation Correction, Applied Electromagnetic, Microwave Remote Sensing, Microwave Technology, Radar Systems, Atmospheric Sciences, Precipitation Microphysics.

VIDYA MANIAN, *Professor*, Ph.D., 2004, University of Puerto Rico, Mayagüez. Research and Teaching interests: Image Processing, Hyperspectral Image Classification, Computer Vision, Pattern Recognition and Algorithm Analysis.

RAFAEL MEDINA-SÁNCHEZ, *Assistant Professor*, Ph.D., 2013, University of Massachusetts. Research and Teaching interests: Phased Array Antennas, Microwave Systems.

LIZDABEL MORALES-TIRADO, *Adjunct Professor*, Ph.D., 2009, Virginia Tech. Research and Teaching interests: Cognitive Radio.

EFRAÍN O'NEILL-CARRILLO, *Professor*, Ph.D., 1999, Arizona State University. Research and Teaching interests: Power Quality, Distribution Systems, Power Electronics, Chaotic Dynamics, Load Modeling.

LIONEL R. ORAMA EXCLUSA, *Professor*, Ph.D. 1997, Rensselaer Polytechnic Institute. Research and Teaching interests: Electrical discharges in vacuum and gases, vacuum switching technology, fields stress analysis in electric power devices, power systems transients, alternative energy sources, distributed generation, power systems protection.

EDUARDO ORTIZ, *Professor*, Ph.D., 2006, Michigan State University. Research and Teaching interests: Photovoltaic Systems, Mathematical Modeling of Renewable Energies, Optimization, Power Electronics, Resonators, Nonlinear Control, Electric Drives.

ROGELIO PALOMERA-GARCÍA, *Professor*, Docteur des Sciences, 1979, Swiss Federal Polytechnical Institute. Research and Teaching interests: Integrated Circuits, Circuit Theory, Fuzzy Logic, Neural Networks.

HAMED PARSIANI, *Professor*, Ph.D., 1979, Texas A&M University. Research and Teaching interests: Multispectral Image Processing and Compression.

ALBERTO RAMÍREZ, *Professor*, Ph.D., 2002, Texas A&M University. Research and Teaching interests: Energy System Economics, Planning, Operation and Organization: Congestion Management; Ancillary Services, Rational Use of Energy.

DOMINGO A. RODRÍGUEZ-RODRÍGUEZ, *Professor*, Ph.D., 1988, City University of New York. Research and Teaching interests: Information Theory, Computational Signal Processing.

RAFAEL A. RODRÍGUEZ-SOLÍS, *Professor*, Ph.D., 1997, The Pennsylvania State University. Research and Teaching interests: Broadband and Tunable Microwave and Millimeter-wave Antennas and Circuits, Phased Array Antennas.

NAYDA G. SANTIAGO-SANTIAGO, *Professor*, Ph.D., 2003, Michigan State University. Teaching and Research interests: Performance Evaluation Methods and Instrumentation, HPC systems, and Parallel Processing.

GUILLERMO J. SERRANO-RIVERA, *Professor*, Ph.D., Georgia Institute of Technology, 2007. Research and Teaching interests: Analogic Integrated Circuits.

MANUEL TOLEDO, *Associate Professor*, Ph.D., 1995, Boston University. Research and Teaching interests: Machine Vision, Instrumentation, Embedded Systems, Semiconductor Process Control.

PEDRO TORRES, *Adjunct Professor*, Ph.D., Michigan State University. Research and Teaching interests: Speech Processing, Digital Signal Processing.

RAÚL TORRES-MUNIZ, *Professor*, Ph.D., 1998, University of Virginia. Research and Teaching interests: Neural Networks, Robotics, Intelligent Systems, Computer Vision, and Manufacturing.

JOSÉ FERNANDO-VEGA, *Professor*, Ph.D., 1989, Syracuse University. Research and Teaching interests: Artificial Intelligence, Digital Libraries, Knowledge-based Systems.

DEPARTMENT OF INDUSTRIAL ENGINEERING

The Department of Industrial Engineering offers two graduate programs: a Master of Science in Industrial Engineering and a Master of Engineering in Industrial Engineering. Students may choose a specialization in Management Systems, Quality Control Systems, or Manufacturing Systems.

MISSION

To develop industrial engineering leaders known for their commitment, integrity, and respect. We serve the Puerto Rican and international communities with excellence by:

- Providing a rigorous educational experience that nurtures industrial engineering professionals known for their solid technical capability, critical thinking skills, and social responsibility.
- Creating knowledge by performing basic and applied research;
- Supporting and improving manufacturing and service industries.
- Stimulating and influencing the efficiency of governmental processes and services;

VISION

Strengthen our position as the preferred alternative for the Puerto Rican community and become recognized internationally for forming Industrial Engineering professionals of global impact. We aim to be a model of excellence in education, research, and administration

SLOGAN

Industrial Engineers make complex decisions simple.

EDUCATIONAL OBJECTIVES

Graduates from our programs are prepared to be competent at an advanced level in their area of specialization.

- Graduates from the Management Systems specialization will be able to design and predict the behavior of integrated systems of people, equipment, materials, and information.
- Graduates from Quality Systems specialization will be able to develop

systems which can assure quality levels and predict failures and cost of quality of products and services.

- Graduates from the Manufacturing Systems specialization will be able to design and implement automated manufacturing systems complying with requirements of safety, productivity and return on investment.

The Master of Science in Industrial Engineering degree with thesis (Plan I) requires 30 credits, including a 6-credits thesis based on original research. The Master of Engineering in Industrial Engineering (Plan II) degree requires 30 credits, which includes a 3-credit master's project. The Master of Engineering degree without project requires 36 credits in course work. This program, known as Plan III is ideal for part-time students and those who are employed in local industries while studying. Students with a background other than Industrial Engineering may be required to complete remedial courses at the Bachelor's degree level.

All students must take three core courses: Experimental Statistics, Advanced Production Control, and Simulation Systems. There are two required courses which depend on the area of specialization: Discrete Linear Optimization and Advanced Engineering Economy for the Management Systems specialization, Multiple Regression Analysis and Quality Control Systems for the Quality Systems specialization, and Material Handling Systems and Automatic Assembly Systems for the Manufacturing Systems specialization. Additionally, there are a number of elective courses which depend on the degree sought and the area of specialization. All students irrespective of their program of study must take two courses outside their area of specialization, and a maximum of 9 credits could be at 5000 level.

Admission to our graduate program is guided by the general regulations and requisites established by the Office of Graduate Studies. This includes a written statement of purpose and three letters of recommendation. In addition to the admission requirements of the Graduate School Office, a Bachelor of Science degree is required. Students with a background in an area other than engineering must have at least three courses of Calculus, two courses of Physics with Calculus, Lineal Algebra, Differential Equation and Computer Programming. Applicants graduated

from non-English speaking foreign universities must present evidence of having taken the TOEFL examination and of their graduating class ranking to be considered for admission.

RESEARCH AND TEACHING LABORATORIES

The Department of Industrial Engineering has well-equipped laboratories and computer facilities. These facilities include the UPRM Model Factory, a Human Factors/Ergonomics and Work Measurement Lab, a Manufacturing Automation Laboratory, a Statistical Quality Control Laboratory, the International Service Systems Engineering Research (ISSER) Lab, Bio-Industrial Engineering and Applied Optimization Lab, and a Lean Logistics (LeLo) Lab. The Department also has a modern computing and information technology infrastructure for teaching and research purposes.

UPRM Model Factory

The UPRM Model Factory integrates modern equipment, materials, and people into a manufacturing system. Its mode of operation is through interdisciplinary working teams from several engineering and business disciplines. This is a coordinated effort between several Engineering Departments. The goals of these laboratory facilities are to provide the following:

- Practice based experiences dealing with all aspects of an actual manufacturing system.
- A space where local manufacturing industry issues can be studied.
- A place where modern production technology and techniques can be studied as they are applied in an integrated manufacturing system.
- The opportunity to assist local manufacturers in the development of their production system.
- Incubator facilities where products and process can be developed or improved.
- Serve as a meeting place where people from several disciplines can meet and learn to work in teams, and get an appreciation of the technical aspects of the other's area of knowledge.

Currently, this laboratory houses a for-profit manufacturing activity and provides students from various engineering disciplines with an exemplary manufacturing experience inside the university. The factory houses a printed circuit

assembly line for surface mount components in which production and prototype runs are performed for customers in the electronics sector. Part of the charter of the Model Factory is to share process breakthroughs with partners of the electronics sector. Close to ten companies have contributed to this initiative, with special mention of Hewlett Packard and Solectron Corporation.

Human Factors/Ergonomics and Work Measurement Lab

This laboratory has been designed to provide students with hands on experience in the analysis and evaluation of humans and their working environment. Tasks are simulated and evaluated based on anthropometrics, biomechanics, cardiovascular, and force requirements. The laboratory is equipped with modern equipment for the analysis of work systems and computers with software for the analysis of manual material handling activities. The following is a list of some of the equipment available in the laboratory for teaching and research purposes.

- Computers with licenses of ErgoIntelligence for analysis and evaluation of workstation design as well as the analysis of lifting tasks with the NIOSH lifting guide,
- Chatillon digital force measurement gauges and equipment for the analysis of pushing and pulling tasks,
- Hand dynamometers and pinch gauges to measure hand force,
- Anthropometers and calipers for the collection of anthropometric data,
- Heart rate meters and a treadmill for the evaluation of cardiovascular requirements of physical tasks,
- Electromyography with data collection software for the analysis of muscular activity,
- Goniometers and data collection software for the analysis of flexion, extension, and rotation of body members,
- Heat stress monitors and Wet-bulb globe temperature meter for the analysis of environmental variables,
- Dosimeters and sound level meters for the evaluation of noise levels,
- Photometers for studies of illumination, and
- Stop watches and digital recording equipment for Time Study and Work Measurement analysis, among many others.

Manufacturing Automation Laboratory

This teaching-learning facility is the hands-on laboratory for the Real Time Process Control course. Students design, build, and control scaled models, mainly emulating real manufacturing operations. The emphasis is in the use of programmable logic controllers (PLC), industrial sensors and actuators, pneumatics, and computer-based human machine interfaces.

The lab counts with 20 workstations equipped with all the necessary software and hardware. The facility is available for demonstration, research and custom trainings.

Statistical Quality Control Laboratory

The lab is equipped with Statistical software for data analysis, design of experiments, and validation procedures. It can also provide hands-on demonstrations for applied statistics courses and for simulation courses.

Bio-Industrial Engineering and Applied Optimization Lab (Bio IE Lab)

The Bio IE Lab focuses on the use of engineering analysis methods to extract biological knowledge from scientific in-silico, in-vitro and in-vivo experiments. The laboratory integrates high computing capabilities and state-of-the-art algorithms to lead data-based biological discovery. The lab work relates statistical, soft-computing and optimization techniques to biological data analysis. In particular, the search and discovery of biomarkers of cancer is a central line of work of the Bio IE lab. Located in the Industrial Engineering Department, the laboratory is equipped with four MacPro workstations and one iMac capable of running UNIX, Mac and Windows software.

Lean Logistics (LELO) Lab

The Lean Logistics (LELO) Lab is a student-centered lab seeking to provide hands-on experience while creating practical research-based solutions to contemporary logistics problems, particularly those of Latin American countries. Currently the lab has three main streams of research: facility logistics, humanitarian logistics, and supply chain networks security. Consulting and training at the supply chain, facility, or production line level are available through the lab. The LELO lab is partly

funded by the National Science Foundation and Department of Homeland Security.

Socially Responsible Operations (SRO) Research Center

Socially Responsible Operations Research Center (SRO) mission is to foster a new generation of innovative decision makers committed to issues that have a direct impact on the wellbeing of our society. The center strategy is to utilize the synergy created by the interaction and collaboration amongst research groups to create a culture of innovation and problem solving of societal issues. The research groups associated with the center are: Improving Design Decisions in Engineering & Applied Systems (IDDEAS), Integrative Solutions for High Dimensions (iSoHD), Governmental Operational & Logistics Decisions, and International Service Systems Engineering Research (ISSER).

Computing and Information Infrastructure

The Department of Industrial Engineering has a modern computing and information technology infrastructure. Servers running on Windows Server 2008 and Mac OSX platforms support the computing infrastructure. There are two servers dedicated to the development of WEB-based applications. The other servers support all software packages and general applications used by the students in the IE courses.

The computing center located in II-108 was recently remodeled and is equipped with 36 stations connected to the department's local area network and to the Internet. It serves as a general purpose computing facility and training center. It provides printing and plotting capabilities. The computer center has extended operation hours during weekdays and Sundays. An additional virtual computing laboratory is available as a remote desktop to students and faculty for use with simulations, analytics, modeling, and computing demanding software.

A video conferencing room is available in II-114. This multifunctional facility is equipped with 30 computer stations and is used as a regular classroom for technical courses, computer center, and for distance learning.

INDUSTRIAL ENGINEERING (ININ)

Advanced Undergraduate Courses

ININ 5005. MODERN OPTIMIZATION METHODS. Three credit hours. Three hours of lecture per week. Prerequisites: ININ 4021 or ININ 4150 or authorization of the Director of the Department.

Advanced undergraduate course addressed to industrial engineering students to studies the most common heuristic search methods. Topics such as simulated annealing, genetic algorithms, tabu search, and combinatorial and continuous optimization problems are discussed. The main techniques and their variations presented and are critically discussed. Key papers from the literature, including applications, are discussed.

ININ 5006. SYSTEMS ENGINEERING AND ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisites: ININ 4015 or ININ 4007 or INCI 4055 or INCI 4026 or authorization of the Director of the Department.

Introduction to the design of systems considering their lifecycle from conceptualization until disposal, including the basic theory of systems lifecycle management. Study of techniques to evaluate the design of systems that could be industrial, mechanical, electronic, or organizational, with application to multiple disciplines.

ININ 5007. COMPLEX SYSTEMS MODELING AND SYSTEM DYNAMICS. Three credit hours. Two hours of lecture and two hours of laboratory per week. Prerequisites: ININ 4021 or ININ 4150 or authorization of the Director of the Department.

Introduction to modeling of system dynamics for the analysis of business decisions with a focus on industrial, service and public policy applications, particularly those decisions forced by structural changes, policies and strategies that affect how the system behaves. Includes the conceptual tools to understand the structure and dynamics of complex systems.

ININ 5009. LEAN SIX SIGMA METHODOLOGY. Three credit hours. Three hours of lecture per week. Prerequisites: (ININ 4078 and (ININ 4039 or ININ 4155)) or authorization of the Director of the Department.

Discussion of the basic principles of lean and six sigma methodologies to maximize the value of a product or service focusing primarily on customer satisfaction. Use of the DMAIC methodology as a

structured way to integrate the tools of industrial engineering to solve problems related to processes and systems improvement.

ININ 5105. INTRODUCTION TO MEDICAL DEVICE DESIGN METHODS. Three credit hours. Three hours of lecture per week. Prerequisites: ININ 4020 or INME 4055 or INEL 4205 or INQU 4008 or authorization of the Director of the Department.

Discussion of fundamental methods for medical device development. Study of the process of medical device development, from concept to marketing. Analysis of procedures of product definition, design, risk management, production planning and market introduction, FDA (Food and Drug Administration) regulations, and intellectual property protection. Case studies illustrating important considerations to manage the complexities of the development process are included.

ININ 5405. STATISTICAL METHODS IN BIOINFORMATICS. Three credit hours. Three hours of lecture per week. Prerequisites: ININ 4010 or ININ 5559 or INCI 4136 or AGRO 5005 or ESMA 3101 or ESMA 4001 or ESMA 4006 or ESTA 3002 or authorization of the Director of the Department.

Study and application of statistical methods related to bioinformatics analysis including sequence analysis, gene expression and phylogenetic trees. Use of methods such as inferential statistics, statistical modeling, clustering analysis and Markovian processes.

ININ 5505. TOTAL QUALITY MANAGEMENT. Three credit hours. Three hours of lecture per week. Prerequisite: ININ 4078 or authorization of the Director of the Department.

Introduction to innovative philosophies in total quality control. The impact of leadership, organizational infrastructure and client satisfaction on quality management. Utilization and management of information, personnel, processes and product design for continuous quality improvement.

ININ 5559. ENGINEERING STATISTICS. Three credit hours. Three hours of lecture per week. Prerequisites: (MATE 3032 and INGE 3016) or authorization of the Director of the Department.

Development of probability theory for scientific and engineering inference. Discrete and continuous random variables and distributions and their applications in engineering. Hypothesis testing and

confidence intervals. Regression analysis. Applications to engineering problem solving.

ININ 5565. MEASUREMENT AND PREDICTION OF PRODUCT RELIABILITY. Three credit hours. Three hours of lecture per week. Prerequisite: ININ 4020 or authorization of the Director of the Department.

Introduction to reliability theory; system analysis; constant failure rate models; time dependent failure rate models; state dependent systems; availability; maintainability; complete and censored data analysis (parameter estimation and distribution fitting); prediction of reliability.

ININ 5575. SEQUENCING AND SCHEDULING OF RESOURCES. Three credit hours. Three hours of lecture per week. Prerequisites: ININ 4021 or ININ 4150 or authorization of the Director of the Department.

Conceptual and practical aspects involved in the scheduling of resources. Examples and applications drawn from areas such manpower, computer, and transportation.

ININ 5595. DESIGN AND MANAGEMENT OF SERVICES PROCESSES. Three credit hours. Three hours of lecture per week. Prerequisites: ININ 4009 and (ININ 4039 or ININ 4155 or authorization of the Director of the Department).

Industrial engineering techniques and models to design and manage the operations of service organizations or services processes in manufacturing enterprises. Development, evaluation, and implementation of alternative solutions to the operational problems of service organizations. Use of models and techniques in marketing, quality assurance and management, work measurement and design, operations research, production planning and control, engineering economics, human resources, management information systems, and facilities layout.

ININ 5997. SELECTED TOPICS IN INDUSTRIAL ENGINEERING. One to six credit hours. One to six hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Discussion of selected topics in Industrial Engineering or related fields.

Graduate Courses

ININ 6005. EXPERIMENTAL STATISTICS. Three credit hours. Three hours of lecture and/or discussion per week. Prerequisite: authorization of the Director of the Department.

Applications of multiple regression to analysis of variance and experimental designs. Analysis of multiple classifications involving fixed, random, and mixed effects, including crossed and nested variables of classification. Emphasis on computer model applications.

ININ 6008. NETWORK FLOWS AND GRAPHS IN MANAGEMENT SCIENCE. Three credit hours. Three hours of lecture and discussion per week. Prerequisite: authorization of the Director of the Department.

Principles of network flows and graphs theory and their applications in management science. Classical network flow problem formulations including maximal flow-minimal cut, assignment, transportation and others. Representation of optimization problems as network formulations, and the use of the out of kilter algorithm for their solution. Single versus multicommodity flow, as well as the relation of graphs and networks to combination problems.

ININ 6010. MULTIPLE REGRESSION ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analysis of unplanned experimental data to develop models for predicting complex systems behavior. Topics include: matrix formulation and properties of least squares estimators in multiple linear regression; analysis of residuals; diagnostics for influential data; strategies for variable selection; diagnostics, effects, and corrective measures for problems with correlated predictor variables; biased regression and other estimation criteria; autocorrelated residuals; simultaneous inference, model validation; use of computer programs to analyze real data and to develop a model.

ININ 6016. HUMAN FACTORS ENGINEERING. Three credit hours. Three hours of lecture and discussion per week. Prerequisite: authorization of the Director of the Department.

Human factors applications in the design of equipment and work environment. Methods for the analysis of human errors and skills and their utilization in the design of control systems and information displays.

ININ 6019. ADVANCED PRODUCTION CONTROL. Three credit hours. Three hours of lecture and discussion per week. Prerequisite: authorization of the Director of the Department.

Advanced topics in forecasting, inventory and applied stochastic processes as they relate to production control systems. Integration of these topics in the production planning process using mathematical optimization techniques and case studies.

ININ 6020. QUEUEING THEORY AND APPLICATIONS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Development and use of analytical models for the design of queueing systems. Introduction to stochastic-process models. Applications to analysis, design, and optimization of queueing systems in service and manufacturing organizations.

ININ 6025. LINEAR AND DISCRETE OPTIMIZATION. Three credit hours. Three hours of lecture and discussion per week. Prerequisite: authorization of the Director of the Department.

Basic theory and development of the simplex method for solving linear programming problems with discrete variables. Dual problems and sensitivity analysis. Formulation of problems with discrete variables. Developments of implicit enumeration and related methods for integer problems. Application of linear and discrete optimization methods to problems of industry and government. Use of computer programs.

ININ 6026. SYSTEMS SIMULATION. Three credit hours. Three hours of lecture and discussion per week. Prerequisite: authorization of the Director of the Department.

Principles of feedback dynamics; levels; rates, delays. Simulation languages and their applications in industrial and service systems. Analysis and interpretation of results. Recommendation and justification of proposed alternatives.

ININ 6030. ADVANCED ECONOMICS FOR ENGINEERS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Formulation of economic problems in terms of quantifiable models. Use of deterministic, probabilistic, risk and multiattribute techniques to evaluate design alternatives and to select an acceptable solution.

ININ 6036. INTRODUCTION TO TIME SERIES ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Univariate and bivariate time series in frequency and time domain, use of autocorrelation and spectral analysis for model identification. Uses of model diagnostic and forecasting techniques, dynamic systems modeling and stochastic estimation by means of the Kalman filter.

ININ 6045. MATERIAL HANDLING SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Fundamentals of material handling systems including types of equipment and their applications, relationship between material handling and design of facilities, computer control, and automation. A project will be required.

ININ 6046. ADVANCED INDUSTRIAL EXPERIMENTATION. Three credit hours. Three hours of conference per week. Prerequisite: ININ 6005 or authorization of the Director of the Department.

Applications, analogies and differences among confidence intervals, prediction intervals, and tolerance intervals. Fundamental concepts and applications of response surface methodology and evolutionary operations to manufacturing processes. Case study of manufacturing experiments with dichotomous or polytomous response variables. Use of logistic regression for modeling the relationship between a categorical variable and a set of covariates. Effective modeling strategies and the interpretation of results are emphasized. Fundamental concepts in the design and analysis of experiments with mixtures. Statistical techniques and methods for designing, modeling, and analyzing mixture data. Extensive use of software packages for statistical data analysis.

ININ 6048. KNOWLEDGE DISCOVERY IN ENGINEERING MULTIVARIATE DATA. Three credit hours. Three hours of lecture per week. Prerequisites: authorization of the Director of the Department.

Development of empirical linear and non-linear model building skills using a variety of tools from multivariate statistics and data mining. Development of skills to identify the model that best represents the natural relationship between a numerical and/or categorical response, and a high-dimensional set of explanatory variables. Special

attention is given to data pre-processing, missing value imputation, outlier detection, feature extraction/selection, and models validation. Introduction to unsupervised learning and modeling techniques for multiple response variables.

ININ 6055. MATHEMATICAL MODELS IN DISTRIBUTION LOGISTICS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study on the logistics involved in transporting finished goods from manufacturers to customers. Particular emphasis is given to the design and operation of container terminals, cross-docks, and distribution centers, as well as the management of freight transportation modes. Emphasis will be given on mathematical models for the optimization of distribution systems and their implementation.

ININ 6078. QUALITY CONTROL SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Advanced topics in statistical process control. Design of control charts. EWMA charts. The SPRT and its applications in quality engineering: CUSUM and continuous sampling plans. Multivariate control charts. Principles of quality engineering and Taguchi methods. The loss function and its applications to multiresponse experiments.

ININ 6995. SPECIAL PROGRAMS. One to three credit hours. One to three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of previous work and literature on a selected topic of the industrial engineering field.

ININ 6998. ENGINEERING PROJECT. Three to six credit hours.

Comprehensive study of a special industrial engineering problem selected so as to integrate the knowledge acquired in the graduate program study. This project fulfills one of the terminal requirements of the Master of Engineering program, and will be governed by the norms established for this purpose.

ININ 6999. THESIS. One to six credit hours.

Research in the Industrial Engineering field leading to the presentation and approval of a thesis.

INDUSTRIAL ENGINEERING FACULTY

A list of professors who engage in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

NOEL ARTILES-LEÓN, *Professor*, Ph.D., 1989, Iowa State University. Teaching and Research interests: Applied Statistics, Queuing Theory, Quality Control, Operations Research.

SONIA M. BARTOLOMEI-SUÁREZ, *Professor*, Ph.D., 1996, Pennsylvania State University. Teaching and Research interests: Production Control, Facility Layout Planning, Material Handling Systems, Work Measurement, and Simulation.

MAURICIO CABRERA-RÍOS, *Professor*, Ph.D., 2002, Ohio State University. Teaching and Research interests: Manufacturing, Applied Statistics, Design of experiments, Identification of Biomaker genes, Bioinformatics.

HÉCTOR J. CARLO-COLÓN, *Professor*, Ph.D., 2007, University of Michigan, Ann Arbor. Teaching and Research interests: Production, Distribution, Logistics, Material Handling Systems, Operations Research.

VIVIANA I. CESANÍ-VÁZQUEZ, *Professor*, Ph.D., 1998, University of Wisconsin, Madison. Teaching and Research interests: Production Systems, Cellular Manufacturing, Engineering Economics, Risk Analysis, and Design and Management of Services Processes.

SAYLISSE DÁVILA-PADILLA, *Associate Professor*, Ph.D., 2010, Arizona State University. Teaching and Research interests: Applied Statistics, Multivariate Data Analysis, Data Mining, Statistical Process Control, and Healthcare.

MERCEDES FERRER-ALAMEDA, *Associate Professor*, MEMS, 1993, University of Puerto Rico at Mayagüez. Teaching and Research interests: Applied Statistics, Statistical Process Control, Engineering Management, Process Improvement, Lean six Sigma Methodology, and Institutional Research.

DAVID R. GONZÁLEZ-BARRETO, *Professor*, Ph.D., 1996, Pennsylvania State University. Teaching and Research interests: Statistical Quality Control, Applied Statistics and Simulation.

WILLIAM HERNÁNDEZ-RIVERA, *Professor*, Ph.D., 1996, Texas A&M University. Teaching and Research interests: Information Systems, Real Time Process Control, Optimization, and Genetic Algorithms.

MARÍA DE LOS A. IRIZARRY-SERRANO, *Professor*, Ph.D., 1996, North Carolina State University. Teaching and Research interests: Production, Ergonomics, Work Systems and Simulation.

ALEXANDRA MEDINA-BORJA, *Associate Professor*, Ph.D., Virginia Polytechnic Institute and State University. Teaching and Research interests: Performance Evaluation Systems in Service Organizations, Engineering Economy and Cost Estimation, Management Systems Engineering.

LOURDES A. MEDINA-AVILÉS, *Associate Professor*, Ph.D., 2012, Pennsylvania State University. Teaching and Research interests: Product Design and Development, Medical Devices, Regulations, Healthcare Engineering, Decision Analysis, Automation and Real Time Process Control.

MAYRA MÉNDEZ-PIÑERO, *Associate Professor*, Ph.D. 2009, Texas A&M University. Teaching and Research interests: Cost Analysis and Control, Cost Modeling, Engineering Economy.

OMELL PAGÁN-PARÉS, *Professor*, Doctor of Engineering, 1995, Universidad Politécnica de Madrid. Teaching and Research interests: Production Systems, Total Quality Management, Layout, Logistics, Design and Management of Services Processes.

CRISTINA POMALES-GARCÍA, *Professor*, Ph.D., 2006, University of Michigan, Ann Arbor. Teaching and Research interests: Human Factors and Ergonomics, Web-based Distance Learning and Engineering Education.

NAZARIO D. RAMÍREZ-BELTRÁN, *Professor*, Ph.D., 1988, Texas A&M University. Teaching and Research interests: Operations Research, Applied Statistics, Time Series Analysis, Optimization and Neural Networks.

PEDRO RESTO-BATALLA, *Professor*, Ph.D., 1982, Texas A&M University. Teaching and Research interests: Manufacturing, Automation, and Simulation.

BETZABÉ RODRÍGUEZ-ÁLAMO, *Associate Professor*, Ph.D., 2010, University of Michigan-Ann Arbor. Teaching and Research Interest: Healthcare, Lean Manufacturing, Distribution and Logistics, Services Industries, Production Scheduling, Supply Chain Management, Manufacturing, Game Theory Operation Management.

AGUSTÍN RULLÁN-TORO, *Professor*, Ph.D., 1990, Lehigh University. Teaching and Research interests: Automation, Robotics, Facility Layout Planning, Modern Material Handling Systems and Cost Modeling.

WANDALIZ TORRES GALARZA, *Assistant Professor*, Ph.D., 2011, Arizona State University. Teaching and Research interests: Simulation, Applied Statistics, Probability, Data Mining, Bioinformatics, and Data Analytics.

MATERIALS SCIENCE AND ENGINEERING

MASTER'S PROGRAMS

The Materials Science and Engineering (MSE) graduate program was designed as an interdisciplinary venture to attract highly qualified graduate students, considered as backbone of any research in academia. Although there are several UPRM departments involved in MSE research, there is no appealing accretion program available on this area. Therefore, the program offers specialization in different fields of materials science such as materials selection, nanostructured materials, magnetic materials, electronic materials, biomaterials, materials characterization, materials recycling, among others.

The MSE program confers two degrees, depending on the plan of study selected by the participating student: a) Master of Science; and b) Master of Engineering. Accordingly, there are three plans of study available:

- **Plan I (Master of Science)**

A total of 35 credit-hours that includes 8 credits of core courses in the area of specialization, up to 6 credits of masters thesis, technical electives in the area of specialization, and technical electives outside the area of specialization.

- **Plan II (Master of Engineering):**

A total of 35 credit-hours that includes 8 credits of core courses in the area of specialization, up to 3 credits of master project, technical electives in the area of specialization, and technical electives outside the area of specialization.

- **Plan III (Master of Engineering):**

A total of 35 credit-hours that includes 8 credits of core courses in the area of specialization, technical electives in the area of specialization, and technical electives outside the area of specialization.

Mission

The mission of this graduate program is to advance fundamental knowledge in Materials Science and Engineering applied to the creation, development and optimization of materials, devices, and processes through innovative research. The program seeks to educate and train a highly competitive and resourceful cohort of professionals in this area. This program responds to current and anticipated technical and societal needs of Puerto Rico and the world.

This MSE graduate program is to benefit the industry and government of Puerto Rico by offering their participants with the following:

- Advanced technical skills and research experience in material selection, testing and design, materials engineering, device fabrication, smart materials and mechanic of materials.
- A flexible graduate program where professionals from industry can customize their graduate studies, which can be completed within an attractive time-frame from the employers.
- An interdisciplinary program where faculty and students of various science and engineering departments can participate, conduct research and learn from each other.
- Well-prepared MSE faculty, making UPRM even more effective in academic research and community service in a high demand, high profile and well-funded field.

Vision

This program will have considerable impact on the growth and development of Puerto Rican industry in the design, fabrication, characterization of materials, and product evaluation and, in achieving so, it will serve its community in vital areas, consistent with the University of Puerto Rico's mission.

COURSES OF INSTRUCTION

MATERIALS SCIENCE AND ENGINEERING

CIIM 6000. MASTER'S THESIS. One to six credit hours.

Research and preparation of a thesis under the supervision of a faculty member.

CIIM 6005. FUNDAMENTALS OF ADVANCED MATERIALS. Four credit hours. Three hours of lecture and one hour of seminar per week.

Integrated study of the fundamental concepts of advanced materials necessary to understand the development of their structures and properties, as well as their engineering applications. Analysis of the structure and properties of ceramic, composite, electronic, metallic, and polymer materials; atomic- and nanometer-scale microstructures, including long-range and short-range order atomic arrangements, as well as the development of microstructures and their transformations. Case studies on the design of materials and their synthetic pathways.

CIIM 6006. STRUCTURE AND PROPERTIES OF MATERIALS. Three credit hours. Three hours of lecture per week.

Study of solid-state physics applied to functional materials, which will allow the explanation of the synthesis-structure-properties relationship and its application to materials processing. Discussion of the relationship between crystal structure and the phenomenon of diffraction, structural defects, lattice vibration, and their relationship with the thermal properties of materials. In addition, the principles of the semiconducting and superconducting behavior of materials will be studied, as well as the mechanistic bases of high- and low-temperature materials synthesis options, including nucleation and diffusion processes.

CIIM 6007. KINETICS AND PHASE TRANSFORMATION. Three credit hours. Three hours of lecture per week.

Study of thermodynamic and diffusion concepts applied to the kinetics of phase transformations, which will permit the development of skills necessary for the analysis of such transformations in diverse systems. Nucleation and growth

phenomena applied to the processes of recovery, recrystallization, precipitation, and solidification will be studied, as well as spinoidal, order-disorder, and athermal transformations.

CIIM 6008. DIFFRACTOMETRY AND COMPLEMENTARY TECHNIQUES. Three credit hours. Two hours of lecture and one two-hour laboratory per week.

Study of the theory, practice, and applications of X-ray diffraction and other complementary techniques, which will allow the identification of the most suitable characterization techniques for the type of information (morphological, structural, qualitative, and quantitative) required for materials of interest. Discussion of experimental methods and applications of electron and neutron diffraction techniques, as well as electron microscopy. Presentation of the principles of complementary techniques such as SPM, XPS, Auger, Mossbauer, solid-state nuclear magnetic resonance, and SIMMS and their application to structural problems in the solid state.

CIIM 6010. MATERIALS MICROPROCESSING AND ENGINEERING. Three credit hours. Three hours of lecture per week.

Discussion of synthesis routes applied to the microprocessing of engineering materials, including epitaxial growth in ion beam processing. The processing conditions for thin films of semiconductors and other functional materials for superconducting, magnetic, and tribological applications are also discussed. The students will be able to propose and explain the most suitable microprocessing route for a specific engineering application.

CIIM 6015. COMPUTATIONAL MATERIALS SCIENCE. Three credit hours. Two hours of lecture and one two-hour laboratory per week.

Study of the concepts of computer-assisted modeling and their applications to atomistic processes, which will permit the development of skills necessary for the computational analysis of processes such as kinetics and diffusion phenomena. The behaviors governed by isotropic or anisotropic properties (e.g., texture development) and phase transformation processes (e.g., segregation, precipitation, quenching), are also covered.

CIIM 6016. POLYMER SCIENCE AND ENGINEERING. Three credit hours. Three hours of lecture per week.

Discussion of the concepts related to the structure, properties, synthesis, and selection of polymeric materials, which will permit the explanation and prediction of the behavior of such materials. Application of these concepts to the study of the mechanical behavior of polymers, viscosity, and creep, as well as to processing issues, including copolymerization in blends and alloys.

CIIM 6017. FUNDAMENTALS OF MATERIALS CHEMISTRY. Three credit hours. Three hours of lecture per week.

Study of the scientific foundations of the chemical origin of materials properties and the structure of solids, in order to apply these concepts in the analysis of homogeneous and heterogeneous systems. The physicochemical principles of dissolution, precipitation, and crystal growth processes are presented and discussed on mechanistic and practical application bases. The theory and applications of mechanochemistry and mechanoactivation of materials, as well as the chemistry of surfaces and interfaces in sols, gels, colloids, and nanoparticle systems, self-assembly and film formation, will be discussed.

CIIM 6018. NANOSTRUCTURED MATERIALS. Three credit hours. Three hours of lecture per week.

Study of the dependence of materials properties on crystal size at the nanoscale. Nanotechnology is discussed from the perspectives of characterization techniques, processing, and applications of nanostructures composed of functional materials. After completing the course, the students will be able to analyze, debate, and suggest synthesis, characterization, and application alternatives for nanostructures of different materials.

CIIM 6019. THERMODYNAMICS AND PHASE EQUILIBRIA. Three credit hours. Three hours of lecture per week.

Study of the thermodynamic principles and concepts applied to materials science, which will permit the analysis of the stability of the phases of a material based on thermodynamic considerations. The thermodynamics of solutions, fusion and vaporization processes, and

surfaces and interfaces will be studied. Discussion of thermodynamic concepts applied to the study of binary and pseudo-binary systems with corresponding phase diagrams, including metastable phases. Analysis and application of ternary phase diagrams.

CIIM 6020. DIFFUSION PHENOMENA IN MATERIALS. Three credit hours. Three hours of lecture per week.

Study of the bases of atomic transport phenomena and diffusion mechanisms in solids, Fick's laws and the Kirkendall effect. Discussion of the characteristics of diffusion in ionic solids. Mathematical analysis of diffusion phenomena and the application of Green's function. The students will be able to analyze multi-component diffusion processes as well as other forms of diffusion in materials processing.

CIIM 6026. SOLIDIFICATION PROCESSES. Three credit hours. Three hours of lecture per week.

Study of heat and mass transfer concepts applied to solidification processes. The properties of crucibles and molds as well as the metallurgy of molten alloys and cast metal matrix composites will be studied. Computational simulation of solidification processes to analyze them from a mechanistic and practical viewpoint.

CIIM 6027. GRADUATE SEMINAR. One credit hour. One hour of seminar per week.

Oral presentation on a research topic in materials science and engineering.

CIIM 6995. SELECTED TOPICS. One to six credit hours. One to six hours of lecture per week.

Selected topics in materials science and engineering.

CIIM 6996. MASTER'S PROJECT. One to three credit hours.

Design and development of a project in materials science and engineering. A final written report is required.

INGE 5005. STABILITY AND PROCESSING OF MATERIALS. Three credit hours. Three hours of lecture per week. Prerequisites: INGE 4001 or INGE 3045 or INME 4107 or authorization of the Director of the Department.

Study of materials stability driven by thermodynamic and kinetic considerations. Analysis of phenomena that operate and regulate syntheses and materials processing at different scales. Study of solidification and gas phase processes based on energetics considerations. Control and prediction of materials processing based on interfacial phenomena.

INGE 5015. THEORY AND MANAGEMENT OF SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: third year standing or higher or authorization of the Director of the Department.

Introduction to the systems approach and to systems analysis. Analytical methods applicable to interactive contexts, such as economic and ecological systems and to organizations. Topics include: Problem formulation, information management, evaluation and selection of alternatives, implementation and monitoring of solutions.

INGE 5016. INTRODUCTION TO MATERIALS CHARACTERIZATION. Three credit hours. Three hours of lecture per week. Prerequisites: INGE 4001 or INGE 3045 or INME 4107 or authorization of the Director of the Department.

Study of the theory and practice of microcharacterization techniques, including optical microscopy, thermal analysis, electron beam diffraction, and x-ray and photon-induced interactions. Discussion of complementary surface analysis techniques. Identification of the most suitable characterization techniques for functional and nanostructured materials.

INGE 5020. INTRODUCTION TO CERAMIC MATERIALS. Three credit hours. Three hours of lecture per week. Prerequisites: INGE 4001 or INGE 3045 or INME 4107 or authorization of the Director of the Department.

Introduction to the fundamental principles of ceramic materials including their crystalline structure, electronic and ionic defects and subsequent transport phenomena, microstructure,

mechanical properties, processing and diverse modern applications. Study of related topics such as glass formation and applications of nanostructured ceramic materials.

INGE 5037. APPLIED SIGNAL PROCESSING FOR ENGINEERING MECHANICS. Three credit hours. Three hours of lecture per week. Prerequisites: (INGE 3016 and MATE 3063) or authorization of the Director of the Department.

Practical introduction to signal processing, including time-domain, frequency-domain, and time-frequency domain approaches. Development of skills to manipulate, analyze, and extract useful and reliable information from different types of signals. Practical applications of methods and principles including signal de-noising, outlier analysis, vibration based system identification, irregularities detection, system health monitoring and non-stationary signals characterization.

INGE 5040. ENGINEERING ACOUSTICS. Three credit hours. Three hours of lecture per week. Prerequisites: (MATE 4009 and (INGE 3032 or INGE 3035)) or authorization of the Director of the Department.

Basic acoustics theory and practice, modeling of acoustic sources, sound propagation and transmission, acoustics measurements, sound in enclosed spaces, design of sound enclosures and barriers and design of muffling devices.

INGE 5065. MATERIALS SELECTION. Three credit hours. Two hours of conference and one two-hour laboratory per week. Prerequisite: INGE 4001 or INGE 3045 or INME 4007 or authorization of the Director of the Department.

Analysis of engineering materials and their properties. Development of systematic procedures for the selection of engineering materials and shapes that optimally satisfy design specifications. Study of the structure-property-performance relationship. Aesthetic and industrial design considerations.

INGE 5066. RECYCLING OF MATERIALS. Three credit hours. Three hours of lecture per week. Prerequisite: INGE 4001 or INGE 3045 or INME 4007 or authorization of the Director of the Department.

Analysis of the recycling situation in the global context and its laws and regulations. Design of separation and collection centers for recyclable waste materials including electronic devices, aluminum cans, bottles, plastics, steel, tires, construction debris, and hazardous wastes. Planning of processing facilities.

INGE 5075. NANOMATERIALS AND FINE PARTICLES PROCESSING. Three credit hours. Three hours of lecture per week. Prerequisite: INGE 4001 or INGE 3045 or INME 4007 or authorization of the Director of the Department.

Study of the nanoscale and the perspective of nanotechnology, nanomaterials, and their properties. Fundamentals and practice of particle nucleation and growth. Analysis of conditions leading to particle stability and the formation of solid solutions at the micro- and nanosize scale. Fundamental and industrial applications such as ceramics, magnetic materials, semiconductors, ferroelectrics, optical materials, catalysts, pigments, and biological and medical devices. Study of nanotechnology and its relation with the environment.

INGE 5085. MATERIAL SCIENCE AND ENGINEERING SEMINAR. One credit hour. One hour of lecture per week. Prerequisites: INGE 4001 or INGE 3045 or INME 4107 or authorization of the Director of the Department.

Oral and written presentations about materials science and engineering topics.

INGE 5095. BIOMECHANICS OF THE MUSCULOSKELETAL SYSTEM. Three credit hours. Three hours of lecture per week. Prerequisites: INGE 3032 or INGE 3035 or authorization of the Director of the Department.

Study of the mechanisms of human musculoskeletal system. Analysis of the highly complex and intricate movements of various joints in the body. Study of the mechanical properties of bones, cartilages, tendons, ligaments and muscles that comprise a joint. Analysis techniques of static and dynamic equilibrium that explain the musculoskeletal interactions which causes joint movement.

INGE 5104. NANOMEDICINE FUNDAMENTALS. Three credit hours. Three hours of lecture per week. Prerequisites: INGE

4001 or INGE 3045 or INME 4107 or authorization of the Director of the Department.

Overview of the distinctive features of nanotechnology and their application to biomedical problems. Contrasts among macro/micro/nano to bring out the unique properties of nanotechnology in medicine. Introduction to cutting-edge of nanomedical technologies for sensing and imaging, drug delivery, and therapeutic applications will be addressed.

INGE 5996. SPECIAL TOPICS. One to six credit hours. One to six hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of selected topics in general engineering. The selection and scope of the topics shall be in accordance with the interests and needs of the students.

Faculty

BARBARA CALCAGNO, *Professor*, Ph.D., 2010, Materials Science, University of Wisconsin-Madison.

YANG LI, *Professor*, Ph.D., 1993, Materials Physics, University of Science and Technology, Beijing, China.

CARLOS MARIN, *Associate Professor*, Ph.D., 2002, Mechanical Engineering, Rensselaer Polytechnic Institute.

AGNES PADOVANI, *Professor*, Ph.D., 2002, Chemical Engineering, Georgia Institute of Technology.

OSCAR PERALES, *Professor*, Ph.D., 1998, Materials Processing, Tohoku University, Sendai, Japan.

JEANETTE SANTOS, *Professor*, Ph.D., 1995, Chemical Engineering, Louisiana State University.

OSCAR MARCELO SUAREZ, *Professor and Coordinator of the program*, Ph.D., 2000, Metallurgical Engineering, University of Wisconsin-Madison.

OSWALD UWAKWEH, *Professor*, Ph.D., 1990, Materials Science and Engineering, Université De Nancy I, France.

MECHANICAL ENGINEERING

The Mechanical Engineering Department offers graduate programs at the Master's and Doctorate of Philosophy level. At the Master's level, students may earn either a Master of Science (MS) or a Master of Engineering (ME) degree. The research facilities include state of the art laboratories that support activities for materials development, bioengineering device development, vehicle development, prototype manufacturing, controls and instrumentation, mechanical system response testing, alternative energy testing, fluid, heat and mass transfer analysis.

The program opened at the master's level in 1967. Last year the Ph.D. program was initiated. Graduates from our program are expected to complete their master's work in 2-3 years.. For the Ph.D. program, students entering the program with a Master's degree are expected to complete their studies in 3-4 years while students entering with a Bachelor's are expected to complete their degree in 4-6 years.

The Department of Mechanical Engineering has a diverse faculty performing research in various areas including: Thermodynamics; Heat transfer; Air conditioning; Manufacturing processes; Fluid mechanics; Mechanical metallurgy; Fracture mechanics; Transport phenomena; Gas dynamics; Mechanics of composite materials; Conservation and alternative energy systems; Control system design; Finite element analysis; Vibrations; Damage Detection; MEMS; Kinematics; Automatic assembly systems; Biosensors; Biomaterials; and Energy.

The program's structure is flexible enough to allow participants to specialize in one or more subject areas. Students can choose a concentration in thermal sciences, machine sciences, materials and manufacturing, or a program which combines courses from two concentration areas. The required courses depend on the area selected by the student and the research of project work.

STUDENT PROFILE

	Masters	Ph.D.
Students Enrolled/yr	70	4
Total Program Enrollment	70	4
Number of International Students	15	0

ADMISSION

Applicants to graduate study in Mechanical Engineering must have a Bachelor of Science degree in Mechanical Engineering from an accredited institution. Applicants with a bachelor degree from other fields related to Mechanical Engineering are also considered. During the evaluation process the academic record is analyzed and deficiencies may be assigned to compensate for the lack of essential coursework at the bachelor's level.

Prospective students should have a general 2.75 GPA (on a scale of 4.0) and a 3.0 GPA or better in the field of specialty. International applicants must provide evidence of available financial resources to cover educational and living expenses for at least the first year of study.

Minimum English Requirements:

Students are expected to understand English and Spanish since courses may be taught in either language. The students are also expected to write effectively in English in a wide range of formats including business and personal letters, reports, book reviews, literature reviews and academic essays.

COURSE REQUIREMENTS

Students select a main research area to focus their coursework and research. The four focus areas are:

- Thermal sciences,
- Machine sciences,
- Materials and manufacturing
- Bio and Micro-scale Engineering

A detailed list of the requirements is available at: <http://engineering.uprm.edu/inme/academic/grad/current-graduate-students/courses/list-inme-grad-courses/>

Students in the Ph.D. program are required to take a minimum of sixty-one (61) credit hours if they enroll with a bachelors' degree. Eighteen (18) of these credits are in research/thesis work. Students entering the Ph.D. program with a master's degree may transfer up to twenty-four (24) credits taken for their master's pending the approval of their advisor and the Graduate Committee.

For the Master of Science (MS) program the requirements are a minimum of twenty-five (25)

credit hours in coursework, work on a research project, and write a thesis for a total of thirty-one (31) credits (Plan I).

Students in the master of Engineering (ME) program could enroll in Plan II of Plan III. In Plan II they are required to take a minimum of thirty-one (31) credit hours in coursework, work on a design or development project, and write an engineering report for a total of thirty-four (34) credits. In Plan III they are required to take a minimum of thirty-six (36) credit hours.

CENTERS

Center for Aerospace and Unmanned Systems Engineering (CAUSE) is the First Center of Excellence in the Caribbean to provide a framework for broad-based, competitive, multi-institutional, multidisciplinary science and engineering research that will advance the aims of space, aeronautic, and astronautic Mission Directorates across the nation and world at large. The center will foster synergy between the following science and engineering directorates: (i) unmanned systems, (ii) aeronautic, and (iii) space. The center provides an interdisciplinary environment that enables and facilitates participants to carry out collaborative educational and research of a scope and complexity that is not possible through traditional funding models. The Center's overall mission is to leverage our strong theoretical, computational, and experimental programs to advance the frontiers of fundamental and applied research while educating a new cadre of STEM students. We intend to create strong collaborative relationships with the current aerospace industries, centers, institutes, schools and universities.

CAUSE allows students and faculty to learn and apply concepts about flight and unmanned systems, whether in the atmosphere or space.

BUILDINGS AND RESEARCH FACILITIES

The Mechanical Engineering Department maintains well-equipped research facilities which include laboratories for vehicle design, vibration control, material development and characterization, health monitoring and diagnostics, sensor development and applications, fatigue characterization from fluid structure interaction and development of computer aided engineering techniques.

The department has several computer facilities for research purposes. Workstations are connected to campus mainframes and are accessible to faculty and students on a continuous basis. A cluster with sixty-four (64) cores is available for Fluid Mechanics studies. The nodes are connected with the master through an infiniband network. The Partnership for Collaborative Engineering Education (PACE) and collaborations with local industries, such as Infotech, provides most of the software, which includes, LS Dyna, ANSYS Multiphysics, Fluent, Altair Hyperworks, Siemens NX, MSC Nastran, MSC Adams, and MSC Marc

In the field of performance materials, **the New Materials Development Laboratory (NMDL)** is responsible for matching many new differentiated materials and technologies with market needs in the areas of bioengineering, alternative energy and electronics. The NMDL include a materialographic laboratory, a mechanical testing facility (including a DMA), thermal chambers, tribometers. Basic equipment for materialographic preparation, hardness testers, heat treatment furnaces and a sophisticated optical imaging system are available. NMDL performs sponsored research from various government agencies such as: DoD, NSF, NIH, and various private industries for example Lockheed Martin.

The **Biosensing and Microfluidics Research Laboratory (BMRL)**, led by Dr. Rúben Díaz-Rivera and Dr. Pedro Resto is 900 sq. ft. facility located in the Department of Mechanical Engineering at UPRM. The purpose of this laboratory is to facilitate the design, construction and use of microfluidic systems for cell studies and biosensing applications. The laboratory houses a small cell culture facility, a faraday-caged microscopy setup for electrical/optical characterization of microfluidic devices, and tools for performing PDMS soft lithography. The laboratory has a LabSmith Synchronized Video Microscope workstation with black & white and EPI-fluorescent optic modules, controlled with a Dell Precision T1700 desktop computer, for microfluidic visualization and data acquisition. In addition, the laboratory houses a workstation for fluid mechanics and multiphysics simulations. The workstation was built in-house and is powered with the latest generation of Intel's Core i7 processor and 32 GB of RAM. Licensed software includes COMSOL Multiphysics 4.4 and CD-adapco, Star CCM+ Version 9 as well as the usual MS Office Suite. The laboratory has access

to a rapid prototyping facility having a 3D printer, a small scale CNC and an electronics workstation. The laboratory also has access to a Dantec Dynamics Micro Particle Image Velocimetry System for the fluidic characterization with the Bubble Dynamics Laboratory.

The **Mechatronics Center** at the Mechanical Engineering (ME) Department is dedicated to study electromechanical systems. The center offers training and support to industry and existing ME courses while providing facilities and resources for research in the control of mechanical and electromechanical systems. Training facilities are equipped with eight laboratory work stations with basic equipment to perform experiments and projects in mechatronics. The center also includes a prototyping laboratory with additional equipment to conduct independent research projects; a design center where students will be able to share ideas and make presentations; and a full-time technician to support the center's activities. The prototyping laboratory provides students with access to specialized mechanical, electrical, and software tools for the design and realization mechatronics systems. The center also utilizes the equipment available in the Manufacturing Processes Laboratory to handle a wide variety of complex projects involving the fusion of mechanics, electronics, and software technologies.

In collaboration with the Department of Electrical and Computer Engineering and the Department of Engineering Sciences and Materials, the **Micro and Nano Devices Research Laboratory** is a Class 100 (ISO Class 5) cleanroom for photolithography located at the UPRM Research and Development Center. The facility houses a SUSS MicroTec Mask Aligner (MA-6) with backside alignment, a Reactive Ion Etcher with CF₄ chemistry, a multiple target (AC/DC) Sputtering System (AJA Orion Thin Film Deposition System), a Stylus Profilometer (KLA Tencor P-6), a chemistry hood and photolithography peripherals

The Vehicle Design and Research Laboratory is involved with research and development of high performance and alternate fueled vehicles for current and future transportation needs. It is equipped with a Design Center and a Machine Shop, two chassis dynamometers both and emissions measurement equipment. Data acquisition instrumentation is available for vehicle development and optimization. Current

research includes: energy management for solar powered, electric and hybrid vehicles, motorsport vehicle optimization, high speed maglev transportation systems and remote control aircraft. Undergraduate student projects include Formula SAE, SUN, SAE Mini Baja and SAE Aerodesign.

The Mechanical Systems Response Research Laboratory (MSRRL) supports research efforts in areas that focus on mechanical/material component systems. Areas ranging from structural vibration control, material characterization, infrastructure health monitoring and diagnostics, and anomaly detection in turbine temperature measurement devices have been performed. Research that has been funded from various government agencies such as DoD, NSF-EPSCoR, NASA, and private industry has lead to peer review publications and patents.

Projects topics such as:

- Characterization of sandwich composite materials
- Vibration control using shape memory alloys
- Vibration shaker design
- Damage detection and health monitoring using neural networks
- Fluid structure interaction
- Novel dynamic material characterization techniques

The MSRRL laboratory is equipped for research in mechanical/material components systems.

Laboratory facilities include a laser vibrometer, several electromagnetic shakers with corresponding amplifiers, data acquisition equipment, transducers (acceleration, force, and temperature), conditioning amplifiers, power supplies, oscilloscopes, and computer facilities.

At The Bubble Dynamics Laboratory (BDL), cutting edge research is being conducted for understanding, producing and characterizing milli-micro- and nano-bubbles through the design of acoustic resonators. We develop experimental systems for validation and/or formulation of theoretical models involving the generation and collapse of bubbles with applications on the mechanical, naval, biomedical, agricultural and nuclear energy industry. The laboratory, located in the Mechanical Engineering Department at UPRM (Lucchetti Building), houses state of the art equipment including: a 3D stereoscopic PIV

(Particle Image Velocimetry) system with the capability to perform shadow-sizing, micro-PIV and Laser Induced Fluorescence (LIF), a Dynamic Mechanical Analyzer (NTA) and a Static and dynamic light scattering (SLS-DLS) equipment. The BDL laboratory is also equipped with modern data acquisition and measuring devices and it is supported through research funded by the National Science Foundation, Department of Defense, Department of Energy, the US Nuclear Regulatory Commission and the Puerto Rico Science Technology and Research Trust.

The Biomechanics and Biomaterials Laboratory is dedicated to research and education principally in the area of characterization and testing of biomaterials. This Laboratory is equipped with a Tribometer, a DMA, Minimat tensile tester, Potentiostat/Galvanostat and an Analytical balance. Characterization of the wear resistance, tensile, compressive and fatigue properties are performed in this facility. Corrosion resistance and behavior through potentiodynamic polarization, cyclic voltammetry and electrochemical impedance spectroscopy are measured in this laboratory.

The High Performance Computing and Visualization Laboratory (HPCVL) is located in room L-127 of the Lucchetti building in the Mechanical Engineering Department. It performs investigation in computational fluid dynamics of turbulent flows with heat transfer, algorithm development, parallel programming, high performance computing, and scientific visualization; particularly, for fundamental thermal-fluid research with applications to aerospace. The facility is equipped with a powerful GPU cluster, two workstations (with 128 and 64 GB of RAM memory, respectively), a virtual reality kit, a high-resolution monitor, and several terminals for remote connection to supercomputers: Blue Waters, Stampede, and Comet in US as well as MareNostrum 4 in the Barcelona Supercomputing Center (Spain). The Air Force Office of Scientific Research (AFOSR), National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and the Extreme Science and Engineering Discovery Environment (XSEDE) provided initial funding for HPCVLab and its research projects. The mission of the HPCVLab is to promote and facilitate thermal-fluid research by means of cutting edge computing and

visualization technology for faculty, undergraduate and graduate students, and UPRM partners.

The Human-Centered Design Research and Development Laboratory purpose is to enhance quality of life by understanding human behavior and cognition to connect Design and Engineering for the development of knowledge and products for social well-being. Currently, the laboratory focuses in three areas: the intersection between Design and entrepreneurship, Design for aesthetics, and Virtual Reality for Engineering applications. The laboratory is equipped with various high performance computers and head mounted displays (e.g. Oculus Rift) for the virtual reality experiments. In addition, a range of input output devices is available for inclusion in virtual reality experiments. The laboratory offers visualization of complex engineering analysis and product assemblies in support of ME courses and other partnerships.

CONTACT INFORMATION

Department of Mechanical Engineering
Graduate Studies
Call Box 9000
Mayaguez, Puerto Rico 00681 USA

Phone: 1-787-832-4040 ext. 3719, 2560
Fax: 1-787-265-3817

E-mail: gradschool@me.uprm.edu
Internet: <http://engineering.uprm.edu/inme/>

MECHANICAL ENGINEERING (INME)

Advanced Undergraduate Courses

INME 5005. LUBRICATION (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Fundamental principles and concepts of lubrication theory; hydrostatic and hydrodynamic lubrication; examples of journal and thrust bearing design, using both the hydrostatic and hydrodynamic principles; considerations in boundary lubrication.

INME 5007. SOLAR ENERGY APPLICATIONS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INME 4015 or

INQU 4001 or authorization of the Director of the Department.

Fundamentals of solar radiation, its measurement, and methods of estimation. Selected topics on heat transfer relevant to systems design applications of solar energy such as flat plate and focusing collectors, energy storage systems, heating and cooling systems, power systems, and distillation processes.

INME 5008. CORROSION. Three credit hours. Three hours of lecture per week. Prerequisite: INME 4007 or INME 4107 or authorization of the Director of the Department.

Electrochemical principles and corrosion mechanisms; protection and prevention of corrosion in metals; the effects of temperature, environment, and metallurgical factors.

INME 5015. SELECTED TOPICS IN MECHANICAL ENGINEERING. One to six credit hours. One to six hours of lecture per week. Prerequisite: authorization of the Director of the Department.

A study of certain selected topics in Mechanical Engineering not covered by other existing courses.

INME 5018. MATERIALS FAILURE ANALYSIS. Three credit hours. Three hours of lecture per week. Prerequisites: ((INME 4012 and INME 4007) or (INME 4012 and INME 4107)) or authorization of the Director of the Department.

Materials science concepts used to identify, correct and prevent failure due to the improper use of materials or to problems in manufacturing processes. In depth study of failure mechanisms such as fatigue, wear, creep, and corrosion.

INME 5025. METALS FATIGUE (II) (Odd numbered years). Three credit hours. Three hours of lecture per week. Prerequisite: INME 4007 or INME 4107 or authorization of the Director of the Department.

Nature of metal fatigue; modern approaches to design of mechanical components for repeated loadings; importance of residual stresses and stress concentrations; analysis of cumulative damage and life prediction; cycle counting and sequence of events.

INME 5701. GAS TURBINE PERFORMANCE ANALYSIS I. Three credit hours. Three hours of lecture per week. Prerequisites: (INME 4001 and INGE 4015) or authorization of the Director of the

Department. Corequisite: INME 4002 or authorization of the Director of the Department.

Application of concepts in thermodynamics, fluid mechanics, aerodynamics, and compressible flow theory to analysis and design of jet engines. Study of jet engine performance by means of thermodynamic analysis, measurement of pressure, temperature, and velocity parameters and their relation to fuel consumption and thrust output.

INME 5702. GAS TURBINE PERFORMANCE ANALYSIS II. Three credit hours. Three hours of lecture per week. Prerequisites: INME 5701 and (INME 4002 or authorization of the Director of the Department).

Identification and optimization of jet engine components for a well integrated system. Principles of overall system design applied to both design and off-design behavior of turbomachinery, combustion and emissions, acoustics, and operationally stable throttle response. Advanced thermodynamic concepts applied to turbofan optimization.

INME 5707. GAS TURBINE SYSTEM OPERATION. Three credit hours. Three hours of lecture per week. Prerequisites: ((INME 4002 or INME 4045 or INQU 4012) and INGE 3016 and INME 4707) or authorization of the Director of the Department.

Study of jet engine performance using energy budgets and its optimization in the jet engine cycle. Study of turbomachine components, such as compressors, combustors, turbines and nozzles, as integrated into a system that produces power aircrafts. Development of a thermodynamic model for a turbofan engine to investigate design and off-design behavior, and the response to external and internal parameters. Study the influence of design criteria such as structural integrity, emissions, acoustics, and operationally-stable throttle response on the integration process.

INME 5711. AEROSPACE STRUCTURAL DESIGN I. Three credit hours. Three hours of lecture per week. Prerequisite: INME 4011 or authorization of the Director of the Department.

Study and application of the principles of machine design and steady load failure theory to aerospace structures. Design of thin-walled fatigue resistant aerospace structures; analysis of the state of stress and strain in stiffened Shell beams including thermal effects; deformation analysis by the Principle of Virtual Work and Complementary Principle of Virtual Work; and structural dynamics analysis.

INME 5712. AEROSPACE STRUCTURAL DESIGN II. Three credit hours. Three hours of lecture per week. Prerequisite: INME 5711 or authorization of the Director of the Department.

Study of aspects of structural analysis pertinent to the design of flight vehicles. Wing design based on aeroelasticity (wing flutter), wing divergence, vibrational analysis, environmental loads, aerospace materials, bucking of thin-walled compression members. Finite element analysis of elastic structures using the Principle of Virtual Work.

INME 5717. AIRCRAFT STRUCTURAL ANALYSIS AND DESIGN. Three credit hours. Three hours of lecture per week. Prerequisites: (INME 4717 and (INGE 4019 or INGE 4012)) or authorization of the Director of the Department.

Application of work and energy principles, and numerical methods, to the design of flight vehicles. Study of deflection and load analysis using the principle of virtual work, principle of contemporary virtual work, analytical weak form solutions, and the finite element formulation. Wing design considering: fatigue, aeroelasticity, divergence, environmental loads, aerospace materials, dynamic stability of thin-walled compression members, and structural dynamics.

INME 5995. SPECIAL PROBLEMS. One to six credit hours. One to six hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Researches and special problems in Mechanical Engineering and related fields.

INME 5996. SPECIAL PROBLEMS II. One to six credit hours. One hour of lecture per week per credit. Prerequisite: authorization of the Director of the Department.

Study of special problems in Mechanical Engineering and related fields.

INME 5997. SELECTED TOPICS II. One to six credit hours. One to six hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of selected topics in mechanical engineering or related fields.

Graduate Courses

INME 6001. ADVANCED THERMODYNAMICS I (I) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Critical study of thermodynamics laws; property relationships; statistical thermodynamics; thermodynamics design of power plants and refrigeration plants.

INME 6002. ADVANCED THERMODYNAMICS II (II) (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INME 6001 or authorization of the Director of the Department.

Advanced applications of thermodynamics to energy systems; chemical reaction kinetics; combustion; modeling of intermolecular forces and transport properties; solid phase thermodynamics.

INME 6005. HEAT CONDUCTION (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analytical methods for the solution of heat conduction problems in Cartesian, cylindrical, and spherical geometries, separation of variables superposition., Laplace transforms, variational formulation; numerical methods to include finite differences and finite elements.

INME 6006. RADIATION HEAT TRANSFER (Every third semester). Three credit hours. Three hours of lecture per week.

The nature of thermal radiation and radiative characteristics of surfaces. Application of fundamentals to the analysis of evacuated enclosures and of systems containing a thermal radiation absorbing and emitting media. Study of the combined effects of radiation conduction and convection of thermal energy. Applications.

INME 6007. ADVANCED AIR CONDITIONING (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INME 6001 or authorization of Department Director.

Advanced study of psychometrics, dynamic models for buildings, simultaneous heat and mass transfer processes. Energy efficient cooling and heating of building using annual energy consumption criterion and conventional and non-conventional air conditioning systems.

INME 6008. ADVANCED METAL CUTTING Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Mechanics of machining process including friction and temperature. Tools wear analysis, cutting fluids and surface finish. Economics of machining processes. Flexible manufacturing and group technology process design.

INME 6009. ADVANCED MANUFACTURING PROCESSES (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Developments in the removal and deforming processes of materials. Applications of these processes to hard, brittle, conducting and non-conducting materials. Use of the computer in the analysis of these processes.

INME 6010. ADVANCED CONCEPTS IN FLUID MECHANICS AND CONVECTIVE HEAT TRANSFER (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Fluid properties, equations of mass, momentum and energy for viscous flows, exact solutions, low and high Reynolds number flows, velocity and thermal boundary layers, flow in tubes, approximate methods, compressible flows, momentum and energy transfer in turbulent flows.

INME 6011. ANALYSIS OF MACHINE MEMBERS I (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INME 4026 or authorization of Department Director.

An extension of stress and deflection analysis, with emphasis on those topics pertinent to the design of machine members; the application of basic and advanced theory to design analysis in situations in which weight, temperature, fatigue, dynamic loads, and other modes of loading and failure are relevant.

INME 6012. ANALYSIS OF MACHINE MEMBERS II (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: INME 6011 or authorization of Department Director.

A continuation of INME 6011.

INME 6015. DISLOCATION THEORY (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: INME 4007 or authorization of Department Director.

Theory of dislocations in isotropic and anisotropic continua; dislocation reactions; the relation of theory to observed dislocation configurations.

INME 6016. MECHANICAL METALLURGY (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: INME 6015 or authorization of Department Director.

Dislocation theory applied to the deformation of metals; including the mechanisms of glide; fatigue; creep, and fracture.

INME 6017. SEMINAR. Zero to one credit hour. Zero to one hour of lecture per week.

Discussions and presentations on topics related to mechanical engineering and research projects developed by students of the graduate program.

INME 6018. SEMINAR. One credit hour. One hour of seminar per week.

Discussion and reports on selected topics in Mechanical Engineering.

INME 6019. FRACTURE MECHANICS (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Application of fracture mechanics to structural integrity of engineering materials; prevention of fracture, relationship between material toughness, design stress and flaw size, microstructural and environmental effects; transition temperature; fatigue and failure analysis.

INME 6021. ENGINEERING SYSTEMS DESIGN I (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisites or Corequisites: INME 6001 and INME 6011 or authorization of the Director of the Department.

An introduction to the philosophy of problem recognition and design project formulation; practice in this activity through the actual formulation and completion of several small design projects or one large one.

INME 6022. ENGINEERING SYSTEMS DESIGN II (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: INME 6021.

A continuation of INME 6021.

INME 6024. NUMERICAL ANALYSIS OF TRANSPORT PHENOMENA (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Numerical solution of governing equations stemming from heat and mass transfer and fluid flow phenomena.

INME 6025. GAS DYNAMICS (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Fluid properties, equations of mass, momentum and energy, one-dimensional gas dynamics, normal and oblique shocks, expansion fans, flows in ducts and nozzles, flow with friction and heat transfer, small perturbation theory, introduction to characteristic method.

INME 6026. BOILING AND CONDENSATION HEAT TRANSFER. Three credit hours. Three hours of lecture per week.

Fundamentals of boiling and condensation including interface and wetting phenomena, drop and film condensation, pool and flow boiling and instabilities in two-phase flows.

INME 6030. MECHANICS OF COMPOSITE MATERIALS (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analysis of mechanical behavior of composite materials; fiber reinforced composites, and laminated beams and plates; environmental effects; prediction of properties; theories of strength, stiffness, design.

INME 6035. CONSERVATION AND ALTERNATE ENERGY SYSTEMS (On demand). Three credit hours. Three hours of lecture per week.

Technology of energy conservation and of systems for production of electricity which do not use fossil fuels. Case studies of conservation schemes, and of the technology of wind, ocean energy, direct solar, nuclear and biofuels. Energy sources, conversion

processes, transportation and storage, supply systems, and socio-economic and ecological assessment. Individual, in depth, term papers are required on two of the topics covered.

INME 6036. CONTROL SYSTEM DESIGN AND APPLICATIONS (Every third semester, on demand). Three credit hours. Three hours of lecture per week.

Design of electromechanical products; use of electronic parts in design. Applications of logic design. Selection and construction of control loop parts such as sensors and actuators. Design, build, and test of a miniature controlled system.

INME 6037. FINITE ELEMENT ANALYSIS (On demand). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Application of energy and variational principles to approximate ordinary and partial differential equations. Application of weak and strong formulations. Application to structural and heat transfer problems with static and dynamic loading. Computer programming of finite element analysis code to solve one-and two-dimensional problems using isoparametric formulation. Comparison of finite element results with exact and semi-analytical solutions.

INME 6039. VIBRATIONS (Every third semester). Three credit hours. Three hours of lecture per week.

Systems with multiple degrees of freedom, principal modes and coordinates, modal analysis, influence coefficients, transfer matrix. Lagrange's equations. Continuous system, longitudinal, torsional and lateral vibrations. Simulation of vibrational problems on analog and digital computers.

INME 6040. ADVANCED KINEMATICS (Every third semester). Three credit hours. Three hours of lecture per week. Prerequisite: Graduate state.

Kinematic synthesis by analytical and computer assisted methods. Advanced topics in kinematic synthesis of linkages. Computerized design for function, path and motion generation. Spatial mechanisms and robotics.

INME 6045. AUTOMATIC ASSEMBLY SYSTEMS (Every third semester). Three credit hours. Three hours of lecture per week.

Introduction to assembly systems; mechanics of vibratory and non vibratory feeders; parts feeding

and orienting devices; natural resting aspects of parts; performance and economics of automatic assembly and robotic assembly systems; product design improvement for ease of assembly.

INME 6046. DESIGN FOR MANUFACTURE (Every third semester). Three credit hours. Three hours of lecture per week.

Methods to assist in the design of products for manufacture. Guidelines and design rules for quality control and to ease the fabrication of assemblies and products with casting and molding processes, material removal, and deforming.

INME 6047. INTERMEDIATE FLUID MECHANICS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Analysis of fluid flow around a rigid body by applying equations for continuity, momentum and energy, and two-dimensional potential flow. Introduction and application of compressibility effects to analyze fluid flow around transonic wings. Analysis of friction and heat transfer in duct flows. Nozzles, diffusers and propulsion devices will be discussed.

INME 6048. CONTINUUM MECHANICS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of continuum mechanics covering algebra and calculus of tensors, analysis of stress and deformation at a point. Development of the basic equations of a continuous medium by applying the basic laws of conservation of mass, linear momentum, moment of momentum, and the first and second law of thermodynamics. Study of constitutive axioms and constitutive relations for solids and fluids, application to problems of solid mechanics and/or fluid mechanics.

INME 6055. CONDUCTION AND RADIATION HEAT TRANSFER. Three credit hours. Three hours of lecture per week.

Discussion and use of methods for the analytical solution of heat conduction and heat radiation problems including Bessel's functions, separation of variables, superposition, and the Laplace transform. Numerical solution of combined heat conduction and radiation problems using the methods of finite difference and discrete ordinates for radiatively participating and non-participating media.

INME 6065. PRINCIPLES OF BIOMEDICAL ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of advanced general topics as applied to biomedical systems. Brief history of medicine, including human anatomy, physiology, and the rise of modern molecular biology. Description of the development of quantitative methods in biology, and the role of engineering in understanding complex biological systems. Description of relevant laws, professional ethics and regulatory environment.

INME 6099. RESEARCH (I, II). Six credit hours.

Research in the field of Mechanical Engineering. The presentation and approval of a thesis is required in order to obtain the six credits.

INME 6107. SMART MATERIALS AND DEVICES. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of smart materials and their classification according to their response and stimuli ability. Discussion of the effect of crystalline structure on the properties of piezoelectric materials, magnetostrictive alloys, shape memory alloys and others. Application of smart materials in actuators and sensors.

INME 6115. BIOMATERIALS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of advanced materials as applied to biomedical systems. Integration of materials science and engineering concepts with biology for the design of successful interfaces between living cells and organic and inorganic materials as well as medical devices.

INME 6135. TISSUE ENGINEERING. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study of tissue engineering applied to biomedical systems. Review of quantitative cell and tissue biology, cell and tissue characterization, engineering methods and design, and clinical implementation. Discussion of cells and their behavior, followed by the effect of external stimuli on cells. The properties of the extracellular matrix will be studied. Specific cases of vascular tissue engineering, cartilage tissue engineering and bone engineering will be studied. The implications of using stem cells for tissue engineering will be discussed.

INME 6160. FUNDAMENTALS OF MICRO AND NANOFABRICATION. Four credit hours. Three hours of lecture and three hours of laboratory per week. Prerequisite: authorization of the Director of the Department.

Discussion and application of micro and nanofabrication techniques as applied to micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS), such as photolithography, subtractive and additive techniques, surface and bulk micromachining, soft lithography and non-conventional fabrication techniques. Hands-on laboratory experience on mask design, photolithography, surface micromachining and soft lithography.

INME 6165. DESIGN OF MICROFLUIDIC SYSTEMS. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Discussion of advanced concepts and technologies of micro-scale flows. Analysis of microfabrication techniques, special cases of the Navier-Stokes equations, inertial microfluidics, capillary effects, droplet microfluidics, electrokinetics, acoustofluidics, optofluidics, nanofluidics, and transport phenomena in micro-scale flows. Determination of design parameters and optimization of micro-scale fluidic structures based on analytical and computational solutions of the Navier-Stokes, energy and mass transport equations.

INME 6170. BIOMEDICAL MICRO-ELECTRO-MECHANICAL SYSTEMS (BIOMEMS). Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Discussion of advanced topics in biomedical micro-electro-mechanical systems (BioMEMS). Analysis of the underlying physical, chemical and biological phenomena in BioMEMS as applied to medical and biological sciences. Design of BioMEMS based on the current trends in the field of biomedical science and engineering.

INME 6995. SELECTED TOPICS (On demand). One to six credit hours. One to six hours of lecture per week.

Study of selected topics in Mechanical Engineering and related fields.

INME 6998. ENGINEERING PROJECT (On demand). Three to six credit hours.

Comprehensive study of a mechanical engineering problem selected to integrate the knowledge

acquired in the graduate program of study. This project fulfills one of the requirements of the Master of Engineering Degree (ME) and will be governed by the norms established for the Graduate School for this purpose.

INME 8000. DOCTORAL DISSERTATION. Zero to six credit hours.

Academic research and dissertation development based on an original research project in Mechanical Engineering.

INME 8017. DOCTORAL SEMINAR. Zero to one credit hour.

Discussions and presentations on advanced topics related to Mechanical Engineering and research projects developed by students of the doctoral program.

INME 8995. ADVANCED PROBLEMS IN MECHANICAL ENGINEERING. One to six credit hours.

Research and special problems at and advanced level in Mechanical Engineering and/or related fields.

INME 8997. ADVANCED TOPICS IN MECHANICAL ENGINEERING. One to three credit hours.

Advanced fundamentals and research topics not covered by existing graduate courses in Mechanical Engineering and/or related fields.

MECHANICAL ENGINEERING FACULTY

A list of professors who engage in graduate activities in the Department follows, including the highest earned degree, date, and institution granting the degree. Research and teaching interests are also included.

J. GUILLERMO ARAYA, *Assistant Professor*, Ph.D., 2008, Rensselaer Polytechnic Institute. Research and Teaching Interests: Computational Fluid Dynamics of Turbulent Flows with Heat Transfer, Parallel Programming, Algorithm Development and Flow Control for aeronautical and wind energy applications.

JAYANTA BANERJEE, *Professor*, Ph.D., 1969, M.Ed., 1987, University of Waterloo, Canada. Research and Teaching interests: Manufacturing, Technology Transfer and Culture.

PABLO CÁCERES, *Professor*, Ph.D., 1984, University College Cardiff. Research and Teaching interest: Materials characterization using surface and electron microscopy techniques, Nanostructured materials synthesis and characterization, Thermoelectric Materials, Hydrides for Hydrogen Storage.

SILVINA CANCELOS, *Associate Professor*, Ph.D., 2007, Rensselaer Polytechnic Institute. Research and Teaching interest: Two-phase flow and with applications on the biomedical industry and the nuclear energy industry.

SANDRA COUTÍN, *Professor*, Ph.D., 1996, Kansas State University. Research and Teaching interests: Numerical Heat Transfer and Fluid Flow in Manufacturing Processes and HVAC Systems.

RUBÉN E. DÍAZ, *Associate Professor*, Ph.D., 2005, University of California, Berkeley. Research and Teaching interest: Micro/Nano scale bioelectronic systems, Micro-electroporation, Biosensors, Heat and Mass transfer in biological systems.

DAVID B. DOONER, *Professor*, Ph.D., 1991, University of Florida. Research and Teaching interests: Optimal Design of Mechanical Systems, Integrated Cap Cam, Geometric Modeling, Analysis and Synthesis of Mechanisms, gear systems, cam systems.

J. GUSTAVO GUTIÉRREZ, *Professor*, Ph.D., 2002, University of Wisconsin, Milwaukee. Research and Teaching interests: Heat and Mass Transfer, Fluid Flow, Computational Fluid Mechanics.

YI JIA, *Professor*, Ph.D., 1994, Harbin Institute of Technology. Research and Teaching interests: Micro Sensors, Micro Electronic Mechanical Systems (MEMS), Tribology, and Computer-aided Engineering Design.

FREDERICK A. JUST, *Professor*, Ph.D., 1997, Virginia Polytechnic Institute and State University. Research and Teaching interests: Damage, Detection, Vibration Control/Smart Structures, Alternative Vehicle Design.

JOSE LUGO, *Assistant Professor*, Ph.D., 2013, University of Notre Dame. Research and Teaching interest: Design Theory and

Methodology, Optimization, CAE, VR, and Quantification of Product's Aesthetics.

MARCO MENEGOZZO, *Assistant Professor*, Ph.D., 2015, University of Padova, Italy. Research and Teaching interest: Aerospace Structures, Reliability-Based Design Optimization and Aeroelasticity.

NÉSTOR L. PÉREZ, *Professor*, Ph.D., 1989, University of Idaho. Research and Teaching interests: Material Characterization, Alloy Development, Rapid Solidification, Corrosion, Fracture Mechanics and Non-destructive Evaluation.

FERNANDO E. PLA-BARBY, *Emeritus Professor*, Ph.D., 1978, University of Texas-Austin. Research and Teaching interests: Heat transfer, HVAC Systems, Design of Thermal and Energy System Sciences.

PEDRO QUINTERO, *Associate Professor*, Ph.D., 2007, University of Maryland. Research and Teaching interest: Electronic Packaging for Power Electronics, Electronic packaging for High Temperature and Harsh Environments, Pb-Free Electronics: Materials and Manufacturing Processes, Transient Liquid Phase Sintering.

PEDRO RESTO, *Associate Professor*, Ph.D., 2012, University of Wisconsin, Madison. Research and Teaching Interests: Biomedical Engineering, Biomedical Micro-Electro-Mechanical Systems (BioMEMS), Biosensors, Mechatronics, System Dynamics.

FRANCISCO RODRÍGUEZ, *Professor*, Ph.D., 2003, University of Dayton. Research and Teaching interest: Energy conservation, renewable energy conversion, HVAC, micro/nanofluidics, heat transfer, and applied transport phenomena modeling & simulations.

DAVID SERRANO, *Professor*, Sc.D., 1987, Massachusetts Institute of Technology. Research and Teaching interests: Artificial Intelligence, CAE, Concentrating Based Systems.

PAUL A. SUNDARAM, *Professor*, Ph.D., 1988, Ohio State University. Research and Teaching interests: Mechanical Properties of Materials, Materials Science, Biomaterials, Metal-matrix Composites, Material-Environment Interaction, Fracture of Materials.

SHEILLA TORRES NIEVES, *Assistant Professor*, Ph.D., 2011, Rensselaer Polytechnic Institute. Research and Teaching Interests: Experimental and Computational Fluid Dynamics, Turbulence, Boundary Layer, Applications: Aerospace, Turbomachinery, Wind Energy, Environmental and Atmospheric Flows.

RICK VALENTÍN, *Professor*, Ph.D., 2003, University of Maryland. Research and Teaching interest: Electronic Interconnects, Computer-Aided Engineering, Nano-templates, Fuel Cells, Porous media Manufacturing and Transport Analysis.

INTERDISCIPLINARY PROGRAMS

The University of Puerto Rico at Mayagüez regards interdisciplinary programs as an important element of growth in its education and research missions.

Interdisciplinary programs involve a number of academic fields and are offered by faculty from many academic departments. These programs are designed to convey subjects which intersect more than one academic discipline, providing the flexibility and breath needed to undertake fast-moving research and technical innovations.

Interdisciplinary programs are administered by program directors or coordinators, and draw their resources mainly from traditional academic departments. Students are encouraged to contact the directors of these programs to learn more about their range of courses, research and professional opportunities.

DOCTORAL PROGRAM IN COMPUTING AND INFORMATION SCIENCES AND ENGINEERING

The Mayagüez Campus of the University of Puerto Rico offers a program of study leading to the Ph.D in Computing and Information Sciences and Engineering (CISE). Subject areas cover a wide range of advanced studies and research problems of interdisciplinary nature in computing and information sciences and engineering. Due to its interdisciplinary character, the program is composed by areas of specialty which can be renewed according to the evolution of the discipline, availability of specialists, and societal demand. At present, the program offers a specialty in Computer Science and Engineering, which focuses on design, analysis, and development of software and digital information systems; and a specialty in Scientific Computing, which focuses on the use of high-performance computing for the mathematical solution of problems in science and engineering.

The program is designed to prepare leaders of information technology innovation for highly qualified careers in academia, government or industry. A student planning to enter the Ph.D. in CISE should have a B.S. degree in Engineering or

Science, and the equivalent to the undergraduate courses of Data Structures, Introduction to Computing Foundations, Discrete Math, and Programming Languages. Students deficient in one or more of these courses are expected to remove these deficiencies during the first two years of study. Applicants should also submit their GRE score, and an essay explaining their personal vision of the discipline, and professional expectations.

The program requires a minimum of 57 academic credits distributed as follows: 9 credits in core courses, 12 credits in elective courses inside the student's specialty, 9 credits in elective courses outside the student's specialty, 6 credits in an area of specialization within the program, 6 credits in advanced topics courses, 3 credits in seminars, and 18 credits in a doctoral dissertation. The core courses are: Analysis of Algorithms, Foundations of Computing, and Computer Architectures. The elective courses for the specialty of Computer Science and Engineering may be selected from the elective courses of the Master in Science in Computer Engineering, while the electives for the specialty of Scientific Computing, from the Master in Science in Scientific Computing. Qualifying and candidacy examinations are also required. The qualifying examination is based on the core courses, and it is usually offered at the beginning of each semester.. The candidacy examination, on the other hand, is based on the student's thesis proposal and it is offered by the student's committee. Overall, the curriculum emphasizes research and creativity over passive learning. Thesis results are expected to be published in a recognized journal before the Ph.D. is conferred.

More information is available at:
<http://cise.uprm.edu>

DOCTORAL PROGRAM IN COMPUTING AND INFORMATION SCIENCES AND ENGINEERING (CIIC)

Graduate Courses

CIIC 6005. COMPUTING FOUNDATIONS. Three credit hours. Three hours of lecture per week.

Concepts and formal definitions of algorithmically solvable problems. Classification of problems by their computability in terms of the time and space required to solve them.

CIIC 8995. ADVANCED TOPICS. One to six credit hours. One to six hours of lecture per week.

Study of advanced topics in science and engineering of information and computing.

CIIC 8996. DOCTORAL SEMINAR. Zero to three credit hours.

Study and dissemination of current research topics in sciences and engineering of information and computing. Each student will select a research topic for which he/she will make a formal and public presentation.

CIIC 8997. INDEPENDENT STUDY. Zero to six credit hours.

Independent studies in sciences and engineering of information and computing.

CIIC 9995. DOCTORAL DISSERTATION. Zero to eighteen credit hours.

Research work leading to a significant and original contribution in sciences and engineering of information and computing.

BIOENGINEERING GRADUATE PROGRAM

BIOENGINEERING MASTER'S PROGRAM

The Bioengineering Master's Program of the University of Puerto Rico – Mayagüez (UPRM) will train students in bioengineering by integrating the skills and competences of engineering, computational sciences, natural sciences, and medicine, while establishing an entrepreneurial culture within the students to focus on product-oriented research and development for future commercialization. Another program objective is to prepare graduates that are aware of the ethical and social responsibilities associated to the solution of technical problems in bioengineering.

The bioengineering program focuses on computational bioengineering and biomedical engineering research. It will draw on internal areas of emphasis in order to guide students in their curriculum and maintain a flexible structure that is adaptable to technological evolutions.

Two master's degrees will be offered, which correspond to Plans I, II and III, as described in Certification 09-09 of the University of Puerto Rico-Mayagüez's Academic Senate.

Master's of Science (Plan I - Thesis). This program consists of a total of 31 credit-hours: nine credit-hours in bioengineering core courses, six credit-hours in bioengineering courses, six credit-hours in courses outside of bioengineering, three credit-hours in elective courses, six credit-hours in master's thesis, and one credit-hour in graduate seminar.

Master's of Engineering (Plan II - Project). This program consists of a total of 31 credit-hours: nine credit-hours in bioengineering core courses, six credit-hours in bioengineering courses, six credit-hours in courses outside of bioengineering, three credit-hours in elective courses, six credit-hours in engineering project, and one credit-hour in graduate seminar.

Master's of Engineering (Plan III). This program consists of a total of 37 credit-hours: nine credit hours in bioengineering core courses, fifteen credit-hours in bioengineering courses, six credit-hours in courses outside of bioengineering, six credit-hours in elective courses, and one credit-hour in graduate seminar.

The degrees conferred will be Master of Science in Bioengineering to students that complete Plan I (thesis) and Master of Engineering in

Bioengineering to students that complete Plan II (project) or Plan III (courses-only). The program's graduate committee will consider transfers from the doctoral program in bioengineering into the master's program, with previous recommendation from the student's thesis committee and from the program's executive director.

Admission Requirements

General requirements for admission into graduate programs at the University of Puerto Rico-Mayagüez are established in Certification 09-09 of the University of Puerto Rico-Mayagüez's Academic Senate. In addition, the Bioengineering Master's Program requires that applicants possess:

- A baccalaureate degree in engineering with a minimum grade point average (GPA) of **3.20** on a scale of **4.00**, from an accredited institution of higher learning. Depending on the applicant's academic background, admission may be granted with deficiency courses. Applicants will be encouraged, but not required, to have approved undergraduate courses in human anatomy and physiology, human cellular and molecular biology, or both.
- A baccalaureate degree in physics, chemistry, biology or related areas with a minimum grade point average (GPA) of **3.20** on a scale of **4.00**, from an accredited institution of higher learning, and with a mathematical background at the level of differential equations. Depending on the applicant's academic background, admission may be granted with deficiency courses. Applicants will be encouraged, but not required, to have approved undergraduate courses in human anatomy and physiology, human cellular and molecular biology, or both.
- International students for whom English is not the first language are required to submit a Test of English as a Foreign Language (TOEFL) exam score.

Graduation Requirements

The general academic requirements for conferring the Master's of Science or Master's of Engineering degrees are established in Certification 09-09 of the University of Puerto Rico-Mayagüez's Academic Senate. Specific requirements for each degree in the graduate program in bioengineering are described below.

Total Credit-Hour Requirement

Students entering the **Master's of Science (Plan I - Thesis)** program are required to approve a minimum of thirty-one (31) credit-hours distributed in the following manner:

- 9 credit-hours in core courses
 - Principles of Biomedical Engineering (INME 6065)
 - Principles of Computational Bioengineering (BING 6004)
 - Molecular and Cellular Biology for Engineers (BING 6002)
- 6 credit-hours in bioengineering courses
- 6 credit-hours in courses outside of bioengineering
- 3 credit-hours in elective courses (either in bioengineering or outside)
- 1 credit-hour in graduate seminar (BING 8998)
 - The topics covered in the seminar will include:
 - Scientific issues
 - Social and ethical issues
 - Entrepreneurship
- 6 credit-hours in master's thesis (BING 6999)

Students entering the **Masters of Engineering (Plan II - Project)** program are required to approve a minimum of thirty-one (31) credit-hours distributed in the following manner:

- 9 credit-hours in core courses
 - Principles of Biomedical Engineering (INME6065)
 - Principles of Computational Bioengineering (BING 6004)
 - Molecular and Cellular Biology for Engineers (BING 6002)
- 6 credit-hours in bioengineering courses
- 6 credit-hours in courses outside of bioengineering
- 3 credit-hours in elective courses (either in bioengineering or outside)
- 1 credit-hour in seminar (BING 8998)
 - The topics covered in the seminar will include:
 - Scientific issues
 - Social and ethical issues
 - Entrepreneurship
- 6 credit-hours in engineering project (BING 6998)

Students entering the **Master's of Engineering (Plan III – Courses Only)** program are required to approve a minimum of thirty-seven (37) credit-hours distributed in the following manner:

- 9 credit-hours in core courses
 - Principles of Biomedical Engineering (INME6065)
 - Principles of Computational Bioengineering (BING 6004)
 - Molecular and Cellular Biology for Engineers (BING 6002)
- 15 credit-hours in bioengineering courses
- 6 credit-hours in courses outside of bioengineering
- 6 credit-hours in elective courses (either in bioengineering or outside)
- 1 credit-hour in seminar (BING 8998)
 - The topics covered in the seminar will include:
 - Scientific issues
 - Social and ethical issues
 - Entrepreneurship

Students will prepare a plan of study before the second month of their second semester of studies, and under the guidance of the student's graduate committee. The plan of study will be prepared taking into consideration: the student's academic and research interests, suitability of courses to prepare students for their research or project work, and academic offer. No more than 9 credit-hours of advanced undergraduate level courses can be used to complete degree requirements.

Minimum Academic Index Requirements

In order to complete the master's degree, each student must approve the required minimum credit-hours with a GPA of 3.0 or higher. Students enrolled in the graduate program may repeat a course with an earned grade of C or lower only once. Courses with a final grade of A or B cannot be repeated.

Maximum Number of Transfer Credits Allowed

Graduate courses taken at UPRM to fulfill requirements of another program may be utilized to fulfill the requirements of the bioengineering program. Courses taken at other institutions of higher learning may be utilized to fulfill master's program requirements, but are subject to residency requirements as specified in Certification 09-09 of the University of Puerto Rico-Mayagüez's Academic Senate. These norms stipulate that 60% of the courses in a student's plan of study must have been taken at UPRM. The program's graduate committee will determine which courses could be transferred. All transfer courses must be approved

with a minimum grade of B. Under no conditions may thesis credits be transferred.

Residency

The "Norms that Regulate Graduate Studies at UPRM" stipulate the residency requirements as follows:

"Residency requirements at the Master's level: a minimum of two semesters of study at UPRM and having completed sixty (60) percent of the course work for the program at UPRM."

Graduate Seminar

Master's students will be required to register for the Graduate Seminar in Bioengineering course for the duration of their studies and will be awarded one credit-hour the end of their last semester of studies. Besides scientific and technical topics, the graduate seminar will also cover topics related to entrepreneurship, intellectual property, and social and ethical issues related to the field of bioengineering.

Master's Thesis or Project (Plan I and Plan II only)

Master's students enrolled in **Plan I (Master of Science degree)** are required to conduct a research project in bioengineering. Students are required to submit a thesis proposal for the approval of the student's graduate committee, complete the proposed research work, prepare a thesis and orally defend the thesis.

Master's students enrolled in **Plan II (Master of Engineering degree)** are required to develop an engineering project in bioengineering. Students are required to submit a project proposal for the approval of the student's graduate committee, complete the project, prepare a written project report, and orally defend this project.

BIOENGINEERING DOCTORAL PROGRAM

The Bioengineering Doctoral Program of the University of Puerto Rico – Mayagüez (UPRM) will train students to become researchers in bioengineering by integrating the skills and competences of engineering, computational sciences, natural sciences, and medicine, while establishing an entrepreneurial culture within the students to focus on product-oriented research for future commercialization. Another program objective is to prepare graduates that are aware of the ethical and social responsibilities associated to the solution of technical problems in bioengineering.

The program will draw on internal areas of emphasis in order to guide students in their curriculum and research and to maintain a flexible structure that will allow the program to adapt itself to technological evolutions. The bioengineering program focuses on **computational bioengineering** and **biomedical engineering** research, and will consist of a total of **forty nine (49) credit-hours** for students entering the program with a **B.S. degree**, and **thirty-four (34) credit-hours** for students entering the program with an **M.S. or M.E. degree**. Of the forty-nine credit-hours, nine credit-hours will be in bioengineering core courses, six credit-hours in bioengineering courses, nine credit-hours in courses outside of bioengineering, six credit hours in elective courses, one credit-hour in graduate seminar, and eighteen credit-hours in doctoral dissertation. For students entering with an M.S. degree, 34 credit-hours will be required in the following manner: nine credit-hours in core courses, three credit-hours in bioengineering courses, three credit-hours in courses outside of bioengineering, one credit-hour in graduate seminar, and eighteen credit-hours in doctoral dissertation. Each doctoral student will be required to participate in the graduate seminar each semester and will receive one credit at the conclusion of his dissertation. Students will also be required to pass a qualifying exam, prepare a dissertation proposal and complete a dissertation research project that will demonstrate the scope of acquired knowledge and the student's creativity and scientific rigor. The dissertation must be an original contribution to the existing scientific and/or technical body of knowledge in the field of bioengineering.

Admission Requirements

General academic requirements for admission to the Ph.D. are included in Certification 09-09 issued by the UPRM Academic Senate. Additional specific program requirements are:

Students entering the program with a B.S. degree

- A baccalaureate degree in engineering with a minimum grade point average (GPA) of 3.20 on a scale of 4.00, from an accredited institution of higher learning. Depending on the applicant's academic background, admission may be granted with deficiency courses. Applicants will be encouraged, but not required, to have approved undergraduate courses in human anatomy and physiology, human cellular and molecular biology, or both.
- A baccalaureate degree in physics, chemistry, biology or related areas with a minimum grade point average (GPA) of 3.20 on a scale of 4.00, from an accredited institution of higher learning,

and with a mathematical background at the level of differential equations. Depending on the applicant's academic background, admission may be granted with deficiency courses. Applicants will be encouraged, but not required, to have approved undergraduate courses in human anatomy and physiology, human cellular and molecular biology, or both.

- International students for whom English is not the first language are required submit a Test of English as a Second Language (TOEFL) exam score.

Student entering the program with an M.S. or M.E. degree

- A master's degree in engineering from an accredited institution of higher learning. Depending on the applicant's academic background, admission may be granted with deficiency courses. Applicants will be encouraged, but not required, to have approved undergraduate or graduate courses in human anatomy and physiology, human cellular and molecular biology, or both.
- A master's degree in physics, chemistry, biology or related areas from an accredited institution of higher learning, and with a mathematical background at the level of differential equations. Depending on the applicant's academic background, admission may be granted with deficiency courses. Applicants will be encouraged, but not required, to have approved undergraduate or graduate courses in human anatomy and physiology, human cellular and molecular biology, or both.
- International students for whom English is not the first language are required submit a Test of English as a Second Language (TOEFL) exam score.

The same norms established by the UPRM's Academic Senate as well as all previously described admission guidelines to the doctoral program are applicable to transfer students. The program's graduate committee will consider transfers from the doctoral program into the master's program, with previous recommendation from the student's thesis committee and from the program's executive director.

Graduation Requirements

The general academic requirements for conferring the doctoral degree are stated in Certification 09-09 of the UPRM's Academic Senate. Specific requirements for the Doctoral Program in Bioengineering are described below.

Students entering the program with a **B.S. degree** are required to approve a minimum of **forty-nine (49) credit-hours** distributed in the following manner:

- 9 credit-hours in core courses
 - Principles of Biomedical Engineering (INME6065)
 - Principles of Computational Bioengineering (BING 6004)
 - Molecular and Cellular Biology for Engineers (BING 6002)
- 6 credit-hours in bioengineering courses
- 9 credit-hours in courses outside of bioengineering
- 6 credit-hours in elective courses (either in bioengineering or outside)
- 1 credit-hour in seminar (BING 8998)
 - The topics covered in the seminar will include:
 - Scientific issues
 - Social and ethical issues
 - Entrepreneurship
- 18 credit-hours in doctoral dissertation (BING 8999)

Students entering the program with an **M.S. or M.E. degree** are required to approve a minimum of **thirty-four (34) credit-hours** distributed in the following manner:

- 9 credit-hours in core courses
 - Principles of Biomedical Engineering (INME6065)
 - Principles of Computational Bioengineering (BING 6004)
 - Molecular and Cellular Biology for Engineers (BING 6002)
- 3 credit-hours in bioengineering courses
- 3 credit-hours in courses outside of bioengineering
- 1 credit-hour in seminar (BING 8998)
 - The topics covered in the seminar will include:
 - Scientific issues
 - Social and ethical issues
 - Entrepreneurship
- 18 credit-hours in doctoral dissertation (BING 8999)

Students will prepare a plan of study before the second month of their second semester of studies, and under the guidance of the student's graduate committee. The plan of study will be prepared taking into consideration: the student's academic and research interests, suitability of courses to prepare students for their research work, and academic offer. No more than 9 credit-hours of advanced undergraduate level courses can be used to complete doctoral degree requirements.

Minimum Academic Index Requirements

In order to complete the doctoral degree, each student must approve a minimum of 49 credit-hours with a GPA of 3.0 or higher. Students enrolled in the doctoral program may repeat a course with an earned grade of C or lower only once. Courses with a final grade of A or B cannot be repeated.

Maximum Number of Transfer Credits to be Allowed

Courses taken at UPRM in fulfillment of requirements of another graduate program may be utilized to fulfill the requirements of the proposed program. Courses taken at other institutions of higher learning may be utilized to fulfill doctoral program requirements, but are subject to residency requirements as specified in Certification 09-09 which establishes that 60% of the courses in a student's plan of study must have been taken at UPRM. The program's graduate committee will determine which courses could be transferred. All transfer courses must be approved with a minimum grade of B. Under no conditions may thesis credits be transferred.

Residency

The "Norms that Regulate Graduate Studies at UPRM" stipulate the residency requirements as follows:

"Residency requirements at the Doctoral level: a minimum of four semesters for students entering with a Bachelors degree, and a minimum of two semesters for students entering with a Master's degree. In both cases the student will complete sixty (60) percent of the course work for the program at UPRM."

Graduate Seminar

Doctoral students will be required to register for the Graduate Seminar in Bioengineering course for the duration of their doctoral studies and will be awarded one credit-hour the semester the dissertation is turned in. Besides scientific and technical topics, the graduate seminar will also cover topics related to entrepreneurship, intellectual property, and social and ethical issues related to the field of bioengineering.

Qualifying Exam

All doctoral students will be required to take a doctoral qualifying examination in order to evaluate the candidate's competency in bioengineering core areas. The examination consists of three written parts, which will be prepared, supervised and

evaluated by the program's Graduate Studies Committee in coordination with its faculty.

A student who has passed the examination will be allowed to register in BING 8999 – Doctoral Dissertation. This student is henceforth regarded as a doctoral degree candidate in the Bioengineering Program at UPRM.

A student who has failed the qualifying examination the first time may retake it a second and final time within one semester of the first attempt. According to UPRM regulations, a second failure will result in the student's dismissal from the graduate program. If the student does not hold a Master's degree in Bioengineering, the student will be given the opportunity to transfer to the Bioengineering's Master of Science or Master of Engineering programs. If none of these options is selected, the student will be suspended from the Bioengineering graduate program. After one year of suspension, the student may apply for a second and final admission to the same program or to another UPRM graduate program.

Dissertation Proposal

After successfully passing the qualifying examination, the doctoral student is required to submit a research proposal regarding his/her project of interest. Following the acceptance of the research proposal, the student is given a comprehensive examination to determine initiative, originality, breadth, and high level of professional commitment to the problem selected for investigation. This dissertation proposal exam consists of a written part (the proposal) and an oral defense of the proposal.

Dissertation

All Ph.D. candidates must undertake an independent research project that becomes a significant contribution to the advancement of knowledge in a particular area of bioengineering. All doctoral candidates must pass the oral exam in defense of his/her dissertation. Students must have passed the qualifying examination in order to register for the doctoral dissertation course, and have passed the preliminary exam before defending his/her thesis.

Publication in Peer-Reviewed Journals

All students should have at least one (1) scientific article related to the dissertation submitted in a peer-reviewed journal before the thesis defense.

BIOENGINEERING GRADUATE PROGRAM (BING)

Graduate Courses

BING 6002. MOLECULAR AND CELLULAR BIOLOGY FOR ENGINEERS. Three credit hours. Three hours of lecture per week.

Study of the biology of cells, emphasizing examples relevant to bioengineering. Topics such as protein structure and function, cellular membranes and organelles, cell growth and oncogenic transformation, cellular transport, receptors and cell signaling, the cytoskeleton, the extracellular matrix, and cell movement will be included.

BING 6004. PRINCIPLES OF COMPUTATIONAL BIOENGINEERING. Three credit hours. Three hours of lecture per week.

Study of computational issues and methods employed in molecular biology. Biological data sources available on the internet will be introduced and analyzed.

BING 6016. ERGONOMICS FOR ENGINEERS AND BIOMEDICAL SCIENTIST. Three credit hours. Three hours of lecture per week.

Study of anatomical and physiological concepts that describe and predict human motor capabilities, with particular emphasis on the evaluation and design of manual activities in diverse occupations. Use of quantitative and simulation models to explain muscle strength performance, cumulative and acute musculoskeletal injuries, physical fatigue, and human motion control.

BING 6017. ADVANCED BIOSTATISTICS APPLICATIONS. Three credit hours. Three hours of lecture per week.

Application of statistical methods to solve biomedical and bioengineering problems. Use of generalize linear models, including logistic, Poisson, and binomial regressions. Design of experiments under biological process constraints and appropriate data analysis. Use of artificial neural network techniques to model nonlinear relationships among qualitative and quantitative variables of a biomedical system.

BING 6998. ENGINEERING PROJECT. Zero to six credits.

Comprehensive study of a specific bioengineering problem selected to integrate the knowledge acquired in the graduate program of study.

BING 6999. MASTER THESIS. Zero to six credit hours.

Research in the field of Bioengineering and presentation of a thesis.

BING 8202. STRUCTURAL BIOINFORMATICS. Three credit hours. Three hours of lecture per week.

Analysis and prediction of the conformation of biological macromolecules. Study of the relation between macromolecular structure and function, with emphasis on proteins.

BING 8995. ADVANCED TOPICS IN BIOENGINEERING. One to six credit hours. One to six hours of lecture per week.

Study of advanced topics in bioengineering and related fields.

BING 8997. INDEPENDENT STUDIES. One to three credit hours. Three to nine hours of independent study per week.

Independent studies in bioengineering and related fields.

BING 8998. GRADUATE SEMINAR. Zero to one credit hour. One hour of seminar per week.

Oral presentations and discussions in areas of interests in bioengineering.

***BING 8999.** DOCTORAL DISSERTATION. Zero to eighteen credit hours.

Development, preparation and defense of a dissertation based on an original research work in bioengineering.

*Doctoral Program

FACULTY

The UPRM Bioengineering Graduate Program has a very active interdisciplinary group of faculty members. Faculty members come from various academic departments within the Colleges of Engineering and Arts and Sciences.

JORGE L. ALMODOVAR-MONTAÑEZ, *Assistant Professor*, Ph.D., 2001, Colorado State University. Research areas: Biomaterials.

NOEL ARTILES-LEÓN, *Professor*, Ph.D., 1988, Iowa State University. Research areas: Statistics, Experimental Design.

MAURICIO CABRERA-RÍOS, *Professor*, Ph.D., 2002, Ohio State University. Research areas: Bioinformatics, Probability and Statistics.

SILVINA CANCELOS, *Assistant Professor*, Ph.D., 2007, Rensselaer Polytechnic Institute. Research areas: Biomedical Acoustics, Bubble Dynamics.

MIGUEL E. CASTRO, *Professor*, Ph.D., 1991, University of Texas. Research areas: Nanoscaled Sensors.

RUBÉN DÍAZ, *Associate Professor*, Ph.D., 2005, University of California, Berkeley. Research areas: Transport Phenomena in Biological Systems, Micro/Nano Fabrication Technologies.

MARIBELLA DOMENECH-GARCÍA, *Associate Professor*, Ph.D., 2010, University of Wisconsin, Madison. Research areas: Tumor cell Signaling, Microfluidic Systems for 3D Cell Culture.

DAVID R. GONZÁLEZ-BARRETO, *Professor*, Ph.D., 1996, Pennsylvania State University. Research area: Experimental Design.

SAMUEL P. HERNÁNDEZ-RIVERA, *Professor*, Ph.D., 1986, Johns Hopkins University. Research area: Spectroscopy.

EDUARDO J. JUAN-GARCÍA, *Professor*, Ph.D., 2001, Purdue University. Research areas: Biomedical Acoustics, Bioinstrumentation.

MAGDA LATORRE-ESTEVEZ, *Associate Researcher*, Ph.D., 2006, Harvard Medical School. Research area: Nanoparticle-cell interactions.

JUAN LÓPEZ-GARRIGA, *Professor*, Ph.D., 1986, Michigan State University. Research areas: Structure and Function Relationships in Hemeproteins.

VIDYA MANIAN, *Associate Professor*, Ph.D., 2004, University of Puerto Rico – Mayagüez. Research areas: Brain Computer Interfaces, Brain Imaging, Image Processing, Biosensory Data Fusion.

LOURDES A. MEDINA-AVILÉS, *Assistant Professor*, Ph.D., 2012, Pennsylvania State University. Research areas: Medical Device Development and Manufacturing.

JUAN C. MARTÍNEZ-CRUZADO, *Professor*, Ph.D., 1988, Harvard University. Research area: Molecular Biology.

ENRIQUE MELÉNDEZ, *Professor*, Ph.D., 1990, University of Utah. Research areas: Metal-based Drugs and Biosensors.

TARAS OLEKSYK, *Associate Professor*, Ph.D., 2001, The University of Georgia. Research area: Genetics and Computational Biology.

PATRICIA ORTIZ-BERMUDEZ, *Associate Professor*, Ph.D., 2005, University of Wisconsin, Madison. Research areas: Biotechnology, Microbiology.

OSCAR PERALES-PEREZ, *Professor*, Ph.D., 1998, University of Tohoku, Sendai (Japan). Research areas: Nanotechnology, Material Sciences.

NAZARIO RAMÍREZ-BELTRÁN, *Professor*, Ph.D., 1988, Texas A&M University. Research areas: Experimental Design, Prediction of Drug Stability.

PEDRO RESTO, *Associate Professor*, Ph.D., 2012, University of Wisconsin, Madison. Research area: Microfluidic Devices.

KAREN RÍOS-SOTO, *Professor*, Ph.D., 2008, Biometry/Computational Biology Cornell University. Research area: Biological Statistics and Computational Biology.

MANUEL RODRÍGUEZ-MARTÍNEZ, *Professor*, Ph.D., 2001, Computer Science University of Maryland. Research area: Database Management Systems.

JAIME SEGUEL, *Professor*, Ph.D. 1987, City University of New York. Research areas: Parallel and Distributed Computing, Bioinformatics.

DAVID SERRANO, *Professor*, Sc.D., 1987, Massachusetts Institute of Technology. Research area: Rehabilitative Medical Devices.

PAUL A. SUNDARAM, *Professor*, Ph.D., 1988, The Ohio State University. Research area: Biomaterials.

MADELINE TORRES-LUGO, *Professor*, Ph.D., 2001, Purdue University. Research areas: Polymers, Biomaterials, Hydrogel-Based Drug Delivery.

BIENVENIDO VÉLEZ, *Associate Professor*, Ph.D., 1999, Massachusetts Institute of Technology. Research areas: Distributed Systems, Information Discovery and Retrieval.

FOOD SCIENCE AND TECHNOLOGY PROGRAM

The Mayagüez Campus of the University of Puerto Rico offers a program of study leading to the Master of Science degree in Food Science and Technology. Subject areas cover a wide range of basic and applied approaches in a multidisciplinary setting; including chemistry, engineering, microbiology, and food processing. The program is designed to prepare individuals for technical careers in the food and allied industries, government agencies, academia, and international agencies.

A student planning to enter the program should have a B.S. degree in a recognized branch of agriculture, biology, chemistry, engineering, microbiology, physics, or nutrition. Applicants should have the following courses or their equivalent: Microbiology (BIOL 3770), Food Microbiology (BIOL 4366), Calculus for Biological Sciences II (MATE 3022) or Engineering Calculus I (MATE 3031), Biochemistry (QUIM 5071), and Introductory Physics with Laboratory (FISI 3091 and FISI 3093). Candidates deficient in the areas of food science will be expected to remove these deficiencies during the first year. The application process also requires scores from the GRE General section.

Vision

To be the best alternative for the formation of food scientists through an innovative curriculum, creative research development, and leadership in outreach and technology transfer activities.

Mission

The Program of Food Science provides the needed tools to solve problems pertinent to the processing and manufacturing of foods from agricultural commodities, ensuring that citizens can make healthful choices from an abundant supply of affordable, safe, nutritious, and appealing foods.

Our Food Science Program accomplishes this by preparing students for future leadership roles in the food and agriculture portion of the economy, conducting creative food-related research, and delivering outreach programs that contribute to the competitiveness and profitability of the food manufacturing industry and consumer well-being.

Programs Goals

- Develop professional resources capable of integrating, applying, and incorporating food science principles to the growth and improvement of the food industry.
- Develop the professional resources Puerto Rico needs to assure an abundant, diverse, safe, and nutritious food supply for our society.
- Promote the research and development of value-added products to foster local agricultural industry growth and opening of new markets for such goods.
Promote entrepreneurship.

PROGRAM OF STUDY

POSSIBLE CURRICULUM

FIRST YEAR

First Semester

Number	Credits	Course
QUIM 5085	4	Food Chemistry
CITA 6601	3	Food Processing I
CITA 6603	1	Food Processing Lab
	<u>3</u>	Professional Elective
	11	

Second Semester

Number	Credits	Course
BIOL 6705	3	Advanced Food Microbiology
CITA 6615	3	Food Technology
CITA 6999	<u>2</u>	Thesis
	8	

SECOND YEAR

First Semester

Number	Credits	Course
CITA 6655	1	Seminar
CITA 6999	2	Thesis
	<u>3</u>	Professional Elective
	6	

Second Semester

Number	Credits	Course
CITA 6999	2	Thesis
	<u>3</u>	Professional Elective
	5	

RECOMMENDED PROFESSIONAL ELECTIVES

Number	Credits	Course
AGRO 5005	3	Agricultural Biometrics
AGRO 6000	3	Advanced Biometrics
CITA 5005	3	Food Quality Control
CITA 5006	3	Food Quality & Safety in Processing
CITA 6005	3	Food Packaging
CITA 6006	3	Food Safety
CITA 6007	3	Fruit and Vegetable Safety
CITA 6016	3	Sensory Properties of Food
CITA 6017	3	Food Toxicology
CITA 6605	3	Food Quality Management
CITA 6990	3	Prof. Occupational Experience
CMOB 6016	2	Advanced Seafood Technology
CMOB 5006	4	Seafood Processing
CMOB 6026	3	Adv. Technology of Fish Products
HORT 6650	3	Post Harvest of Horticultural Crops
INPE 5346	3	Dairy Products
INPE 5357	3	Science & Tech. of Fresh Meats
INPE 6609	3	Milk Microbiology
INQU 8025	3	Food Fermentation and Biotech.
QUIM 6335	4	Food Analysis
QUIM 6919	3	Enzymes

FOOD SCIENCE AND TECHNOLOGY (CITA)

Advanced Undergraduate Courses

CITA 5005. QUALITY CONTROL IN THE FOOD INDUSTRY. Three credit hours. Three hours of lecture per week. Prerequisite: MATE 3172 or authorization of the Director of the Department.

Study of quality control tools and the processes of continuous improvement applied to the food industry.

CITA 5006. QUALITY AND SAFETY MANAGEMENT IN FOOD PROCESSING. Three credit hours. Two hours of lecture and three hours of laboratory per week.

Safety and quality principles of the management of a food processing plant in Puerto Rico.

CITA 5995. SPECIAL PROBLEMS IN FOOD SCIENCE AND TECHNOLOGY. One to three credit hours. One hour of lecture per week per credit.

Study and research of a specific problem in the area of Food Science and Technology selected by the student and the professor.

CITA 5996. SPECIAL PROBLEMS IN FOOD SCIENCE AND TECHNOLOGY II. One to three credit hours. One hour of lecture per week per credit.

Study and research of a specific problem in the area of Food Science and Technology selected by the student and the professor.

CITA 5997. SELECTED TOPICS I (On demand). One to three credit hours. One to three hours of lecture per week.

Selected topics in food science and technology and related areas.

CITA 5998. SELECTED TOPICS II (On demand). One to three credit hours. One to three hours of lecture per week.

Selected topics in food science and technology and related areas.

Graduate Courses

SAGA 5005. EQUIPMENT FOR APPLICATION OF CHEMICAL AND BIOLOGICAL PRODUCTS. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: (TMAG 4015 or SAGA 4015) or authorization of the Director of the Department.

Study of techniques and equipment used for the application of chemical and biological products in agriculture.

SAGA 5006. MANAGEMENT OF AGRICULTURAL MACHINERY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: (TMAG 4015 or SAGA 4015) or authorization of the Director of the Department.

Study of the principles and practices for managing agricultural machinery. Analysis of the relationship

among machinery, implements, agricultural production and economic aspects.

SAGA 5007. ADVANCED SOIL AND WATER MANAGEMENT. Three credit hours. Three hours of lecture per week. Prerequisite: (TMAG 4035 or SAGA 4035) or authorization of the Director of the Department.

Soil water and plant relationships. Principles and practice of irrigation and drainage of farm lands. Land improvement by mechanical procedures or structures for soil and water management and conservation.

SAGA 5008. GEOGRAPHIC INFORMATION SYSTEM IN NATURAL RESOURCES MANAGEMENT. Three credit hours. Two hours of lecture and two hours of laboratory per week. Prerequisites: MATE 3172 or authorization of the Director of the Department.

Study of fundamentals of a geographic information system (GIS) and its applications in agriculture and natural resources management. Development of interfaces with hydrology-hydraulic models, watershed management, soil erosion and sediment transport models, crop simulation models, and precision agriculture models.

SAGA 5015. MICROIRRIGATION SYSTEMS. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: (AGRO 3005 or (AGRO 3011 and AGRO 3013)) or authorization of the Director of the Department.

Study of the microirrigation systems and its components, soil-water-plant relationships, crop water requirements and field evaluation.

SAGA 5016. ANAEROBIC DIGESTION OF AGRICULTURAL WASTE. Three credit hours. Two hours of lecture per week and one period of laboratory of three hours per week. Prerequisites: (QUIM 3131 and QUIM 3133) or authorization of the Director of the Department.

Study of the use of anaerobic digesters for agricultural waste management. Production of methane gas and its conversion to electrical and mechanical energy.

SAGA 5017. AGROCLIMATOLOGY. Three credit hours. Three hours of lecture per week. Prerequisite: authorization of the Director of the Department.

Study and application of the climatology and meteorology related to agriculture with emphasis on the Caribbean Region.

SAGA 5025/CITA 6005. FOOD PACKAGING. Three credit hours. Three hours of lecture per week.

Study of food packaging and its multiple roles in protecting packaged food and beverage products and facilitating distribution and communication with retailers, consumers and users. Study of the relationship between food packaging and health, safety and economic well being. Use of technology and its integration with products, distribution, and marketing.

SAGA 5026/CITA 6006. FOOD SAFETY. Three credit hours. Three hours of lecture per week.

Practices and methods to guarantee food safety and product integrity. Topics such as laws and regulations, good manufacturing practices (GMP's), hazard analysis and critical control points (HACCP), and food labeling will be discussed.

SAGA 5030. PRECISION AGRICULTURE TECHNOLOGIES. Three credit hours. Two hours of lecture and three hours of laboratory per week. Prerequisites: TMAG 4015 or SAGA 4015 or authorization of the Director of the Department.

Analysis of the foundations of precision technologies in modern agriculture including Global Positioning System (GPS) receivers, Geographical Information Systems (GIS) software, automatic tractor guidance systems, variable rate technologies, and sensing technologies.

HORT 6007/CITA 6007. SAFETY OF FRUIT AND VEGETABLE PRODUCTS (On demand, I). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Advanced study of intrinsic and extrinsic factors that determine the growth of microorganisms, during post-harvest, processing, storage, and transportation of fruits and vegetables that may affect public health.

CITA 6016. SENSORY PROPERTIES OF FOOD (On demand). Three credit hours. Two hours of conference and one three-hour laboratory per week.

Study of the descriptive and qualitative aspects of sensory analysis of food. Discussion and application of methodology for data collection and analysis. Group projects are required.

CITA 6017. FOOD TOXICOLOGY (II). Three credit hours. Three hours of lecture per week.

Study of the formation, characteristics, and control of potentially toxic components that occur naturally or are induced during food processing.

CITA 6601. FOOD PROCESSING I (I). Three credit hours. Three hours of lecture per week.

Fundamentals and commercial practice of food preservation by heat treatment, drying, freezing, canning, irradiation, and microwaves. Topics included are selection of raw material, preparation, unit operations, packaging, and storage. Processes covered will include aseptic packaging of juice and milk as well as canning of fruits and vegetables.

CITA 6603. FOOD PROCESSING LABORATORY I (I). One credit hour. One four-hour laboratory per week. Co requisites: HORT 6601 or CITA 6601.

The topics in the laboratory will include tray drying, freeze drying, freezing, canning, heat penetration process studies in canned products, and fermentation.

CITA 6605. QUALITY MANAGEMENT IN THE FOOD INDUSTRY. Three credit hours. Three hours of lecture per week.

Study of quality management systems applicable to the food industry: components and implementation, compliance with the specifications and requirements of customers and regulatory agencies.

CITA 6615. FOOD TECHNOLOGY (II). Three credit hours. Two hours of lecture and one three-hour laboratory per week.

Units of operations: filling and packaging, reverse osmosis, ultrafiltration, electrodialysis, evaporation, freeze concentration. Quality control of raw materials and finished products; laws and regulations that apply to food industry.

CITA 6655. SEMINAR (II). One credit hour. One hour of seminar per week.

Lectures, discussions, and reports on selected topics that may include results of research work.

CITA 6990. SUPERVISED PROFESSIONAL OCCUPATIONAL EXPERIENCE FOR COOP STUDENTS (On demand). From three to six credit hours. Only three credits will be considered within the minimum of the required 30 credits for the graduate program. Prerequisite: Authorization of the Director of the Department.

Practical experience in Food Science and Technology in cooperation with the private sector or government. To be jointly supervised by the academic department, the Coop program coordinator, and an official from the cooperating entity. A written report will be required upon completion of each work period.

CITA 6995. SPECIAL PROBLEMS IN FOOD SCIENCE AND TECHNOLOGY (On demand). One to three credit hours. One to three research periods per week.

Study and research of a specific problem in the field of food science and technology, selected by the professor and the student.

CITA 6996. SPECIAL PROBLEMS IN FOOD SCIENCE AND TECHNOLOGY (On demand). One to three credit hours. Three to nine hours of laboratory per week. Prerequisite: authorization of the Director of the Department.

Study and research of a specific problem in the field of food science and technology, selected by the professor and the student.

CITA 6997. SELECTED TOPICS. One to six credit hours. One to six hours of lecture.

Selected topics in Food Science and Technology. Themes will vary according to the needs and interests of students and faculty.

CITA 6998. SELECTED TOPICS (On demand). One to three credit hours. Prerequisite: authorization of the Director of the Department.

Selected topics in Food Science and Technology. Themes will vary according to the needs and interests of students and faculty.

CITA 6999. THESIS (On demand). Three to six credit hours.

Preparation and presentation of a thesis.

FOOD SCIENCE AND TECHNOLOGY FACULTY

A list of professors who engage in graduate activities in the Program follows:

ROSA N. CHAVES-JÁUREGUI, *Assistant Professor*, Ph.D., 1999, University of São Paulo, Brazil. Research and Teaching interests: Food Science, Food Sensory, Nutrition.

MARCOS A. DE JESUS, *Associate Professor*, Ph.D., 2004. UT, Knoxville. Research interest and Teaching interest: Analytical chemical separations, Chemical Sensing and Raman Spectroscopy.

JOSE A. DUMAS, *Professor*, Ph.D., 1999, University of Puerto Rico. Research and Teaching interest: Food Chemistry, Analytical Chemistry.

JAVIER HUERTAS MIRANDA, *Associate Professor*, Ph.D., 2012. University of Puerto Rico at Mayagüez. Research and Teaching interest: Fermentation, Computer Process Control.

JOSÉ R. LATORRE, *Professor*, Ph.D., 1986, University of Arkansas. Research and Teaching interests: Poultry Physiology and Reproduction.

MARTHA LAURA LÓPEZ, *Assistant Professor*, Ph.D., 2007, University of Texas at El Paso. Research and Teaching interests: Environmental chemistry, Toxicity of nanomaterials in plants. Mechanisms of metal translocation in plants. Phytohormones in plants.

JOSÉ PABLO MORALES-PAYÁN, *Professor*, Ph.D., 1999, University of Florida, Gainesville. Research and Teaching interests: Organic horticulture, fruit crops, post harvest handling.

LYNETTE ORELLANA, *Professor*, Ph.D., 2004, Washington State University. Research and Teaching interest: Food Microbiology, Food Processing Food Safety, and Product Development.

PATRICIA ORTIZ, *Associate Professor*, Ph.D., 2005. University of Wisconsin - Madison. Research and Teaching interest: Development of Antimicrobial Materials, Bioengineering, Food Fermentation and Biotechnology, Biorefineries and Bioproducts.

OSCAR J. PERALES, *Professor*, Ph.D., 1998, Tohoku University. Research and Teaching interest: Synthesis and Ferroelectric Characterization.

FERNANDO PÉREZ-MUÑOZ, *Associate Professor*, Ph.D., 1996, Iowa State University. Research and Teaching interest: Food Processing, Process Improvement Engineering. Post-harvest Handling, Physical Properties of Food, Food Sensory and Product Development.

MARÍA L. PLAZA, *Assistant Professor*, Ph.D., 2010, University of Florida, Gainesville. Research and Teaching interest: Food Chemistry, Food Processing and Product Development.

LEYDA PONCE DE LEÓN, *Professor*, Ph.D., 1999, University of Wisconsin. Research and Teaching interest: Manufacture of dairy products, dairy microbiology.

PEDRO RESTO-BATALLA, *Professor*, Ph.D., 1982, Texas A&M University. Research and Teaching interests: Manufacturing, Automation, and Simulation.

AIXA RIVERA, *Professor*, M.S., 1987, University of Puerto Rico Mayagüez. Research and Teaching interests: Beef cattle production, Meat Science and Technology.

FÉLIX R. ROMÁN VELAZQUEZ, *Professor*, Ph.D., 1989, University of Nebraska-Lincoln. Research and Teaching interest: Pesticides in biological and environmental matrices; Determination of heavy metals, antioxidants and other compounds in food samples.

ANGEL O. CUSTODIO-GONZALEZ, *Associate Professor*, Ph.D., 2005, Harvard University. Research and Teaching interests: Molecular Genetics, Food Safety, Product Development and Culinary.

MATÍAS J. CAFARO, *Professor*, Ph.D., 2003, University of Kansas, Lawrence. Research and Teaching interests: Mycology, Molecular Systematics, Food Microbiology and Food Safety.

RAFAEL MONTALVO, *Professor*, Ph.D., 2003, University of Nebraska. Research and Teaching interests: Physiology and Genetics of Archaea, Mycology and Food Safety.

JOSÉ C. VERLE-RODRIGUES, *Associate Professor*, Ph.D., 2001, Universidade de São Paulo, Brazil. Research and Teaching interests: Plant Virology and Food Safety.