Proposal for the Establishment of a Graduate Program in

Bioengineering

at the
College of Engineering
of the
University of Puerto Rico at Mayagüez

June 20, 2008

College of Engineering
University of Puerto Rico at Mayagüez
Mayagüez, Puerto Rico

TABLE OF CONTENTS

Proposal for the Establishment of a Graduate Program in Bioengineering at the College of Engineering of the University of Puerto Rico at Mayagüez

1. INTRODUCTION

1.1 Title of the Program and Degree Conferred

The proposed title for the program is Graduate Program in Bioengineering (BioE) and the final degrees granted will be **Doctor of Philosophy in Bioengineering, Master of Science in Bioengineering or Master of Engineering in Bioengineering**.

1.2 Brief Description of the Proposed Program

The proposed program will train students to become researchers in bioengineering by integrating the skills and competences of engineering, 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 develop in graduate students a high level of consciousness of ethical and social responsibility; emphasizing the importance of safety, health and environmental protection aspects of technical problems.

The program will neither include specialty nor concentration areas. Instead, it will utilize internal areas of emphasis in order to guide students in their curriculum and research. This is done in order to maintain a flexible structure which will allow the program to adapt itself to technological evolutions. The proposed bioengineering program will initially target at **computational bioengineering**, **biomedical engineering** and **bioprocesses** research, and will consist of a total of **fifty two (52) credit-hours** for students entering the program with a **B.S. degree**, and **thirty-seven (37) credit-hours** for students entering the program with an **M.S. degree**. Of the fifty two credit-hours, twelve 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, 37 credit-hours will be required in the following manner: twelve 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 preliminary exam and prepare a dissertation proposal as part of the process of evaluating their ability to engage in doctoral level research. Finally, students will be required to pass 18 dissertation credits. The dissertation will measure the scope of acquired knowledge and it will evidence the student's degree of creativity and scientific rigor. It will require an original contribution to the existing scientific and/or technical body of knowledge in the field of bioengineering.

A **Master of Science and Master of Engineering** degree will be available only for students admitted to the doctoral program and which, for some reason, decide not to continue with their doctoral studies. The master's programs will correspond to Plans I, II and III, as described in Certification 97-21 of the University of Puerto Rico-Mayagüez's Academic Senate.
The Master's of Science (Plan I - Thesis) program will consist of a total of 31 credit-hours, from which twelve will be in bioengineering core courses, three credit-hours in bioengineering courses, six credit-hours in courses outside of bioengineering, three credit hours in elective courses, 6 credit hours in master's thesis, and one credit-hour in graduate seminar. The Master's of Engineering (Plan II - Project) program will consist of a total of 31 credit-hours, from which twelve will be in bioengineering core courses, three credit-hours in bioengineering courses, six credit-hours in courses outside of bioengineering, three credit hours in elective courses, 6 credit hours in engineering project, and one credit-hour in graduate seminar. The Master's of Engineering (Plan III) program will consist of a total of 37 credit-hours, from which twelve will be in bioengineering core courses, twelve 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 degree conferred will be Master of Science in Bioengineering to students that complete the Plan I program (thesis) and Master of Engineering in Bioengineering to students that complete Plan II (project) or Plan III (courses-only). It will be the program's initial policy **not** to admit students directly into the master's program, so that most efforts are focused on doctoral students and their research. Transfers from the doctoral program into the master's program will be considered by the program's graduate committee, with previous recommendation from the student's thesis committee and from the program's executive director.

The Integrated Postsecondary Education Data System (IPEDS) code most closely related to the proposed program is: *IPEDS Code 14.0501 – Biomedical/Medical Engineering.*

1.3 Non-conventional Educational Modalities

It is expected that the program will eventually include non-conventional education modalities, particularly the sharing of courses with other UPR campuses and other universities However, it is not contemplated that the offering of these modalities will make up more than fifty percent of the proposed program's educational activities

1.4 Expected Starting Date

The program will begin as soon as it is approved by the corresponding authorities. The tentative starting date of the proposed program is the first semester of the 2010-2011 academic year.

1.5 Program Duration and Maximum Allowed Time to Complete the Program

Students entering the program holding a **master's degree** are expected to complete the doctoral degree in **three years**. Students entering the doctoral program with a **baccalaureate degree** are expected to finish the program in **four years**. The maximum time allowed for a student to complete the doctoral degree, as specified in Certification 97-21 of the University of Puerto Rico-Mayagüez's Academic Senate, is:

- **Ten** years, if the student begins with a **Bachelor's degree** when starting the program.

- **Eight** years, if the student begins with **Master's degree** at the initiation of the program.

Students that opt to transfer into **master's program** have a maximum of **six** years (from the moment they first registered for graduate studies) to obtain their degrees.

2. PROFESSIONAL ACCREDITATIONS AND REQUIREMENTS FOR PROFESSIONAL PRACTICE

2.1. Professional Accreditations

The proposed program does not require professional accreditation.

2.2. Requirements for Professional Practice

According to actual Puerto Rico laws, a person practicing the engineering profession is required to: have a Bachelor's degree in engineering from an accredited university, pass a board exam, register with the Department of State, and be a member of the CIAPR ("Colegio de Ingenieros y Agrimensores de Puerto Rico").

3. PROGRAM JUSTIFICATION

Bioengineering is a field that is rooted in physics, mathematics, chemistry, biology, and life sciences. It is the application of a systematic, quantitative, and integrative way of thinking about and approaching the solutions of problems important to biology, medical research, clinical practice, and population studies. The National Institutes of Health (NIH) Bioengineering Consortium agreed on the following definition for bioengineering research on biology, medicine, behavior, or health recognizing that no definition could completely eliminate overlap with other research disciplines or preclude variations in interpretation by different individuals and organizations[1]:
"*Bioengineering integrates physical, chemical, or mathematical sciences and engineering principles for the study of biology, medicine, behavior, or health. It advances fundamental concepts, creates knowledge for the molecular to the organ systems levels, and develops innovative biologics, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health*."

BioE is frequently confused with similar terms such as biomedical engineering and biotechnology. It is thus important to first define the similarities and difference between these terms. For instance, biomedical engineering is seen as a subdivision of BioE that focuses on (i) the acquisition of new knowledge and understanding of living systems through the innovative and substantive application of experimental and analytical techniques based on the engineering sciences, and (ii) the development of new devices, algorithms, processes and systems that advance biology and medicine and improve medical practice and health care delivery. BioE would also include agricultural, veterinary, and other applications beyond the biomedical sciences.

[1] Bioengineering Consortium, National Institutes of Health, http://www.becon.nih.gov/bioengineering_definition.htm.

Biotechnology can be broadly defined as the use of living organisms or their products for commercial purposes. As such, biotechnology has been practiced by human society since the beginning of recorded history in such activities as baking bread, brewing alcoholic beverages, or breeding food crops or domestic animals. A narrower and more specific definition of this field is that it involves the use and development of a set of biological techniques built through basic research and applied to product development. In particular, biotechnology refers to the industrial use of recombinant DNA, cell fusion, and new bioprocessing techniques. Summarizing, biotechnology focuses more on the biological, rather than the engineering, aspects of the biological technologies.

Puerto Rico is one of the top manufacturing sites for many international biotechnology and medical device companies, such as Amgen and Ely Lilly, and Medtronic, Becton Dickinson, Guidant and Johnson & Johnson, respectively. Because of the strong presence of such companies on the Island, the Government of Puerto Rico has been advertising Puerto Rico worldwide as the "Bio-Island". However, the "Bio-Island" concept encompasses more than manufacturing. An important goal of the "Bio-Island" concept is to bring a paradigm shift in the Island's economy from one depending mostly on manufacturing to one that is also based on technological and knowledge-based innovation. Graduate programs at universities play a key role in this transformation, as they provide the scientific and technological discoveries on which most high-tech startup companies are based, and also provide the professionals needed to support the research and development endeavors of both start-ups and well-established companies.

The proposed doctoral program in bioengineering will support mostly the medical device industry sector, although significant impact in the areas of biotechnology and pharmaceutical can also be expected. Although BioE programs are proliferating in the US, the proposed program will be the first of its kind in Puerto Rico, as there are no equivalents or similar programs on the Island. Also, and because of its multidisciplinary structure, the proposed program will provide a unique graduate profile not possible to achieve through existing graduate programs at UPRM.

It is expected that the proposed program will bring synergistic opportunities in the establishment of long-term research and educational relationships between the UPRM, other University of Puerto Rico (UPR) campuses, top U.S. and international universities and federal and private research funding agencies. Envisioned as unique opportunities, these collaborations will improve the education and research capabilities of Puerto Rico in bioengineering.

Employment Opportunities for Program Graduates

The program intends to develop engineering professionals capable of contributing to the development of industrial research and development, academic research and discoveries, and college education. This broad spectrum of possibilities provides all program graduates with concrete and diverse employment options in Puerto Rico, the United States and Latin America.
According to existing statistics provided by a study published by Schreiner [2], 35% of doctoral level graduates from bioengineering went on to further education and 61% went directly to a job. Only 4% of the polled graduates were still seeking employment. As demonstrated by these statistics, the

[2] Schreiner S., *Placement of Bioengineering and Biomedical Engineering Graduates*, Proceedings of the 2005 American Society for Engineering Education Annual Conference and Exposition, 2005.

job market for PhD's in bioengineering is a healthy one, which means that graduates of the proposed program should have no major difficulties obtaining a job, at least in the continental United States.

Proposal Development Process

The proposal development process started in the Fall of 2005, when the Dean of Engineering, Dr. Ramón Vásquez, named an Ad-Hoc Committee for Bioengineering, with the purpose of discussing the course of action the College of Engineering should take regarding the field of bioengineering. The committee consisted of seven members, each one representing each of the academic programs within the college of engineering. The committee members were Dr. Eduardo J. Juan (ECE), Dr. Julio Briano (ChE), Dr. Jaime Ramírez-Vick (MSE), Dr. Nazario Ramírez (IE), Dr. San Hwang (CE), Dr. Jaime Seguel (ECE), and Dr. Ricky Valentín (ME).
After a series of meetings, the committee arrived to the following unanimous recommendations:

a. Bioengineering is an important field that will contribute to the economic development of Puerto Rico. Having a PhD program in bioengineering at UPRM would lead to new discoveries and technologies that could potentially result in new businesses, or the improvement of current industry. Such program will strengthen the ability of UPRM to attract and retain top scientists and engineers in the field, resulting in a significant improvement of current educational programs.
b. The committee agrees that creating a multidisciplinary PhD program in BioE would allow students to choose a distinct profile specifically designed for this discipline.
c. The committee recommends that a multidisciplinary BioE PhD program be established at UPRM.

After considering the committee's recommendations, the Dean of Engineering requested the committee to prepare the proposal for establishing the program.

4. PROGRAM RELATIONSHIP TO INSTUTIONAL STRATEGIC PLAN AND TO OTHER PROGRAMS

4.1. Program Relationship to the University Strategic Plan – Ten for the Decade

The strategic plan for the University of Puerto Rico is presented in the document "Ten for the Decade"[3]. The proposed bioengineering program is properly aligned with this strategic plan, in particular to items II, III, VI, VII and X.

4.2. Program Relationship with Current Programs

4.2.1. Within the Mayagüez Campus

The proposed doctoral program intends to be related to current graduate programs within the college of engineering. All engineering graduate programs are involved (at various levels) in activities and initiatives related to bioengineering research and education. For example, approximately twelve of the courses that will form part of the BioE program are already been offered by various engineering graduate programs. Several externally-funded bioengineering research projects are also been

[3] http://www.upr.edu/diezdecada.pdf

performed at the College of Engineering. The proposed program will have an academic structure that unifies all these efforts in a concerted fashion to provide students with an educational experience that will result in a unique graduate profile that would not have been achieved individually by existing engineering graduate programs.

Qualified graduates of current master's degree programs (Chemical Engineering, Electrical Engineering, Mechanical Engineering, etc.) may be admitted into the BioE doctoral program and may transfer some (see credit transfer requirements in section 7.3.3.) earned credits (except those obtained for thesis or project work) towards the doctoral program. The proposed program is related to existing baccalaureate degree programs within the college of engineering at UPRM. Some advanced undergraduate courses from these programs can form part of the proposed program. Any qualified student who has graduated from any of these programs may be admitted directly into the doctoral program. Depending on an applicant's academic background (see admission requirements in section 7.1), graduates from the sciences or agricultural sciences programs at UPRM will also be considered for admission into the BioE doctoral program.

4.2.2. In other UPR Campuses

The proposed program will be the only doctoral program of its type offered within the UPR System. Graduates from science programs at other UPR institutions will be considered for admission into the BioE doctoral program.

4.2.3. In Other Institutions of Higher Learning in Puerto Rico

The proposed program will be the only doctoral program of its type offered in Puerto Rico. Nevertheless, there are master's and BS degree programs (science and engineering) at other institutions of higher learning that are related to this one. The proposed program will provide qualified graduates from those programs the opportunity to pursue a doctoral degree in Bioengineering.

5. PROGRAM'S CONCEPTUAL FRAMEWORK

5.1. Mission

The mission of the proposed doctoral program is:

- **Mission:** Advance fundamental knowledge of engineering and computing principles as applied to biological systems and processes, enhance advances in health care through innovative research, and educate and train a highly competent and resourceful bioengineering workforce.

5.2. Program Goals

The proposed program will have the following general goals:

(a) Serve as the top Bioengineering education and research center in Puerto Rico.
(b) Increase international exposure for the engineering departments involved in the program and thus, the University of Puerto Rico, through sound research projects.

(c) Establish collaborative programs with other educational institutions and local industry to provide solutions to technical problems within the scope of bioengineering and biotechnology.
(d) Strengthen the Baccalaureate and Masters' programs through a commitment to academic excellence and scientific research.
(e) Establish an entrepreneurial culture within the program to focus on product-oriented research for future commercialization.

5.3. Program Objectives

The program's objectives are as follows:

(a) Educate and train graduate students in the application of the scientific method as a fundamental tool in research.
(b) Develop in graduate students critical thinking and capability to make original contributions to technical literature.
(c) Develop in graduate students a high level of consciousness of ethical and social responsibility; emphasizing the importance of safety, health and environmental protection aspects of technical problems.
(d) Develop in graduate students a high level of entrepreneurial consciousness.

5.4.Educational Philosophy

The educational philosophy of the proposed program focuses in training students to become researchers in bioengineering by integrating the skills and competences of engineering, natural sciences and medicine, while establishing an entrepreneurial culture that focuses on product-oriented research for future commercialization. Another key component of the program is to develop in graduate students a high level of consciousness of ethical and social responsibility; emphasizing the importance of safety, health and environmental protection aspects of technical problems.

5.5.Graduate Profile

Students graduating from the **doctoral** program will possess the following qualifications:

a) In-depth knowledge in a specific area of bioengineering.
b) Breadth of knowledge in the core areas of bioengineering and supporting disciplines.
c) Ability to independently conduct research.
d) Ability to formulate a complex bioengineering problem and outline viable solution by integrating and applying basic principles of biology and engineering/physical sciences.
e) Ability to work in a multidisciplinary environment.
f) Ability to effectively communicate technical and scientific findings.
g) Awareness of ethical and social issues.
h) Entrepreneurial consciousness.

Students graduating from the **masters** program will possess the following qualifications:

a) In-depth knowledge in a specific area of bioengineering.
b) Breadth of knowledge in the core areas of bioengineering and supporting disciplines.

c) Ability to formulate a complex bioengineering problem and outline viable solution by integrating and applying basic principles of biology and engineering/physical sciences.
d) Ability to work in a multidisciplinary environment.
e) Ability to effectively communicate technical and scientific findings.
f) Awareness of ethical and social issues.
g) Entrepreneurial consciousness.

5.6.Coherence and Sufficiency of Conceptual Framework

5.6.1. Doctoral Program

The proposed doctoral program will be comprised of three main components: **coursework**, **research** and the **seminar series**. The content and the interaction of each of these components seek to fulfill the program's mission, goals and objectives, and ensure that students graduating from the program posses the qualifications described in the graduate profile. Table 1 shows how the main program components address the program goals, objectives, and graduate profile.

Table 1. Correspondence of program components to goals, objectives and graduate profile.

	Program Components		
	Coursework	**Research**	**Seminar Series**
Program Goals			
(a) Serve as the top Bioengineering education and research center in Puerto Rico.	√	√	√
(b) Increase international exposure for the engineering departments involved in the program and thus, the University of Puerto Rico, through sound research projects.		√	
(c) Establish collaborative programs with other educational institutions and local industry to provide solutions to technical problems within the scope of bioengineering and biotechnology.		√	
(d) Strengthen the Baccalaureate and Masters' programs through a commitment to academic excellence and scientific research.	√	√	
(e) Establish an entrepreneurial culture within the program to focus on product-oriented research for future commercialization.		√	√
Program Objectives			
(a) Educate and train graduate students in the application of the scientific method as a fundamental tool in research.	√	√	√
(b) Develop in graduate students critical thinking and capability to make original contributions to	√	√	

technical literature.			
(c) Develop in graduate students a high level of consciousness of ethical and social responsibility; emphasizing the importance of safety, health and environmental protection aspects of technical problems.	√	√	√
(d) Develop in graduate students a high level of entrepreneurial consciousness.	√		√
Graduate Profile			
(a) In-depth knowledge in a specific area of bioengineering.	√	√	
(b) Breadth of knowledge in the core areas of bioengineering and supporting disciplines.	√		√
(c) Ability to independently conduct research.	√	√	
(d) Ability to formulate a complex bioengineering problem and outline viable solution by integrating and applying basic principles of biology and engineering/physical sciences.	√	√	
(e) Ability to work in a multidisciplinary environment.	√	√	√
(f) Ability to effectively communicate technical and scientific findings.	√	√	√
(g) Awareness of ethical and social issues.	√	√	√
(h) Entrepreneurial consciousness.			√

5.6.2. Masters Program

The proposed masters program will be also be comprised of three main components: **coursework, research** and the **seminar series**. In the case of the masters program, the content and the interaction of each of these components seek to fulfill the program's mission, **most** of its goals and objectives, and ensure that students graduating from the program posses the qualifications described in the graduate profile for the masters option. Table 2 shows how the main program components address the program goals, objectives, and graduate profile.

Table 2. Correspondence of M.E.BioE program components to goals, objectives and graduate profile.

	Program Components		
	Coursework	**Research**	**Seminar Series**
Program Goals			
(a) Serve as the top Bioengineering education and research center in Puerto Rico.	√	√	√
(d) Strengthen the Baccalaureate and Masters' programs through a commitment to academic excellence and scientific research.	√	√	

(e) Establish an entrepreneurial culture within the program to focus on product-oriented research for future commercialization.		√	√
Program Objectives			
(a) Educate and train graduate students in the application of the scientific method as a fundamental tool in research.	√	√	√
(b) Develop in graduate students critical thinking and capability to make original contributions to technical literature.	√	√	
(c) Develop in graduate students a high level of consciousness of ethical and social responsibility; emphasizing the importance of safety, health and environmental protection aspects of technical problems.	√	√	√
(d) Develop in graduate students a high level of entrepreneurial consciousness.	√		√
Graduate Profile			
(a) In-depth knowledge in a specific area of bioengineering.	√	√	
(b) Breadth of knowledge in the core areas of bioengineering and supporting disciplines.	√		√
(d) Ability to formulate a complex bioengineering problem and outline viable solution by integrating and applying basic principles of biology and engineering/physical sciences.	√	√	
(e) Ability to work in a multidisciplinary environment.	√	√	√
(f) Ability to effectively communicate technical and scientific findings.	√	√	√
(g) Awareness of ethical and social issues.	√	√	√
(h) Entrepreneurial consciousness.			√

6. CURRICULUM DESIGN

This section describes the key curricular components of the proposed program. Emphasis is placed on the credit-hour distribution required for students entering with either a BS or MS degree, and on how the program components relate to the desired graduate profile.

6.1.Curricular Scheme

6.1.1. Doctoral Program

Students entering the program with a **B.S. degree** are required to approve a minimum of fifty-two (52) credit-hours distributed in the following manner:

- 12 credit-hours in core courses

    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 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
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship
- 18 credit-hours in doctoral dissertation

Students entering the program with an **M.S. degree** are required to approve a minimum of thirty-seven (37) credit-hours distributed in the following manner:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 3 credit-hours in Bioengineering courses
- 3 credit-hours in courses outside of Bioengineering
- 1 credit-hour in seminar
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship
- 18 credit-hours in doctoral dissertation

No more than 9 credit-hours of advanced undergraduate level courses can be used to complete doctoral degree requirements.

6.1.2. Masters Program

Students entering the **Masters of Science (Plan I - Thesis)** program are required to approve a minimum of thirty-one (31) credit-hours distributed in the following manner:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 3 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
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship
- 6 credit-hours in Master's Thesis

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:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 3 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
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship
- 6 credit-hours in Engineering Project

Students entering the **Masters of Engineering (Plan III – Courses Only)** program are required to approve a minimum of thirty-seven (37) credit-hours distributed in the following manner:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 12 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
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship

No more than 9 credit-hours of advanced undergraduate level courses can be used to complete master's degree requirements.

6.2. Course Descriptions

The following courses will comprise the academic offerings of the doctoral program in Bioengineering:

6.2.1. Existing Courses and/or Courses in Process of Approval

INEL 5208 PRINCIPLES OF BIOMEDICAL INSTRUMENTATION. 4 credit-hours. Three hours of lecture and two hours of laboratory practice per week. Prerequisite: INEL 4201 or consent of the department head. Theoretical and practical aspects of the methods used to measure physiological events with emphasis in the cardiovascular, pulmonary and nervous systems.

INEL 6XXX BIOMEDICAL ACOUSTICS. 3 credit-hours. Three hours of lecture per week. Prerequisite: Graduate standing or consent of the instructor. Application of acoustics principles toward the design of diagnostic and therapeutic medical devices. Use of computer tools to simulate the acoustic response of systems composed of biological tissues.

ICOM 6XXX BIOINFORMATICS ALGORITHMS. 3 credit-hours. Three hours of lecture per week. Prerequisite: Graduate standing. Introduction to fundamental algorithms and algorithmic principles in Bioinformatics. General discussion on the many aspects that link Computer Science to Molecular Biology. In depth discussions on selected relevant problems in Biology, their formulations as Computer Science problems and their best known algorithmic solutions.

INQU 8027 CHEMICAL ENGINEERING PRINCIPLES APPLIED TO DRUG THERAPY. 3 credit-hours. Three hours of lecture and two hours of laboratory practice per week. Prerequisite: This is an elective course intended for graduate students in chemical engineering or related fields. The course focuses on the application of chemical engineering principles applied to drug therapy including knowledge of pharmacokinetic and pharmacodynamic concepts, design of therapeutic regimens, and emphasis on the application of transport phenomena for the design and modeling of drug delivery devices. Upon completion of this course students are expected to understand the basic principles, models and theories of drug delivery, analyze physiological characteristics of biological systems and evaluate their implication in biological transport, design and calculate dosage regimes, create transport models for biological molecules, estimate diffusion coefficients, and design drug delivery systems from experimental data.

INQU 8XXX TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS. 3 credit-hours. Three hours of lecture per week. Prerequisite: INQU6016 or consent of the instructor. This is an elective course intended for graduate students in chemical engineering or related fields. The course discusses the integration of the fundamentals of transport phenomena to biological systems. It focuses on the application of momentum and mass transport from the cellular to the organ level, including artificial organs. Upon the completion of the course the students are expected to understand the fundamental

principles of biological transport processes by formulating the mathematical expressions of these principles and their solution; analyze physiological characteristics of biological systems, and evaluate their implication in biological transport.

INCI 6005 BIOLOGICAL WASTEWATER SYSTEMS. 3 credit-hours. Three hours of lecture. Prerequisite: INCI5015. Principles on microbial metabolism, energy generation, growth kinetics, and biological treatment will be discussed. Treatment technologies include suspended growth, attached growth, oxidation ponds, and sludge digestion for aerobic processes; UASB, expanded-bed, and sludge digestion for anaerobic processes. Nitrification, denitrification, and phosphorus nutrient removal methods will also be included. Stoichiometry and biotreat model applications will be emphasized.

INCI 6015 SANITARY ENGINEERING MICROBIOLOGY. 3 credit-hours. Three hours of lecture. Prerequisite: INCI 4039 or consent of department head. Biochemical reactions induced by microorganisms, emphasizing microbiological processes related to water and wastewater treatment and to environmental pollution control.

INCI 6076 PHYSICO CHEMICAL TREATMENT OF WATER AND WASTEWATERS. 3 credit-hours. Three hours of lecture. Prerequisite: INCI 5015 or equivalent. A detailed analysis of the theory and applications of physical-chemical processes to the treatment of water and wastewaters.

INCI 6060 POLLUTANT TRANSPORT. 3 credit-hours. Three hours of lecture. Prerequisite: INCI 4008, 4138 and 5008. 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.

INME 6105 PRINCIPLES OF BIOMEDICAL ENGINEERING. 3 credit-hours. Three hours of lecture per week. Prerequisite: Authorization of the Director. Application of engineering principles and quantitative methods in biology to analyze and describe complex biological systems. Survey of human anatomy and physiology, modern molecular biology, professional ethics, and regulatory issues.

INME 6115 BIOMATERIALS. 3 credit-hours. Three hours of lecture per week. Prerequisite: Authorization of the Director. Study of advanced materials as applied to biomedical systems. Integration of materials science and engineering concepts with biology for the successful design of interfaces between living cells and organic and inorganic materials.

INME 6135 TISSUE ENGINEERING. 3 credit-hours. Three hours of lecture per week. Prerequisite: Permission of department head. Study of tissue engineering applied to biomedical systems with emphasis on quantitative cell and tissue biology, cell and tissue characterization, engineering methods and design, and clinical applications.

6.2.2. New Courses

The course creation forms and syllabi are presented in Appendix A.

BIOE 6XXX PRINCIPLES OF COMPUTATIONAL BIOENGINEERING. 3 credit-hours. Three hours of lecture per week. Prerequisite: Graduate standing or permission of department head. This course introduces the basic computational issues and methods employed in molecular biology. Biological data sources available on the internet will be utilized and analyzed.

BIOE 6XXX PRINCIPLES OF BIOPROCESS ENGINEERING. 3 credit-hours. Three hours of lecture per week. Prerequisite: Graduate standing or permission of department head. Principles of bioprocess engineering, with emphasis in: biology fundamentals, kinetics of enzymatic reactions, cell cultivation and fermentation, cell kinetics and fermenter design, enzyme and cell immobilization, downstream processing, purification and quality control, scale up.

BIOE 8XXX STRUCTURAL BIOINFORMATICS. 3 credit-hours. Three hours of lecture per week. Prerequisite: BIOE6XXX (Principles of Computational Bioengineering). Analysis and prediction of the conformations of biological macromolecules and the study of the relationships between macromolecular structure and function. The study of protein molecules will be emphasized.

BIOE 6XXX MOLECULAR AND CELLULAR BIOLOGY FOR ENGINEERS. 3 credit-hours. Three hours of lecture per week. Prerequisite: Graduate standing or consent of the instructor. This course is designed for first year graduate students with a background in engineering. This course covers the biology of cells of higher organisms: 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. Emphasis will be placed on examples relevant to bioengineering.

BIOE 6XXX ERGONOMICS FOR BIOMEDICAL SCIENTISTS AND ENGINEERS. 3 credit-hours. Three hours of lecture per week. Prerequisite: Permission of department head. This course introduces anatomical and physiological concepts to understand and predict human motor capabilities, with particular emphasis on the evaluation and design of manual activities in various occupations. Quantitative and simulation models are used to explain (1) muscle strength performance; (2) cumulative and acute musculoskeletal injury; (3) physical fatigue; and (4) human motion control.

BIOE 6XXX ADVANCED BIOSTATISTICS APPLICATIONS. 3 credit-hours. Three hours of lecture per week. Prerequisite: ININ-4020 Applied Industrial Statistics or BIOE-5XXX Fundamentals of Biostatistics. This course focuses on statistical applications to solve relevant biomedical and bioengineering problems. This course will also focus on modeling biomedical observations that includes qualitative and quantitative variables by using the general linear model, which includes Logistic, Poisson, and Binomial

regressions. Experimental design techniques will be used to conduct experiments under biological process constraints and perform the appropriate data analyses. Artificial neural network techniques will be used to model nonlinear relationships among qualitative and quantitative variables of a biomedical system.

BIOE 6998 ENGINEERING PROJECT. 0-6 credit-hours. Variable contact period. Prerequisite: Permission of program's director. Comprehensive study of a specific bioengineering problem selected so as to integrate the knowledge acquired in the graduate program of study.

BIOE 6999 MASTER'S THESIS. 0-6 credit-hours. Variable contact period. Prerequisite: Permission of program's director. Research in the field of Bioengineering and presentation of a thesis.

BIOE 8995 ADVANCED TOPICS IN BIOENGINEERING. 1-6 credit-hours. Variable contact period. Prerequisite: Permission of program's director. Study of advanced topics in bioengineering.

BIOE 8997 INDEPENDENT STUDIES. 1-3 credit-hours. Variable contact period. Prerequisite: Permission of program's director. Independent studies in bioengineering.

BIOE 8998 GRADUATE SEMINAR. 0-1 credit-hours. One hour of seminar per week. Prerequisite: Permission of program's director. Oral presentations and discussions in areas of interests in bioengineering.

BIOE 8999 DOCTORAL DISSERTATION. 0-9 credit-hours. Variable contact period. Prerequisite: Permission of program's director. Development, preparation and defense of a dissertation based on an original research work in bioengineering.

6.3. Course Sequences

This section presents typical course sequences for students admitted into the doctoral program with either a B.S. degree or M.S. degree, as well as the course sequences for students enrolled in the various master's program options. Tables 3-7 show the distribution of credits for all cases.

6.3.1. Typical course sequence for a student admitted with a B.S. degree

Courses	First Semester	Credits
BIO6XXX	Molecular and Cellular Biology for Engineers	3
INME6XXX	Principles of Biomedical Engineering	3
BIOE 6XXX	Principles of Bioprocess Engineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Second Semester	Credits
BIOE6XXX	Principles of Computational Bioengineering	3
----------	Course in Bioengineering	3
----------	Course in Bioengineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Preliminary Exam (Summer)

Courses	Third Semester	Credits
----------	Course Outside of Bioengineering	3
----------	Course Outside of Bioengineering	3
----------	Elective Course	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Fourth Semester	Credits
----------	Elective Course	3
----------	Course Outside of Bioengineering	3
BIOE8998	Graduate Seminar	0
		Total 6

Courses	Fifth Semester	Credits
BIOE8999	Doctoral Dissertation	3
BIOE8998	Graduate Seminar	0
		Total 3

Courses	Sixth Semester	Credits
BIOE8999	Doctoral Dissertation	3
BIOE8998	Graduate Seminar	0
		Total 3

Courses	Seventh Semester	Credits
BIOE8999	Doctoral Dissertation	6
BIOE8998	Graduate Seminar	0
		Total 6

Courses	Eighth Semester	Credits
BIOE8999	Doctoral Dissertation	6
BIOE8998	Graduate Seminar	1
		Total 7

6.3.2. Typical course sequence for a student admitted with an M.E. degree:

Courses	First Semester	Credits
BIO6XXX	Molecular and Cellular Biology for Engineers	3
INME6XXX	Principles of Biomedical Engineering	3
BIOE 6XXX	Principles of Bioprocess Engineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Second Semester	Credits
BIOE6XXX	Principles of Computational Bioengineering	3
----------	Course in Bioengineering	3
----------	Course Outside of Bioengineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Preliminary Exam (Summer)

Courses	Third Semester	Credits
BIOE8999	Doctoral Dissertation	3
BIOE8998	Graduate Seminar	0
		Total 3

Courses	Fourth Semester	Credits
BIOE8999	Doctoral Dissertation	3
BIOE8998	Graduate Seminar	0
		Total 3

Courses	Fifth Semester	Credits
BIOE8999	Doctoral Dissertation	6
BIOE8998	Graduate Seminar	0
		Total 6

Courses	Sixth Semester	Credits
BIOE8999	Doctoral Dissertation	6
BIOE8998	Graduate Seminar	1
		Total 7

6.3.3. Typical course sequence for a student pursuing the Masters of Science (Plan I - Thesis) degree:

Courses	First Semester	Credits
BIO6XXX	Molecular and Cellular Biology for Engineers	3
INME6XXX	Principles of Biomedical Engineering	3

BIOE 6XXX	Principles of Bioprocess Engineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Second Semester	Credits
BIOE6XXX	Principles of Computational Bioengineering	3
----------	Course in Bioengineering	3
----------	Course Outside of Bioengineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Third Semester	Credits
----------	Elective Course	3
----------	Course Outside of Bioengineering	3
BIOE6999	Master's Thesis	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Fourth Semester	Credits
BIOE6999	Master's Thesis	3
BIOE8998	Graduate Seminar	1
		Total 4

6.3.4. Typical course sequence for a student pursuing the Masters of Engineering (Plan II - Project) degree:

Courses	First Semester	Credits
BIO6XXX	Molecular and Cellular Biology for Engineers	3
INME6XXX	Principles of Biomedical Engineering	3
BIOE 6XXX	Principles of Bioprocess Engineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Second Semester	Credits
BIOE6XXX	Principles of Computational Bioengineering	3
----------	Course in Bioengineering	3
----------	Course Outside of Bioengineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Third Semester	Credits
----------	Elective Course	3
----------	Course Outside of Bioengineering	3
BIOE6998	Engineering Project	3

BIOE8998	Graduate Seminar	0
		Total 9

Courses	Fourth Semester	Credits
BIOE6998	Engineering Project	3
BIOE8998	Graduate Seminar	1
		Total 4

6.3.5. Typical course sequence for a student pursuing the Masters of Engineering (Plan III – Courses Only) degree:

Courses	First Semester	Credits
BIO6XXX	Molecular and Cellular Biology for Engineers	3
INME6XXX	Principles of Biomedical Engineering	3
BIOE 6XXX	Principles of Bioprocess Engineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Second Semester	Credits
BIOE6XXX	Principles of Computational Bioengineering	3
----------	Course in Bioengineering	3
----------	Course Outside of Bioengineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Third Semester	Credits
----------	Course in Bioengineering	3
----------	Course in Bioengineering	3
----------	Course Outside of Bioengineering	3
BIOE8998	Graduate Seminar	0
		Total 9

Courses	Fourth Semester	Credits
----------	Course in Bioengineering	3
----------	Elective Course	3
----------	Elective Course	3
BIOE8998	Graduate Seminar	1
		Total 10

Table 3. Summary of Credit Distribution for a student admitted into the doctoral program with a BS degree.

Semester	Credits				
	Core Courses	**Other Courses**	**Seminar**	**Thesis**	**TOTAL**
1	9	-	0	-	**9**
2	3	6	0	-	**9**
3	-	9	0	-	**9**
4	-	6	0	-	**6**
5	-	-	0	3	**3**
6	-	-	0	3	**3**
7	-	-	0	6	**6**
8	-	-	1	6	**7**
TOTAL	**12**	**21**	**1**	**18**	**52**

Table 4. Summary of Credit Distribution for a student admitted into the doctoral program with an MS degree.

Semester	Credits				
	Core Courses	**Other Courses**	**Seminar**	**Thesis**	**TOTAL**
1	9	-	0	-	**9**
2	3	6	0	-	**9**
3	-	-	0	3	**3**
4	-	-	0	3	**3**
5	-	-	0	6	**6**
6	-	-	1	6	**7**
TOTAL	**12**	**6**	**1**	**18**	**37**

Table 5. Summary of Credit Distribution for a student pursuing the Masters of Science (Plan I - Thesis) degree.

Semester	Credits				
	Core Courses	**Other Courses**	**Seminar**	**Thesis**	**TOTAL**
1	9	-	0	-	**9**
2	3	6	0	-	**9**
3	-	6	0	3	**9**
4	-	-	1	3	**4**
TOTAL	**12**	**12**	**1**	**6**	**31**

Table 6. Summary of Credit Distribution for a student pursuing the Masters of Engineering (Plan II - Project) degree.

Semester	Credits				
	Core Courses	**Other Courses**	**Seminar**	**Project**	**TOTAL**
1	9	-	0	-	**9**
2	3	6	0	-	**9**
3	-	6	0	3	**9**
4	-	-	1	3	**4**
TOTAL	**12**	**12**	**1**	**6**	**31**

Table 7. Summary of Credit Distribution for a student pursuing the Masters of Engineering (Plan III – Courses Only) degree.

Semester	Credits			
	Core Courses	**Other Courses**	**Seminar**	**TOTAL**
1	9	-	0	**9**
2	3	6	0	**9**
3	-	9	0	**9**
4	-	9	1	**10**
TOTAL	**12**	**24**	**1**	**37**

6.4. Relationship Between the Proposed Curriculum and the Program Goals, Objectives, and Graduate Profile

The educational methods to be employed in the proposed academic program will seek to fulfill the program's mission, goals and objectives, and ensure that students graduating from the program posses the qualifications described in the graduate profile. Tables 8-10 show how the main program components address the program goals, objectives, and graduate profile, respectively.

Table 8. Relation between program components and program goals.

Program Components	**Program Goals**				
	a	*b*	*c*	*d*	*e*
Core Courses	√			√	
Bioengineering Courses	√			√	
Other Courses	√			√	
Seminar	√				√
Thesis	√	√	√	√	√

Table 9. Relation between program components and program objectives.

Program Components	**Program Objectives**			
	a	*b*	*c*	*d*
Core Courses	√	√	√	√
Bioengineering Courses	√	√	√	√
Other Courses	√			
Seminar	√		√	√
Thesis	√	√	√	

Table 10. Relation between program components and graduate profile.

Program Components	**Graduate Profile Skills**							
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
Core Courses		√		√	√		√	√
Bioengineering Courses	√	√	√	√	√		√	√
Other Courses		√			√			
Seminar					√	√	√	√
Thesis	√		√	√	√	√	√	

6.5. Educational Methodology

The educational methodology of the proposed program will aim at the development of deep critical thinking and the integration of different complex problems solving techniques. The educational strategies used for teaching the program courses will be diverse. These include effective lecture techniques, independent work, collaborative learning, work groups, and research. Independent work will be developed through problem assignments and in some courses through the writing of technical papers. Collaborative and work group learning will be motivated and evaluated through projects that demand complex designs and the effective collaboration of various students to reach a common goal. By means of the seminars, students will be trained for independent work and research, and to effectively communicate their research findings. The seminar series also includes a significant component in topics such as entrepreneurship, safety, and ethical issues regarding the field of bioengineering.

6.6.Student Learning Assessment Plan

Student learning will be assessed at various stages throughout the program. The purpose of the assessment plan is to monitor and evidence student progress towards achieving the expected graduate profile. A set of assessment activities for each skill of the graduate student profile, are presented in Table 11. The results obtained from the student learning assessment plan will become part of the program assessment plan (described in section 15), and will be used to determine which adjustments, if any, are needed to dynamically improve the program.

Table 11. Student Learning Assessment Plan.

Graduate Profile Skill	**Assessment Methods**	**Administered By**	**Frequency and Timing**
a) In-depth knowledge of an area in bioengineering	Rubrics to evaluate specialized knowledge, as evidenced in assignments and exams in BioE elective courses	Course instructors	One evaluation per applicable assignment/exam in applicable courses

	Rubric to evaluate specialized knowledge, evidenced in written thesis	Thesis committee	Once at thesis defense
	Evaluation of student performance on oral thesis defense	Thesis committee	Once at thesis defense
b) Broad knowledge of bioengineering and supporting disciplines	Rubric to evaluate student performance on assignments and exams in BioE core courses	Course instructors	One evaluation per applicable assignment/exam in applicable courses
	GPA in BioE coursework	Administrative Assistant	Once per year; cumulative
	Qualifying exam (end of year one)	Graduate Committee	Once during exam administration
c) Ability to independently conduct research	Rubric to evaluate independent research skills	Thesis Advisor	Four times; at end of each semester enrolled in doctoral dissertation hours
d) Ability to formulate and solve complex bioengineering problems	Rubric to evaluate problem-solving skills in course assignments and exams	Course instructors	One evaluation per applicable assignment/exam in applicable courses
	Evaluation of quality of dissertation proposal	Thesis committee	Once during dissertation proposal
e) Ability to work in a multidisciplinary environment	Rubric to evaluate multidisciplinary teamwork in thesis project	Thesis Advisor	Four times; at end of each semester enrolled in doctoral dissertation hours
	Rubric to evaluate multidisciplinary teamwork in class or other projects	Course instructor or research supervisor	One evaluation per applicable project in applicable courses; one evaluation per semester for research projects
f) Ability to effectively communicate technical and	Rubric to evaluate technical writing skills	Course instructors	At least two evaluations per student in courses with written assignments
	Electronic records of graduate seminar presentations	Administrative Assistant	Tabulated at the end of each semester

scientific findings	Electronic records of peer-reviewed scientific presentations and journal articles where student is primary or co-author	Administrative Assistant	Tabulated at the end of each semester
	Records of awards or commendations (e.g., Best Student Paper at XYZ conference)	Administrative Assistant	Tabulated at the end of each semester
g) Awareness of ethical and social issues	Student self-assessment of awareness (survey)	Administrative Assistant	Once per year
	Rubric to evaluate awareness of ethical and social issues evidenced in course assignments and exams	Course instructors	One evaluation per applicable assignment/exam
h) Entrepreneurial consciousness	Student self-assessment of entrepreneurial consciousness and skills (survey)	Administrative Assistant	Once per year
	Rubric to evaluate entrepreneurial consciousness	Course instructors	Once per year; to design course and seminar modules

6.7.Course Syllabi

The course syllabi are presented in Appendix A.

7. ADMISSION, ENROLLMENT AND GRADUATION

7.1.Admission Requirements

Academic requirements for admission to the proposed Ph.D. Program will be according to those specified as per the NORMS WHICH REGULATE GRADUATE STUDIES AT UPRM, which are established in Certification 97-21 issued by the UPRM Academic Senate. Specific program requirements are:

- A baccalaureate or master's 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. The program's graduate committee will evaluate each applicant's qualifications to determine if the applicant fulfills admission requirements.
- A baccalaureate or master's 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.

- All applicants are expected to take the Test of English as a Second Language (TOEFL) exam and obtain a minimum score of at least **70%** of maximum score.

The same norms established by the Office of Graduate Studies as well as all previously described admission guidelines to the doctoral program are applicable to transfer students.
It will be the program's initial policy not to admit students to the masters program. Transfers from the doctoral program into the master's program will be considered by the program's graduate committee, with previous recommendation from the student's thesis committee and from the program's executive director.

7.2. Enrollment Projections

It is estimated that approximately five students will be admitted annually during the initial five years of the program. This approximate admission rate is consistent to those of current PhD programs at UPRM, as evidenced in Figure 1. After five years, and once the program is fully running, it is expected to stabilize the total enrollment at a level of 20-25 doctoral students. At present there is a sufficient research infrastructure to support these five students per year. The establishment of the doctoral program is expected to bring additional external funds for research, which in turn will strengthen the program in terms of additional research facilities and potentially increased enrollment.

7.3.Academic Requirements for Conferring the Degree

The general academic requirements for conferring the doctoral degree (or masters' degree) are specified in the "Norms that Regulate Graduate Studies at UPRM". Specific requirements for the doctoral program in Bioengineering are described below.

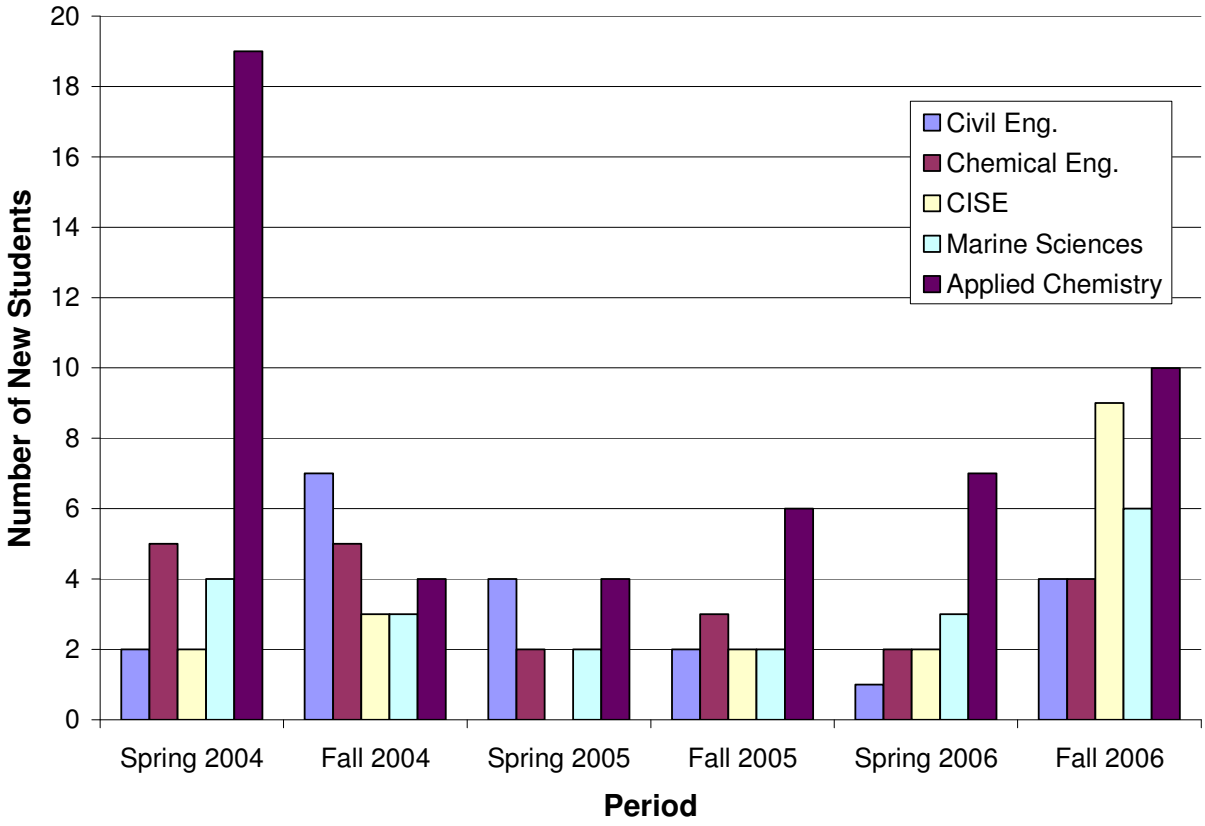

Figure 1. New student enrollment of existing PhD programs at UPRM (Obtained from the UPRM's Office for Graduate Studies).

7.3.1. Total Credit-Hour Requirement

Students entering the program with a **B.S. degree** are required to approve a minimum of **fifty-two (52) credit-hours** distributed in the following manner:

- 12 credit-hours in core courses
  - Principles of Bioprocess Engineering (BIOE6XXX)
  - Principles of Biomedical Engineering (INME6XXX)
  - Principles of Computational Bioengineering (BIOE6XXX)
  - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 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
  - The topics covered in the seminar will include:
    - Scientific
    - Social and ethical issues
    - Entrepreneurship
- 18 credit-hours in doctoral dissertation

Students entering the program with an **M.S. degree** are required to approve a minimum of **thirty-seven (37) credit-hours** distributed in the following manner:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 3 credit-hours in Bioengineering courses
- 3 credit-hours in courses outside of Bioengineering
- 1 credit-hour in seminar
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship
- 18 credit-hours in doctoral dissertation

Students entering the masters program are required to approve a minimum of fifty-two (37) credit-hours distributed in the following manner:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 12 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
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship

No more than 9 credit-hours of advanced undergraduate level courses can be used to complete doctoral degree requirements.

7.3.2. Minimum Academic Index Requirements

In order to complete the doctoral degree, each student must approve a minimum of 52 credit-hours (as described in section 1.6.1) 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 can not be repeated.

7.3.3. 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 "Norms that Regulate Graduate Studies at UPRM". 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 the number of transfer credits. All transfer courses must be approved with a minimum grade of B. Under no conditions may thesis credits be transferred.

7.3.4. 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 student s entering with a Bachelors degree, and a minimum of two semesters for students entering with a Masters degree. In both cases the student will complete sixty (60) percent of the course work for the program at UPRM."

7.3.5. Graduate Seminar

Doctoral students will be required to register for the Graduate Seminar in Bioengineering for the duration of their doctoral studies and will be awarded one credit-hour the semester the dissertation is turned in.

7.3.6. Preliminary Exam

All doctoral students will be required to take a Preliminary Exam. The exam will serve to evaluate the candidate's competency in the Bioengineering. The exam will be prepared, supervised and evaluated by the program's Graduate Committee in coordination with its faculty. The exam will be based on the core BioE courses, and students will be required to take the exam at the end of their first year of study. In accordance with "Norms that Regulate Graduate Studies at UPRM", doctoral candidates who fail this exam will be allowed to repeat the exam only once, and will be suspended after failing twice. Once the qualifying exam is passed, the student becomes a doctoral candidate.

7.3.7. Dissertation Proposal

After successfully passing the preliminary examination, a Graduate Committee is formed and 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 preliminary exam consists of a written part (the proposal) and an oral defense of the proposal. The student cannot be allowed to continue towards the Ph.D. after failing the Preliminary Exam twice.

7.3.8. 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.

7.3.9. Publication in Peer-Reviewed Journal

All students should have at least one (1) scientific article submitted in a peer-reviewed journal before the thesis defense.

7.3.10. Language Requirements

Teaching at the University of Puerto Rico is of a bilingual nature, consisting of English and Spanish. However, the use of written English language will be encouraged on seminar presentations, dissertation proposal, thesis, etc.

8. FACULTY

8.1. Profile of Available Faculty

At the time of submission of this proposal, the College of Engineering has the necessary faculty members to start the program. A total of 23 professors have pledged support to the proposed program. Also, there are currently 2 professors on study leave who are pursuing PhD's in bioengineering at US universities. These professors should become active participants of the program once they complete their degrees. Table 12 summarizes the faculty's academic background and their possible course offerings. All program professors have either tenure-track or tenure status. Individual biosketches of participating professors appear on Appendix B. The faculty available is highly qualified and brings diverse research and educational backgrounds and interests into the proposed program.

This proposal includes only faculty members from the College of Engineering. However, faculty members from other UPRM Colleges having a PhD degree and that are actively involved in bioengineering research and/or education could also participate in the program. **The program's graduate committee will be responsible for evaluating faculty qualifications and determining their elegibility to participate in the program.**

Table 12. Summary of Available Faculty.

							Expected Number of Preparations (per Semester)		
							Credit Hours dedicated to BioE Program (per Year)		
							Expected Academic Load (Total Credits per Semester)		
Name	**Type of Position - Department**	**Rank**	**Degree - Year**	**Institution**	**Specialty Area**	**Courses to Teach**	↓	↓	↓
Noel Artiles	Tenured - IE	Professor	PhD - 1989	Iowa State University	Statistics, Experimental Design	ININ6XXX (Adv. Bio. Stat.) BIOE8999	6	3	2
Rubén Díaz	Tenure-Track – ME	Assistant Professor	PhD - 2005	University of California-Berkeley	Transport Phenomena in Biological Systems, Micro/Nano Fabrication Technologies	INME6XXX (Prin. Biomed. Eng.) BIOE8999	6	6	2
David González	Tenured - IE	Associate Professor	PhD - 1996	Pennsylvania State University	Experimental Design, Experimental Design	ININ6XXX (Adv. Bio. Stat.) BIOE8999	6	3	2
Megh Goyal	Tenured - ESM	Professor	PhD - 1979	Ohio State University	Fluid Mechanics in Biological Systems	INME6XXX (Prin. Biomed. Eng.) BIOE8999	12	3	2
Bo Hu	Tenure-Track - ChE	Assistant Professor	PhD - 2007	Washington State University	Bioprocess Engineering	BIOE6XXX (Prin. Bioproc. Eng.) BIOE6XXX (Cell. Mol. Biol. Eng.) BIOE8999	6	6	2
San Hwang	Tenure-Track - CE	Assistant Professor	PhD - 2001	University of Akron	Bioremediation, Resource Recovery	INCI6005 INCI6015 INCI6060 BIOE8999	6	3	2
Eduardo Juan	Tenured - ECE	Associate Professor	PhD - 2001	Purdue University	Biomedical Acoustics, Bioinstrumentation	INME6XXX (Prin. Biomed. Eng.) INEL5208 INEL6XXX (Biomed. Ac.) BIOE8999	6	6	2
Vidya Manian	Tenure-Track - ECE	Assistant Professor	PhD - 2004	UPR-Mayagüez	Image Processing	INME6XXX (Prin. Biomed. Eng.) BIOE8999	6	3	2
Patricia	Tenure-	Assistant	PhD -	University of	Biotechnology,	BIOE6XX	6	6	2

Ortiz	Track - ChE	Professor	2005	Wisconsin - Madison	Microbiology	X (Prin. Bioproc. Eng.) BIOE6XXX (Cell. Mol. Biol. Eng.) BIOE8999			
Ingrid Padilla	Tenured - CE	Associate Professor	PhD - 1998	University of Arizona	Bioremediation	INCI6005 INCI6015 INCI6060 BIOE8999	6	3	2
Cristina Pomales	Tenure-Track - IE	Assistant Professor	PhD - 2006	University of Michigan	Human Factors and Ergonomics	ININ6XXX (Ergon. Bio.) BIOE8999	6	3	2
Jaime Ramírez-Vick	Tenured - ESM	Professor	PhD - 1997	Arizona State University	Molecular Diagnostics, Microarray Technology Development, Biosensors	BIOE6XXX (Prin. Biomed. Eng.) BIOE6XXX (Prin. Comp. BioE.) BIOE8XXX (Struct. Bioinf.) BIOE6XXX (Cell. Mol. Biol. Eng.) BIOE8999	6	9	2
Nazario Ramírez	Tenured - IE	Professor	PhD - 1988	Texas A&M University	Experimental Design, Prediction of Drug Stability	ININ6XXX (Opt. Meth. Appl. Bioinf.) ININ6XXX (Adv. Biostat. Appl.) BIOE8999	6	6	2
Carlos Rinaldi	Tenured - ChE	Associate Professor	PhD - 2002	Massachusetts Institute of Technology	Nanomaterials, Nanobiotechnology	INME6XXX (Prin. Bio. Eng.) BIOE8999	6	3	2
Pedro Rivera	Tenured - ECE	Professor	PhD - 1990	University of Florida	Computer Science, Parallel and Distributed Processing	ICOM6XXX (Bioinf. Algor.) BIOE8999	9	3	2
Jorge Rivera-Santos	Tenured - CE	Professor	PhD – 1988	University of Colorado	Sanitary Engineering, Water Resources	INCI6005 INCI6015 INCI6060 BIOE8999	6	3	2
Manuel Rodríguez	Tenured - ECE	Associate Professor	PhD - 2001	University of Maryland	Database Management Systems	ICOM6XXX (Bioinf. Algor.)	6	3	2

						BIOE8999			
Lorenzo Saliceti	Tenured - ChE	Professor	PhD - 1996	Purdue University	Biochemical Engineering	BIOE6XXX (Prin. Bioproc. Eng.) BIOE6XXX (Cell. Mol. Biol. Eng.) BIOE8999	6	3	2
Jaime Seguel	Tenured - ECE	Professor	PhD - 1987	City University of New York	Parallel and Distributed Computing, Bioinformatics	BIOE6XXX (Prin. Comp. BioE.) ICOM6XXX (Bioinf. Algor.) BIOE8999	6	6	2
David Serrano	Tenured - ME	Professor	ScD - 1987	Massachusetts Institute of Technology	Rehabilitative Medical Devices	INME6XXX (Prin. Biomed. Eng.) BIOE8999	6	3	2
Paul Sundaram	Tenured - ME	Professor	PhD - 1988	Ohio State University	Biomaterials	INME6XXX (Prin. Biomed. Eng.) INME6XXX (Biomaterials) BIOE8999	6	6	2
Madeline Torres	Tenured - ChE	Associate Professor	PhD - 2001	Purdue University	Polymers, Biomaterials, Hydrogel-Based Drug Delivery	INME6XXX (Prin. Biomed. Eng.) INME6XXX (Biomaterials) INQU8027 INQU8XXX (Transp. Phen. Biol. Sys.) BIOE8999	6	6	2
Bienvenido Vélez	Tenured - ECE	Associate Professor	PhD - 1999	Massachusetts Institute of Technology	Distributed Systems, Information Discovery and Retrieval	BIOE6XXX (Prin. Comp. BioE.) ICOM6XXX (Bioinf. Algor.) BIOE8999	6	6	2

8.2. Faculty Development Plan

The program's faculty does not need special training. Nevertheless, it is expected that professors will keep up to date in their particular fields of expertise through research and in teaching by participating in training workshops and effective teaching strategies offered at UPRM and elsewhere.

8.3. Faculty Recruitment Projections for the Next Five Years

Although the current number of available faculty members is adequate to start the program, a total of 3 faculty members will be hired to support the bioengineering program. Since the proposed program is a joint effort between all engineering departments, these new hires will also support each of the departments' graduate and undergraduate programs.

9. PROGRAM ADMINISTRATION

The graduate program in Bioengineering is supported by an alliance of academic departments from the College of Engineering of UPRM. Therefore, all departments are responsible for the development and success of the program. The proposed administrative structure aggressively pursues avoiding the generation of a virtual department image around the program.

Two interdepartmental committees, the Executive Committee and the Graduate Committee, administer and maintain the program. Each committee consists of one representative from each department in the alliance, and the Executive Director. The administrative chart for the proposed BioE program is depicted in Figure 2.

The Executive Director
The Executive Director is in charge of the day-to-day operations of the program, as well as of the development and execution of the program's development and evaluation plans. Typical duties of the Executive Director include:

1. All duties and responsibilities described as the duties of a Coordinator of an Interdepartmental program in Certification 97-21 of the UPRM Academic Senate.
2. Elaborating and reviewing internal administrative procedures and rules.
3. Elaborating the annual budget for the program.
4. All the administrative paperwork related to the program. The Executive Director signs all documents intended for the signature of a Departmental Director.
5. Supervise program staff.
6. Create and maintain mutually beneficial relations with industry, government, federal agencies, and other academic and research institutions.
7. Generate the annual report, and all other mandatory program reports.

The Executive Director will report directly to the Dean of Engineering and to the Executive Committee (described below), and will be a member with voice, but not vote, of both the Executive and the Graduate Committees. In order to perform these duties, the Executive Director will receive

up to nine credits of release time.

The Executive Committee

The Executive Committee will be composed of the Dean of Engineering and Department Heads from the College of Engineering. This committee approves the recommendations made by the Executive Director regarding the administrative matters of the program, such as course offerings, student registration, and the utilization of human and physical resources. The Executive Committee will also be responsible for nominating, supervising, and evaluating the performance of the Program's Executive Director.

The Graduate Committee

As stated in Certification 97-21 of the UPRM Academic Senate, items C.1.B and C.1.C, the Graduate Committee will consist of one representative from each participating department and the Executive Director, who will preside. The duties of this Committee will be those described in item C.2 of the Certification 97-21 of the UPRM Academic Senate. In addition, the graduate committee makes recommendations on:

1. Research and Fellowship assignments
2. Student's advisor designation
3. New faculty affiliation to the program
4. Evaluating the results of the Preliminary exam

External Advisory Board

An external advisory board will be constituted to help in the program's assessment process and make the appropriate recommendations to both the executive committee and the Executive Director. The advisory board will be composed of at least one of the following professionals; a physician, a scientist, a bioengineering researcher and a representative from industry.

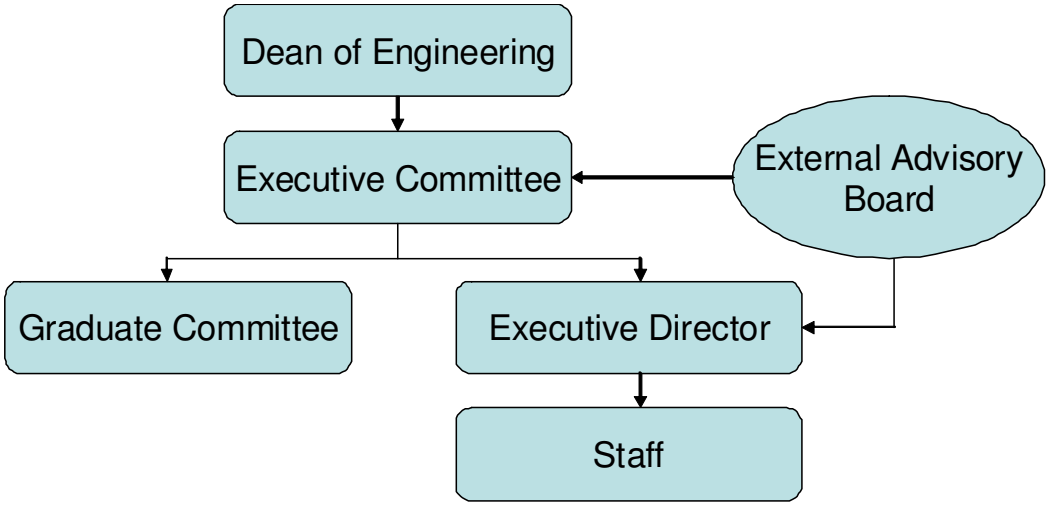

Figure 2. Administrative structure chart for the graduate program in bioengineering.

The position of **Student Affairs Official II** is requested to provide administrative support to the graduate program in Bioengineering.

10. INFORMATION RESOURCES

10.1. Existing Information Resources

The General Library of the University of Puerto Rico, Mayagüez provides the academic community with excellent support. The Library has about one million titles, which makes it the most complete library in the western part of Puerto Rico. An estimate of the library holdings includes 217,114 volumes of books, 6,704 journal titles, 1,576 CDROM, 2,476 theses and dissertations, 488,527 microfiches, 17,683 microfilms, 86,218 microcards, 583,155 documents and 3,203 videocassettes. In addition, the library has access to 25,000 periodicals and 46 databases through Internet subscriptions through Ebscohost, Proquest, H.W. Wilson, Web of Science, Science Direct, Gale, Engineering Information Village 2 and the electronic library for IEEE/IEE (IEEExplorer). Detailed information regarding Internet services at UPRM may be obtained at http://www.uprm.edu/library.
In addition to these resources, the library participates in an interlibrary loan program, which allows access to books and other publications unavailable at UPRM.

10.2. Acquisition of Additional Information Resources

The library is a fundamental source of information that is required to support and stimulate the proposed BioE program. This proposal requests $6,000 per year for five years ($30,000 total) to acquire technical and specialized textbooks, scientific journals, and access to digital databases.

11. TEACHING, RESEARCH AND SERVICES INFRASTRUCTURE

Students enrolled in the proposed bioengineering program will have access to state of the art facilities that are available at the various departments within the UPRM's college of engineering, as well as in other units of the UPR system.

11.1. Facilities at UPRM

The research and educational infrastructure required for the proposed program is distributed among the various departments that comprise the college of engineering at UPRM. These facilities have been put up throughout the years using both institutional and external funds. A list of available facilities is presented in Table 11.

Table 13. Research and educational facilities.

Name	Location	Use
Biomedical Instrumentation Research Laboratory	Electrical Eng.	Research
Laboratory for Applied Remote Sensing and Image Processing	Electrical Eng.	Research
Instrumentation and Process Control Laboratory	Electrical Eng.	Educational
Biomicrofluidics Research Laboratory	Mechanical Eng.	Research
Smart Fibers and Nano-Bioelectronics Packaging Laboratory	Mechanical Eng.	Research
Microscale and Nanoscale Materials Characterization Laboratory	Mechanical Eng.	Research
Mechanical Testing Facilites	Mechanical Eng.	Research/Ed.
Biomaterials and Biomedical Engineering Laboratory	Chemical Eng.	Research
Complex Fluids Laboratory	Chemical Eng.	Research
Magnetic Characterization Laboratory	Chemical Eng.	Research
Biotechnology Laboratory	Chemical Eng.	Research
Environmental Engineering Laboratory	Civil Eng.	Research
Ergonomics Laboratory	Industrial Eng.	Research/Ed.
Cancer Genetics Laboratory	ESM	Research

11.2. Off-Campus Facilities

Program participants will have access to animal care and studies facilities available at the UPR's Medical Sciences Campus. It also expected that, through research collaborations, program participants will be able to use specialized research equipment available at other UPR campuses.

12. STUDENT SERVICES

12.1. General Student Services

The UPRM offers a wide range of student services, which include academic and professional counseling, access to medical facilities, assistance in obtaining visas and other permits, among others. The **Office for Graduate Studies (OGS)** is the main point of contact between graduate

students and the UPRM's administration. The OGS handles applications, offers short courses and workshops on various topics, and provides counsel to graduate students regarding academic rules and procedures such as plans of study, graduate assistantships, thesis defenses, etc.

12.2. Graduate Assistantships

At present, the engineering departments within the College of Engineering have been able to provide a considerable number of graduate assistantships to their current graduate students. These aides fall into two categories: teaching assistantships and research assistantships. Funding for research assistantships stems primarily from external research funds, while funding for teaching assistantships come from the general fund of the University of Puerto Rico. Funds are requested to support ten (10) graduate students during the initial five (5) years of the program, at a rate of $12,684 ($1,057 per month) per student per year.
The establishment of the proposed interdisciplinary program will serve as a mean for increasing investigative efforts. It is expected that this increase in research activity will serve, in turn, to increase external research funding which, among other things, will result in the availability of an increased number of graduate research assistantships.

13. CATALOG INFORMATION

The program's description will be included in the UPRM's graduate catalogue and under the College of Engineering. A particular textual description of the program appears below.

Doctoral Program in Bioengineering

The College of Engineering offers a multidisciplinary doctoral program leading to the degree of Doctor of Philosophy in Bioengineering. The bioengineering program focuses on **computational bioengineering**, **biomedical engineering** and **bioprocesses** research, and consists of a total of **fifty two (52) credit-hours** for students entering the program with a **B.S. degree**, and **thirty-seven (37) credit-hours** for students entering the program with an **M.S. degree**.

Students entering the program with a **B.S. degree** are required to approve a minimum of fifty-two (52) credit-hours distributed in the following manner:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 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
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship

- 18 credit-hours in doctoral dissertation

Students entering the program with an **M.S. degree** are required to approve a minimum of thirty-seven (37) credit-hours distributed in the following manner:

- 12 credit-hours in core courses
    - Principles of Bioprocess Engineering (BIOE6XXX)
    - Principles of Biomedical Engineering (INME6XXX)
    - Principles of Computational Bioengineering (BIOE6XXX)
    - Molecular and Cellular Biology for Engineers (BIOE6XXX)
- 3 credit-hours in Bioengineering courses
- 3 credit-hours in courses outside of Bioengineering
- 1 credit-hour in seminar
    - The topics covered in the seminar will include:
        - Scientific
        - Social and ethical issues
        - Entrepreneurship
- 18 credit-hours in doctoral dissertation

No more than 9 credit-hours of advanced undergraduate level courses can be used to complete doctoral degree requirements. In addition to the courses, students will also be required to pass a preliminary exam and prepare a dissertation proposal as part of the process of evaluating their ability to engage in doctoral level research. Finally, students will be required to pass 18 dissertation credits. The dissertation, which will require an original contribution to the existing scientific and/or technical body of knowledge in the field of bioengineering, will measure the scope of acquired knowledge and it will evidence the student's degree of creativity and scientific rigor.

After the program is approved, an informative program brochure, other printed material and a website, will be prepared to serve as a promotional tool for the program.

14. BUDGET

A total of **$1,903,720**, distributed over a period of five years, is requested to establish the BioE program. Most of these funds **($1,222,769**) will be used to support three (3) new faculty members at the College of Engineering. The proposed budget is presented in Table 14. An inflation rate of 4% per year was assumed to calculate costs of subsequent years. A detailed budget justification is provided in the following section.

14.1. Budget Justification

14.1.1. New Faculty

It is estimated that 5 BioE courses will be offered each semester as part of the new program. At 3 credit-hours per course, the proposed course offering totals 30 credit hours per year. New BioE professors will dedicate approximately 25% of their time (6 credit-hours per year) teaching BioE courses and the rest of their time teaching courses in their home department and working on

research. Therefore, at least three new faculty members will be required to fully implement the academic and research goals of the BioE program. These three faculty positions will be distributed between the academic programs that compose the college of engineering. It is expected that new faculty will be recruited according to the following schedule: 2 faculty members during the first year and 1 faculty members during the second year. The expected annual cost (salary plus fringe benefits) for each new faculty (at the assistant professor level) is $ 80,187. The cumulative annual cost for new faculty is as follows: $160,375 for the first year, and $240,561 (plus inflation) during the remaining years.

14.1.2. Seed Funds

No seed money funds are requested in this proposal. However, once the program begins, efforts will be made to secure seed money funds for newly hired faculty members.

14.1.3. Graduate Assistantships

Funds are requested to support ten (10) graduate students, at a rate of $12,684 per student per year. Providing financial support to graduate students during the initial years of the program fosters exploratory research that can lead to external research funds. Also, these graduate research assistantships can serve as bridge funds to support students while external research proposals are being renewed.

14.1.4. Seminar Series

A total of $5,000 per year is requested to cover expenses associated with the Graduate Seminar Series, such as travel funds for out of campus speakers

14.1.5. Library Resources

The library is a fundamental resource required to support and stimulate the proposed BioE program. The requested amount to cover the annual library costs is $ 6,000, and will be used mostly to acquire technical and specialized textbooks, scientific journals, and accesses to digital databases.

14.1.6. Administrative Support

The administrative costs are mainly associated to cover the annual salary of a **Student Affairs Official II** that provides administrative and/or clerical support to the graduate program in Bioengineering. The expected annual cost (salary and fringe benefits) for the administrative assistant is $ 28,302.

14.1.7. Office Supplies and Related Expenses

The amount of $8,000 per year has been budgeted to cover expenses involved in acquiring office materials and supplies. Materials and supplies may include: computer supplies, office materials and services.

14.1.8. Program Promotion

The promotion of the BioE program is a fundamental activity to establish and develop the program. The requested amount is $ 15,000 per year and is distributed as follows: $6,000 for developing and maintaining a web page and $ 9,000 for traveling and other forms of program promotion (i.e. flyers).

Table 14. Proposed Program Budget

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Recurrent Costs						
Faculty Positions	$ 160,374	$ 250,183	$ 260,191	$ 270,598	$ 281,422	$ 1,222,769
Administrative Assistant	$ 28,302	$ 29,434	$ 30,611	$ 31,836	$ 33,109	$ 153,293
Seminar Series	$ 5,000	$ 5,200	$ 5,408	$ 5,624	$ 5,849	$ 27,082
Library Resources	$ 6,000	$ 6,240	$ 6,490	$ 6,749	$ 7,019	$ 32,498
Office Supplies and Related Expenses	$ 8,000	$ 8,320	$ 8,653	$ 8,999	$ 9,359	$ 43,331
Program Promotion	$ 15,000	$ 15,600	$ 16,224	$ 16,873	$ 17,548	$ 81,245
Graduate Assistantships	$ 63,420	$ 65,957	$ 68,595	$ 71,339	$ 74,192	$ 343,503
Total Recurrent Costs	$ 286,096	$ 380,934	$ 396,172	$ 412,019	$ 428,499	$ 1,903,720
Total Cost	$ 286,096	$ 380,934	$ 396,172	$ 412,019	$ 428,499	$ 1,903,720

15. ASSESSMENT PLAN

A program assessment plan will become an integral component of the proposed program. The purpose of the program assessment plan is to monitor and evidence progress towards achieving the expected program goals and objectives. The program's success will be assessed with respect to: recruitment, retention, graduation and placement of students that participate in the program, student learning, number of scientific publications and patents, amount of obtained external research funds, and the establishment of collaborative programs with other academic institutions and with industry.

A set of assessment activities, including expected results (at five (5) year intervals), are presented in Table 15. The results obtained from the program learning assessment plan will be analyzed by the Executive Director and the External Advisory Board to determine which adjustments, if any, are needed to dynamically improve the program.

Table 15. Program Assessment Plan.

Program Activity to be Assessed	**Assessment Method or Criterion**	**Performed During:**	**Expected Result (Initial 5 Years of Program)**	**Expected Result (Subsequent 5 Year Intervals)**
Recruitment	Advertising in local and international venues	Continuously	At least 5 advertisements in professional publications and websites	At least 5 advertisements in professional publications and websites
	Enrollment	End of each academic year	5-10 students/year; at least two female student per year	5-10 students/year
Student Learning	Student Learning Assessment Plan (see section 6.6)	Continuously	100% of graduates obtaining satisfactory levels as determined by the Student Learning Assesment Plan	100% of graduates obtaining satisfactory levels as determined by the Student Learning Assesment Plan
Student Placement	Exit Interview	Last semester after dissertation	100% Placement	100% Placement
Number of Peer-Reviewed Publications	-Search in Online Journal Databases -Program Faculty Records	Annually	-5 articles in peer-reviewed journals -10 conference proceeding articles	-25 articles in peer-reviewed journals -25 conference proceeding articles
Amount of External Research Funds	-Annual Report of the UPRM's Research and Development Center -Program Faculty Records	Biannually	$1.875M in external research funds (5 grants @ $125k/year for 3 years)	$3.75M in external research funds (10 grants @ $125k/year for 3 years)
Number of Patents	US Patents and	Biannually	1-2 patents	2-4 patents

	Trademarks Office			
Establishment of Collaborative Programs with other Academic Institutions and with Industry	Records by program's Executive Director and/or Dean of Engineering	Biannually	1 Collaborative program with other academic institutions 1 Collaborative program with an industrial partner	2 Collaborative programs with other academic institutions 2 Collaborative programs with industrial partners

16. PROGRAM DEVELOPMENT PLAN

The development plan for the BioE program will be based on five main thrusts: **faculty and student recruitment and retention, infrastructure, external funding, strategic alliances and publications.**

16.1. Faculty and Student Recruitment and Retention

Attracting the most talented faculty and students is of utmost important for the development and growth of the BioE program. As stated in a previous section, it is intended to recruit at least seven (7) new faculty members during the first three years of the program and five (5) graduate students per year in order to have, in the steady state, an average enrollment of twenty-five (25) students.
Faculty positions will be advertised on professional societies such as the IEEE-EMBS, BES, AICHE and ASME, via magazine postings, websites, and conferences.
The recruitment of graduate students will be made through announcements on the BioE program's website, brochures to be distributed to universities in and outside of Puerto Rico, undergraduate research programs, etc.
The program's administrators will also pay special attention to the retention of students, by making sure that all of the Institution's academic and professional counseling and development services are available to students from the program.

16.2. Infrastructure

Since the BioE program will be a consortium of all departments within the college of engineering, efforts will be made to support the infrastructure development/improvement agendas of these departments (i.e. the construction of a new building for the Department of Electrical and Computer Engineering and the expansion of the Chemical Engineering building).

16.3. External Funding

An important goal of the proposed program is to establish a healthy portfolio of externally-funded research, training and education grants. These efforts will be led by the program's faculty and by the executive director. Federal agencies such as the National Science Foundation (NSF), the National

Institutes of Health (NIH) and NASA provide funding opportunities in bioengineering.

16.4. Strategic Alliances

Another important goal of the proposed program is to establish collaborative programs with other educational institutions and local industry to provide solutions to technical problems within the scope of bioengineering and biotechnology. During the first two years of the program, efforts will be made to establish collaborative programs with at least one of each of the following: a) a major US academic research institution, b) a major medical/clinical research institution, and c) an industrial partner.

16.5. Publications

An important factor that determines the productivity of any engineering graduate program is the amount of peer-reviewed publications generated by its students and faculty. A goal has been set to generate 25 peer-reviewed journal articles, 25 conference proceedings, and 2-4 patents, every five years.

17. ADDITIONAL INFORMATION

17.1. Partnership with the Weldon School of Biomedical Engineering at Purdue University

On November 6, 2007, the University of Puerto Rico-Mayagüez and Purdue University's Weldon School of Biomedical Engineering formed a partnership agreement designed to facilitate collaborative research and education efforts between the two institutions. This partnership builds upon the complementary strengths of Purdue and the University of Puerto Rico–Mayagüez, and will allow both institutions to work together in the field of biomedical engineering through faculty and student exchanges, collaborative research, and cooperative curriculum initiatives.

The first step in the implementation of this collaborative effort was the creation of a graduate fellowship program, entitled *Collaboration in Biomedical Engineering Research (CIBER) Student Fellowship Grant*, sponsored by both institutions.

17.2. Collaboration with the UPR's Medical Sciences Campus

A collaboration between the UPRM and the University of Puerto Rico's Medical Sciences Campus is being developed at the time of submission of this proposal. The proposed collaborative model encompasses the broad areas of biomedical engineering and computational bioengineering, and will be elaborated under the following scope:

1) RCM faculty members will be able to directly supervise the research work of bioengineering graduate students by serving as their co-advisors (along with an UPRM faculty member)
    a. Students will be allowed to perform their research work at the RCM
2) Program will benefit from the sharing of expertise and facilities available at both campuses
3) This collaboration will open new research and educational funding opportunities that could not be achieved independently by either UPRM or RCM.

4) The College of Engineering at UPRM will administer and run the program, and will also be responsible for offering all required courses.
5) The RCM will allow and foster BioE students to enroll in their graduate courses (elective courses to BioE students).
6) The UPRM will confer all BioE degrees (PhD, ME, MS).