BIOMEDICAL ENGINEERING

The Biomedical Engineering program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) under the commission's General Criteria and Program Criteria for Bioengineering and Biomedical and Similarly Named Engineering Programs. The Biomedical Engineering curriculum provides both breadth and depth across the range of engineering domains such as mechanical, electrical, computer or software engineering. The program prepares graduates to have an understanding of biology and physiology, as well as the capability to apply advanced mathematics, science and engineering to solve the problems at the interface of engineering and biology. The Biomedical Engineering curriculum prepares graduates with the ability to make measurements on and interpret data from living systems and to address the problems associated with the interaction between living and non-living materials and systems. The curriculum blends theoretical knowledge with hands-on experiential learning that culminates with a year-long, interdisciplinary team-based capstone design project.

The Program Educational Objectives are broad statements that describe what alumni do within a few years following graduation. The Biomedical Engineering program is committed to graduating engineers who within a few years of their graduation are expected to:

1. Utilize their interdisciplinary training to have successful careers in industry, research and development and in regulatory agencies, academia, or clinical work.
2. Demonstrate the organizational, leadership, and communication skills to achieve success in their chosen careers and make reasoned decisions based on a respect for diversity, and welcome it as a source for creativity, innovation, and productive collaboration.
3. Employ critical thinking and problem-solving skills to support interdisciplinary teams that may include physicians, nurses, molecular biologists, physiologists, other engineers, and business professionals.
4. Utilize life-long learning skills and the ethical tools for successful adaptation to the rapidly changing field of Biomedical Engineering.
5. Build upon their sound training in mathematics, biological sciences, the liberal arts and engineering to facilitate successful pursuit of advanced degrees in medicine, law, business, engineering, or related fields.

For the first year of study, all of our engineering programs place major emphasis on the fundamentals of engineering and computer science, mathematics, and the basic sciences to provide the background for later engineering science and design courses. Following preparatory work, the fundamentals of electrical, computer, mechanical, and materials engineering concepts are developed. Advanced courses in Biomedical Engineering further develop knowledge in the discipline. The Biomedical Engineering curriculum program places much emphasis on design assignments. Students may specialize in a specific area of Biomedical Engineering by taking elective courses. Also, students on a pre-medicine track can prepare for medical school entrance by taking their elective courses in psychology, sociology, organic chemistry, biology, and biochemistry.

Students will build skills and knowledge through formal course work, projects, and presentations. Biomedical Engineering program graduates will have attained the following student outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Biomedical Engineering Program Study Abroad

Studying abroad can be a life-changing experience and we highly recommend students explore the many options that are available to them. The Biomedical Engineering department in the School of Engineering and Computing has partnered with the National University of Ireland, Galway (NUI Galway) to allow students the opportunity to spend the fall semester of their junior year in Galway. NUI Galway ranks among the top of Universities in the world. In addition to the many benefits that come from studying abroad, successful Biomedical Engineering students who spend their fall semester of junior year in Galway have the opportunity to enter into the one-year Master's Degree program at NUIG after they complete their undergraduate degree at Fairfield University. To be admitted to the NUIG Biomedical Engineering Master's program, students must have between a 3.2 and 3.7 GPA upon graduation from Fairfield University.

Five-Year integrated BS and MS in Biomedical Engineering

Fairfield University School of Engineering and Computing offers a five-year accelerated bachelor's/master's in Biomedical Engineering for undergraduates enrolled in the program. This accelerated degree program may reduce the time to obtain a master's degree and provides experiential learning through research and design projects giving graduates the credentials needed to prepare for a broad range of careers. Upon completing the program, graduates gain the knowledge, confidence, and skills needed to solve the next generation of complex healthcare problems.

Fairfield University undergraduate Biomedical engineering students may request a change of status to the Five-Year MS in Biomedical Engineering plan of study during or prior to their junior year. Admitted students are advised to consult with their advisor to select two undergraduate major electives (6 credits total) at the 5000 level in order to earn six credits towards the MS program's Biomedical Engineering electives. During the fifth year of study, Fairfield University BME graduates will be required

to take the remaining 24 credits to complete the MS in Biomedical Engineering.

Five-Year Integrated BS in Biomedical Engineering and Master of Science in Data Science with Bioinformatics Concentration

The five-year graduate program MS in Data Science with Bioinformatics concentration is available to undergraduate students in Biomedical Engineering. The Bioinformatics concentration is one of the concentrations offered as part of the interdisciplinary M.S. in Data Science program. The coursework for the M.S. in Data Science consists of 30 graduate coursework credits of which 6 credits (two courses) can be earned during the student's undergraduate program by declaring to opt for this program during junior year. The two graduate courses to be taken during the BS program are Biomedical Imaging and Biomedical Visualization. The MS in Data Science program includes a core set of four courses (12 credits), two electives (6 credits), a Capstone Practicum course sequence (6 credits), and two Concentration courses (6 credits). The core set of courses provides essential computing and math skills for any data science student. These courses are offered by Department of Computer Science and Engineering and by the Department of Mathematics. The Concentration courses provide deep knowledge in at least one data domain.

Programs

- Biomedical Engineering Major
- Biomedical Engineering Five-Year Bachelor of Science and Master of Science Program

Courses

BIEG 1001 Introduction to Biomedical Engineering **3 Credits**
This course utilizes hands-on learning and projects to teach the basic engineering skills important for Biomedical Engineers. Biomedical Engineering is a very interdisciplinary field and students will learn applications of mathematics, statistics, physics, and electronics to solve biomedical problems. Students will work on team projects and will be guided through the engineering design process. In addition, students will practice professional skills such as technical writing and presentation. A variety of career paths within Biomedical Engineering will be covered as well as the roles of Biomedical Engineers in the global society and ethics within the profession.

BIEG 3201 Biomechanics **3 Credits**
Prerequisites: MATH 1141, PHYS 1171.
This course covers solid mechanics of bone with a focus on stress, strain, stiffness, and strength. Joint forces and muscle attachments will be analyzed using free-body diagrams. Introductory musculoskeletal physiology will be covered and Biopac Student Lab software will be used for gait and muscle force analysis.

BIEG 3301 Biomedical Instrumentation **4 Credits**
Attributes: HSST Health Studies: Science and Technology
Fee: $120 Engineering Lab Fee
Prerequisites: ELEG 2213.
This course presents instrumentation and techniques used in acquisition, processing, and presentation of biomedical signals: transducers, sensors, biosensors, and measurement of physical parameters and electrophysiological signals. Physiology relevant for instrumentation labs will be covered.

BIEG 3331 Biomedical Signal Processing **3 Credits**
Prerequisites: CPSC 1131 or SWEG 5407; MATH 1142.
This course presents an overview of different methods used in biomedical signal processing. Signals with bioelectric origin are given special attention and their properties and clinical significance are reviewed. In many cases, the methods used for processing and analyzing biomedical signals are derived from a modeling perspective based on statistical signal descriptions. The purpose of the signal processing methods ranges from reduction of noise and artifacts to extraction of clinically significant features. The course gives each participant the opportunity to study the performance of a method on real, biomedical signals. Graduate equivalent: BIEG 5331, ECEG 5331.

BIEG 3335 Clinical Engineering **3 Credits**
Biomedical engineering is defined by the application of engineering design in service of human health. To solve problems in healthcare, it is crucial to understand the clinical environment within which biomedical engineers develop solutions. This course will provide students with the opportunity to work with faculty and students in the Egan School Simulation Lab to gain an understanding of modern clinical care and work collaboratively on solutions to existing problems in healthcare. Students will have an opportunity to use existing medical devices and gain an understanding of their fundamental operating principles. Students will gain an understanding of the societal underpinnings contributing to existing disparities in healthcare outcomes and how previous technological development has exacerbated to these disparities. Graduate Equivalent: BIEG 5335.

BIEG 4309 Biosensors **3 Credits**
Prerequisites: CHEM 1171, ELEG 2213.
This course will provide an overview of biosensors, including their use in pharmaceutical research, diagnostic testing, and policing the environment. Topics include the fabrication, characterization, testing, and simulation of biosensors. The phenomenon of transducers, biosensor structure, sensor performance, and simulations utilizing molecular simulation software will also be covered. Graduate Equivalents: BIEG 5309, ECEG 5309

BIEG 4311 Biomaterials **3 Credits**
Prerequisites: BIOL 1107 or BIOL 1108 or BIOL 1171 or BIOL 1172 or BIOL 1173; CHEM 1171.
This course will cover the introductory level of understanding on the different types of biomaterials used in biomedical industry, their design and synthesis. Examples include implants, stents, catheters, smart polymer gels, bone grafts, and tissue scaffolds. Modern biology in biomedical engineering such as but not limited to protein adsorption, immuno-isolation, and regenerative medicine will be covered. Ethical issues in biomedical engineering will also be discussed. Current innovative research on nano-biotechnology that extends to 3D bio-matrix, advanced diagnostics, dental composites, sealants, and adhesives. Graduate equivalents: BIEG 5311, ECEG 5311.

BIEG 4314 Introduction to Molecular Modeling **3 Credits**
Prerequisites: CHEM 1171, PHYS 1171.
This course will cover methodological and practical aspects of the application of system analysis and computational tools to biological and biomedical problems. It will cover computational modeling of biological macromolecules such as proteins, DNA, and synthetic self-assembling materials such as polymers, crystals, colloids, and amphiphiles. The course provides the resources to use Visual Molecular Dynamics (VMD) and Nanoscale Molecular Dynamics (NAMD) to solve computational problems related to protein interactions in case of diseases and protein folding. Graduate equivalent: BIEG 5314, ECEG 5314.

BIEG 4332 Biomedical Imaging **3 Credits**
Attributes: HSST Health Studies: Science and Technology
Prerequisite: BIEG 3331 or CPEG 3331.
The fundamentals and applications of medical imaging techniques will be presented, including x-ray and computed tomography, nuclear imaging, ultrasound, and MRI. Image processing and analysis techniques will be introduced through suitable programming exercises. Graduate equivalent: BIEG 5332, ECEG 5332.

BIEG 4333 Biomedical Visualization **3 Credits**
Prerequisite: CPSC 1131.
This course is an introduction to 3-D biomedical visualization. Various technologies are introduced, including ultrasound, MRI, CAT scans, PET scans, etc. Students will learn about spatial data structures, computational geometry and solid modeling with applications in 3-D molecular and anatomical modeling. Graduate equivalent: ECEG 5333.

BIEG 4350 Medical Device Design **3 Credits**
Attributes: HSST Health Studies: Science and Technology
Prerequisite: Junior standing.
This project-based course focuses on important stages of the medical device product lifecycle including: identifying unmet clinical and global health needs, the FDA approval process, material selection, biocompatibility, ethical considerations, intellectual property, and post-market surveillance of similar products. Students will generate project ideas and design a medical device. Graduate equivalent: BIEG 5350.

BIEG 4370 Cardiac Mechanics **3 Credits**
Prerequisite: Junior or Senior standing.
In this course, students will learn quantitative physiological function of the heart and vascular system. Anatomy, physiology, and pathophysiology of the heart will be covered. Constitutive laws for heart muscle will be introduced. Solid and fluid biomechanics and modeling techniques will be studied. Students will gain experience with finite element modeling of the heart. Graduate equivalent: BIEG 5370.

BIEG 4375 Bioelectronics **3 Credits**
Prerequisite: CHEM 1171 and CHEM 1171L, ELEG 2213 and ELEG 2213L.
Bioelectronics have emerged as an exciting research area due to the integration of molecular biology with electronics to create fundamental devices. This course is intended for senior and graduate level engineering students. It will introduce fundamentals of bioelectronics through chemical, biochemical and biophysical concepts from the engineering perspective. It will further apply these concepts to the areas of electron transport through biological macromolecules, microfluidics, electrochemical techniques, DNA and neuron-based electronics, biomaterials and semiconductor-based bioelectronics. Graduate Equivalent: ECEG 5375, BIEG 5375

BIEG 4387 Instrumental Analysis in Biomedical Engineering **3 Credits**
Prerequisite: CHEM 1171 and CHEM 1171L or BIOL 1171 and 1171L or PHYS 1171 and PHYS 1171L.
This course will give an overview on several important analytical tools for characterizing the nanomaterials that are functionally engineered towards biomedical applications. Quantification of mechanical, electrical, electronic and biological properties of the nanomaterials such as carbon nanotubes, metal nanoparticles, quantum dots, nanowires, polymeric nanoparticles and biomedical nanomaterials will be discussed. Fundamental principles of the associated instruments and the evaluation of the physical, chemical and microscopy methods for materials in nano-regime will be highlighted. Modern material science depends on the use of a set of analytical methods that are used normally in specialized laboratories. This course will help the students get familiar with the basics of such specialized methods, their range of applicability and reliability, especially when the materials under test are in sub-100nm dimensions. Graduate Equivalent: BIEG 5387, ECEG 5387.

BIEG 4403 Advanced Biomechanics **3 Credits**
Prerequisite: BIEG 3201.
This course introduces the applications of continuum mechanics to the understanding of various biological tissue properties and biological fluid flow. The structure, function and mechanical properties of bone, muscle, blood vessels and blood flow will be examined. Conservation laws and constitutive equations for solid, fluid, and intermediate biomaterials will be covered. Critical analysis of current research in the field of biomechanics is also emphasized. Graduate Equivalent: BIEG 5403.

Faculty

Associate Professors

Balaji, *chair*
Belfadel
Macwan

Assistant Professor

Drazan
Estrada

Assistant Professors of the Practice

Freudzon

Instructors of the Practice

Cavallo