MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

The Fairfield University School of Engineering and Computing offers a master's degree in Biomedical Engineering. This 30-credit program 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 technological healthcare problems.

Program Overview

The Master's degree program in Biomedical Engineering provides students with an engineering education applied to the medical and biological environment. The educational path is intended to train students in the design of biomedical equipment, devices, materials and procedures. The program combines fundamentals of the biomedical sciences with analysis and design engineering methods. It brings together these two fields in order to contribute to the design of new medical instruments and devices, apply engineering principles for understanding and repairing the human body and other biological systems, and use engineering tools for decision making and cost containment.

Students

The degree is of interest to students who wish to engage in a specialization at the interface between engineering, computing and mathematical sciences, and biology. Students will engage in biomedical engineering areas as diverse as biomechanics, biomedical instrumentation, biomedical imaging, biomaterials, cellular engineering, tissue engineering, physical rehabilitation, and human performance.

Graduates

The degree provides students with the knowledge and tools to develop revolutionary healthcare devices, procedures, and treatment strategies for the 21st century. The field of biomedical engineering is expected to be among the leader in engineering employment growth in the next decade. A degree in biomedical engineering can lead to a career in academia, industry, or government. Connecticut has a growing demand for biomedical engineers who can find employment in organizations such as Hartford HealthCare Corporation, Yale-New Haven Health, Medtronic, Intuitive Surgical, Abbott, Regeneron, Zimmer Biomet, The Jackson Laboratory, Cooper Surgical, Boehringer Ingelheim, and Alexion Pharmaceuticals.

Program

Students with a Bachelor of Science in Biomedical Engineering or a similar degree from other universities apply through the graduate admissions website. Upon admission, 30 credits are required as per the programmatic details below in order to be awarded the M.S. degree in Biomedical Engineering.

The yearlong (two-semester) thesis option provides MS in Biomedical Engineering Students with the opportunity to pursue advanced research with a faculty advisor. The Non-Thesis option consists of 30 credits of coursework. Program requirements for both options are described below.

Thesis Option

Code	Title	Credits
BIEG 5319	Advanced Experimental Design in Biomedical Engineering	3
MATH 5417	Applied Statistics I	3
or SWEG 5317	Computational Statistics for Biomedical Sciences	
BIEG 6971	Thesis I	3
BIEG 6972	Thesis II	3
Select four Biomedical Engineering elective courses from approved list		12
Select two electives from Mechanical, Electrical, Computer, Software Engineering, Computer Science, Mathematics, or Management of Technology with approval from the program director.		6
Total Credits		**30**

Non-Thesis Option

Code	Title	Credits
BIEG 5319	Advanced Experimental Design in Biomedical Engineering	3
MATH 5417	Applied Statistics I	3
or SWEG 5317	Computational Statistics for Biomedical Sciences	
Select five Biomedical Engineering elective courses from approved list		15
Select three electives from Mechanical, Electrical, Computer, Software Engineering, Computer Science, Mathematics, or Management of Technology with approval from the program director		9
Total Credits		**30**

Biomedical Engineering Electives

Code	Title	Credits
Biomedical Engineering Electives		
BIEG 5301	Feedback Control System	3
BIEG 5309	Biosensors	3
BIEG 5311	Biomaterials	3
BIEG 5314	Introduction to Molecular Modeling	3
BIEG 5331	Biomedical Signal Processing	3
BIEG 5332	Biomedical Imaging	3
BIEG 5333	Biomedical Visualization	3
BIEG 5335	Clinical Engineering	3
BIEG 5370	Cardiac Mechanics	3
BIEG 5350	Medical Device Design	3
BIEG 5370	Cardiac Mechanics	3
BIEG 5375	Bioelectronics	3
BIEG 5387	Instrumental Analysis in Biomedical Engineering	3
BIEG 5403	Advanced Biomechanics	3
BIEG 5415	Engineering Applications of Numerical Methods	3
Non-Biomedical Engineering Electives (possible electives may include)		
Mechanical Engineering		
MEEG 5303	Industrial Automation	3

MEEG 5305	Design of Mechatronics Systems	3
MEEG 5312	Advanced Product Design and Manufacturing	3
MEEG 5319	Applications of Finite Element Analysis	3
MEEG 5372	Applications of Theory of Elasticity	3
Electrical Engineering		
ECEG 5315	Nanoelectronics I	3
ECEG 5335	Microelectronics	3
ECEG 5379	Communication Systems	3
ECEG 5480	Wireless Systems I	3
Computer Engineering		
ECEG 5303	Industrial Automation	3
ECEG 5325	Computer Graphics	3
ECEG 5346	Computer Systems Architecture	3
ECEG 5406	Advanced Digital Design	3
SWEG 5355	Artificial Intelligence	3
SWEG 5357	Database Management Systems	3
SWEG 5360	Machine Learning	3
Management of Technology		
MGMT 6584	Global Competitive Strategy	3
MGTN 5460	Project Management	3
MGMT 6508	Strategic Management of Technology and Innovation: The Entrepreneurial Firm	3
MGTN 5415	Information Systems	3
MGTN 5470	Leadership in Technical Enterprise	3

Courses

BIEG 5301 Feedback Control System **3 Credits**

This course emphasizes analysis and synthesis of closed loop control systems using both classical and state-space approaches with an emphasis on electro-mechanical systems. The mathematical requirements include the Laplace transform methods of solving differential equations, matrix algebra and basic complex variables. The discussion of classical control system design includes the modeling of dynamic systems, block diagram representation, time and frequency domain methods, transient and steady state response, stability criteria, controller action [Proportional (P), proportional and integral (PI), Proportional, integral and derivative (PID) and pseudo-derivatives feedback], root locus methods, the methods of Nyquist and Bode and dynamics compensation techniques. The discussion of state-space methods includes formulation and solution (analytical and computer-based) of the state equations and pole-placement design. The course integrates the use of computer-aided analysis and design tools (MATLAB) so as to ensure relevance to the design of real world controlled electro-mechanical systems using case studies and applications to electrical and mechanical systems. Includes hands-on lab (hardware-based) exploration of PID control systems. Undergraduate equivalent: ENGR 4301.

BIEG 5309 Biosensors **3 Credits**

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 students who intend to pursue a MS in BME can take this course.

BIEG 5311 Biomaterials **3 Credits**

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.

BIEG 5314 Introduction to Molecular Modeling **3 Credits**

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.

BIEG 5319 Advanced Experimental Design in Biomedical Engineering **3 Credits**

How do biomedical engineers know which medical problems are worth solving? How do they know that their inventions will work? How do they know that these inventions will be safe across a diverse population? This course uses a “flipped classroom” approach to answer these questions. It will build student skill in experimental design across the diverse disciplines of biomedical engineering with a focus on statistical analysis. Students will spend the first half of the semester reviewing/analyzing classic literature across biomedical engineering and performing classic experiments within our field. Students will spend the second half of the semester designing and performing their own custom-designed experiment that will be presented at Fairfield’s Innovative Research Symposium.

BIEG 5331 Biomedical Signal Processing **3 Credits**

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. Undergraduate equivalents: BIEG 3331, CPEG 3331.

BIEG 5332 Biomedical Imaging **3 Credits**

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. Undergraduate equivalent: BIEG 4332, ECEG 5332.

BIEG 5333 Biomedical Visualization **3 Credits**
An introduction to 3D biomedical visualization. Various technologies are introduced, include ultrasound, MRI, CAT scans, PET scans, etc. Students will learn about spatial data structures, computational geometry and solid modeling with applications in 3D molecular and anatomical modeling. Undergraduate equivalent: BIEG 4333.

BIEG 5335 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.

BIEG 5370 Cardiac Mechanics **3 Credits**
Prerequisite: Graduate 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. Undergraduate equivalent: BIEG 4370.

BIEG 5350 Medical Device Design **3 Credits**
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. Students are required to conduct an independent research, write a research report, create a poster and present the research in annual research symposium at the university or elsewhere. Undergraduate Equivalent BIEG 4350.

BIEG 5375 Bioelectronics **3 Credits**
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.

BIEG 5387 Instrumental Analysis in Biomedical Engineering **3 Credits**
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.

BIEG 5403 Advanced Biomechanics **3 Credits**
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.

BIEG 5407 Computational Genomics **3 Credits**
This course will provide an overview of computational genomics. Students will obtain skill in analyzing genomic data and sequencing experiments. The focus will be on achieving proficiency in data management and processing based on popular file formats in genomic biology.

BIEG 5415 Engineering Applications of Numerical Methods **3 Credits**
This course provides students with the theoretical basis to proceed in future studies. Topics include root-finding, interpolation, linear algebraic systems, numerical integration, numerical solution of ordinary and partial differential equations, modeling, simulation, initial boundary value problems, and two point boundary value problems. Cross-listed with MEEG 5415, ECEG 5415.

BIEG 5990 Independent Study **1-3 Credits**
Graduate students pursue special topics, projects, and/or readings in selected areas. Students must meet with the instructor to discuss the proposed topic of study. Enrollment by departmental approval only.

BIEG 6971 Thesis I **3 Credits**
The master's thesis tests students' abilities to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits students to demonstrate skills that are basic to academic and industry work. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic.

BIEG 6972 Thesis II **3 Credits**
The master's thesis tests students' abilities to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits students to demonstrate skills that are basic to academic and industry work. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic.