BIOMEDICAL ENGINEERING

OVERVIEW

Mission

The mission of the Department of Biomedical Engineering is to motivate and inspire students by providing high-caliber, fully integrated programs to prepare them to lead and participate in advancing the state of the art in health care technologies. In addition, graduates earn advanced degrees and further knowledge in the discipline by actively pursuing scholarly research for publication and dissemination.

Biomedical Engineering Program Educational Objectives

The biomedical engineering program in GW's Department of Biomedical Engineering prepares graduates who, in the years following graduation, will achieve:

- Employment in biomedical and other related industry, government or other organizations using skills and knowledge learned while an undergraduate student in the biomedical engineering program as evidenced by:
- Employment history and/or career advancements.
- Professional visibility (e.g., patents, invention disclosures, honors or awards, refereed journal articles, conference papers and other publications, involvement in professional associations).
- Entrepreneurial activities.

and/or

- Enrollment in biomedical engineering and other related graduate programs using skills and knowledge learned while an undergraduate student in the biomedical engineering program as evidenced by:
- Current enrollment in graduate or professional programs.
- Advanced degree earned.
- Professional visibility (e.g., patents, invention disclosures, honors or awards, refereed journal articles, conference papers and other publications, involvement in professional associations).

Student Outcomes

The Department of Biomedical Engineering aims to produce graduates who are able to:

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- 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.
- Communicate effectively with a range of audiences.
- Recognize ethical and professional responsibilities in engineering situations and make informed judgments that consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
- Function effectively on a team whose members work together too provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- Acquire and apply new knowledge as needed, using appropriate learning strategies.

UNDERGRADUATE

Bachelor's programs

- Bachelor of Science with a major in biomedical engineering (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/bs/)
  - Bachelor of Science with a second major in biomedical engineering (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/bs/)

Combined programs

- Dual Bachelor of Science with a major in biomedical engineering and Master of Science in the field of biomedical engineering (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/combined-bs-ms-biomedical-engineering/)
- Dual Bachelor of Science with a major in biomedical engineering and Master of Science in the field of computer engineering (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/combined-bs-biomedical-engineering-ms-computer-engineering/)
- Dual Bachelor of Science with a major in biomedical engineering and Master of Science in the field of computer science (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/combined-bs-biomedical-engineering-ms-computer-science/)
- Dual Bachelor of Science with a major in biomedical engineering and Master of Science in the field of electrical (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/combined-bs-biomedical-engineering-ms-electrical-engineering/)

Minor

- Minor in biomedical engineering (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/minor/)

GRADUATE

Master's programs

- Master of Science in the field of biomedical engineering (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/ms/)

DOCTORAL

Doctoral program

- Doctor of Philosophy in the field of biomedical engineering (https://bulletin.gwu.edu/engineering-applied-science/biomedical-engineering/phd/)

FACULTY

Professors: E. Entcheva, M. Kay, P. Prakash, J. Zara, V. Zderic (*Chair*)

Associate Professors: H. Choe, Z. Li, L. Lu, A. Papa, C. Park

Assistant Prof: J. Cho

Adjunct Faculty: V. Krauthamer

COURSES

Explanation of Course Numbers

- Courses in the 1000s are primarily introductory undergraduate courses
- Those in the 2000s to 4000s are upper-level undergraduate courses that can also be taken for graduate credit with permission and additional work assigned
- Those in the 6000s and 8000s are for master's, doctoral, and professional-level students
- The 6000s are open to advanced undergraduate students with approval of the instructor and the dean or advising office

BME 1010. Introduction to Biomedical Engineering. 1 Credit.
Basic and emerging concepts in electrical, computer, and biomedical engineering. Hands-on experiments and projects. Introduction to the professional literature and available resources and to technical writing, speaking, and presentation skills. (Fall, Every year)

BME 1020. Introduction to Biomedical Engineering. 2 Credits.
Continuation of BME 1010. Basic and emerging concepts in electrical, computer, and biomedical engineering; practical experiments and projects; introduction to the professional literature and available resources and to technical writing, speaking, and presentation skills. Prerequisite: BME 1010. (Spring, Every year)

BME 2210. Biomedical signals and systems. 3 Credits.
Topics covered include classification of signals and systems; convolution; Fourier series; Fourier transforms; filters; sampling; discrete transforms; and application to analysis of physiological signals and design of medical devices and systems. Prerequisites: ECE 2110 or an equivalent undergraduate course in ordinary differential equations and circuit theory, students who are uncertain about their preparation for this course should consult with the instructor. (Fall, Every year)

BME 2810. Biomedical Engineering Seminar I. 1 Credit.
BME 2810 and BME 2815 are taken in sequence by students in the biomedical engineering major. Overview of the field of biomedical engineering, including biomechanics, bioinformatics, telemedicine, instrumentation, and medical imaging. Prerequisite: BME 1020. (Fall)

BME 2815. Biomedical Engineering Seminar II. 1 Credit.
BME 2810 and BME 2815 are taken in sequence by students in the biomedical engineering major. Overview of the field of biomedical engineering, including biomechanics, bioinformatics, telemedicine, instrumentation, and medical imaging.

BME 2820. Biomedical Engineering Programming I: Data Analysis. 3 Credits.
An introduction to Python programming tailored to BME students. Students learn to set up and use Python development environments, including Conda/Google Collab, and explore fundamental programming concepts and techniques. (Spring, Every year)

BME 2825. Biomedical Engineering Programming II. 3 Credits.
Introduction to C Programming and fundamentals of data structures with a focus on biomedical engineering problems; the use of data structures, pointers, and linked lists and discuss concepts such as binary trees and sorting algorithms. Students are expected to understand the basics of programming concepts such as the use of functions, input/output, selection statements, loop statements, string manipulation, and debugging techniques are understood, but no prior knowledge of C is required. Prerequisites: BME 2820 or permission of the instructor. (Fall, Every year)

BME 3720. BME Programming II: Introduction to Assistive Robotics. 3 Credits.
Students learn applied concepts of programming using Python while studying the basics of robotics. They apply their ideas on advanced programming concepts with actual robotic systems through hands-on programming. Prerequisites: BME 2820 or the permission of the instructor. (Fall, Every year)

BME 3820. Engineering Analysis of Neural, Muscular, and Cardiovascular Physiology. 3 Credits.
Introduction to engineering principles that may be applied advantageously to medicine; considerations of present-day medical measurements (clinical and research); anatomy and physiology of the human body from system and cellular approaches. (Fall, Every year)

BME 3825. Medical Measurement Laboratory. 1 Credit.
Acquisition and measurement of anatomical and physiological parameters. Design and conduction of experiments using medical equipment to investigate medical questions. Development of technical writing using appropriate terminology. Prerequisites: BME 2815. (Fall, Every year)

BME 3907. Special Topics in Biomedical Engineering. 3 Credits.
Topics vary by semester. May be repeated for credit provided topic differs. See department for more details. (Fall, spring, and summer, Every year)

BME 3910. Capstone Design Preparation. 1 Credit.
Elements of project design; formulation of project ideas. Prerequisites: BME 2810 and BME 2815. (Fall, Every year)

BME 3915W. Biomedical Engineering Capstone Project Lab I. 1 Credit.
BME 3915, BME 4920, and BME 4925 are taken in sequence by departmental majors beginning in the second semester of the junior year. After an introduction to the formal design process, the student plans, refines, designs, and constructs a one-year project. Includes a significant engagement in writing as a form of critical inquiry and scholarly expression to satisfy the WID requirement. Prerequisite: BME 3910. (Same as ECE 3915W) (Spring, Every year)

BME 4480. Bioelectricity. 3 Credits.
Origin and applications of bioelectric phenomena; engineering tools for excitable cells, tissues and organs; biophysical and equivalent electrical engineering analysis; heart and brain abnormalities from a quantitative perspective. (Spring, Every year)

BME 4482. Medical Measurements. 3 Credits.
Theory of measurements in biological areas and techniques for electronic measurements on biological specimens. Experiments in acquisition, processing, and measurement of physiological signals, ECG, EEG, and EMG. (Fall, Every year)

BME 4488. Cell and Molecular Imaging. 3 Credits.
Basics of optics, microscopy, spectroscopy, and fluorescence in the context of imaging at the cellular and molecular level; advanced techniques for probing protein interactions and live cell functions; image processing algorithms and principles of scientific visualization. Restricted to juniors and seniors. Prerequisites: BME 2825 and ECE 3220. (Same as BME 6488) (Fall, Every year)

BME 4820. Anatomy and Physiology for Engineers. 3 Credits.
Human anatomy and physiology from an engineering viewpoint. Analysis of major physiological systems. Biopotentials, mechanics, gas exchange, chemical balance, electrical and chemical signaling, nervous control, voluntary and reflex factors. (Fall, Every year)

BME 4825. Biomedical Properties Laboratory. 1 Credit.
Introduction to biophysical concepts in a laboratory setting; emphasis on biomedical engineering. (Spring)

BME 4830. Introduction to Medical Imaging Methods. 3 Credits.
Application of linear systems analysis methods to medical imaging techniques; basic properties of imaging systems; physics and instrumentation behind modalities; advantages, disadvantages, and primary applications of modalities. Prerequisites: BME 3820 and ECE 3220. (Spring, Every year)

BME 4831. Introduction to Bioelectronics. 3 Credits.
Comprehensive introduction to materials, devices, and designs of bioelectronics and their application in lab-on-a-chip devices, wearables, neuroscience, and cardiology. Focus on state-of-the-art bioelectronic technologies.

BME 4832. Nanotherapeutics and Drug Delivery. 3 Credits.
The multiple aspects of the field of nanoparticle-based drug delivery, from basic concepts of syntheses and characterization of nanoparticles to their surface functionalization and activity in vitro and in vivo. (Fall, Every year)

BME 4835. Introduction to Assistive Robotics. 3 Credits.
Introduction to the basics of robotics and hands-on python programming. Covers multiple programming modules to access and control robotic components and architecture, with applications on assistive robots and biomedical solutions. Prerequisites: BME 2820. (Spring, Every year)

BME 4920W. Biomedical Engineering Capstone Project Lab II. 3 Credits.
BME 3915, BME 4920, and BME 4925 are taken in sequence by departmental majors beginning in the second semester of the junior year. After an introduction to the formal design process, the student plans, refines, designs, and constructs a one-year project. Includes a significant engagement in writing as a form of critical inquiry and scholarly expression to satisfy the WID requirement. Prerequisite: BME 3915W. (Same as ECE 4920W) (Fall, Every year)

BME 4925W. Biomedical Engineering Capstone Project Lab III. 3 Credits.
BME 3915, BME 4920, and BME 4925W are taken in sequence by departmental majors beginning in the second semester of the junior year. Students are introduced to the formal design process, and plan, refine, design, and construct a one-year project. Includes a significant engagement in writing as a form of critical inquiry and scholarly expression to satisfy the WID requirement. (Spring, Every year)

BME 4990. Research. 1-3 Credits.
Applied research and experimentation projects, as arranged. Restricted to juniors and seniors. (Fall and spring, Every year)

BME 6045. Special Topics. 1-3 Credits.
Topics to be announced in the Schedule of Classes.

BME 6050. Research. 1-12 Credits.
Applied research and experimentation projects, as arranged. May be repeated for credit. (Spring, Every year)

BME 6333. Biomedical Engineering Graduate Teaching Assistant Practicum. 3 Credits.
Provides students with supervised teaching experience, focusing on developing effective instructional methods and materials in engineering education, as well as mentoring skills in a professional setting. Restricted to doctoral candidates. (Spring and fall, Every year)

BME 6482. Medical Measurements. 3 Credits.
Theory of measurements in biological areas and techniques for electronic measurements on biological specimens. Experiments in acquisition, processing, and measurement of physiological signals, ECG, EEG, and EMG. (Fall)

BME 6483. Medical Instrumentation Design. 3 Credits.
The medical device design process and many of its key aspects, including needs assessment, regulatory processes and concerns, intellectual property, patient safety, and market analysis. (Spring)

BME 6484. Biomedical Signal Analysis. 3 Credits.
Origin, acquisition, and analysis of physiological signals. Deterministic and probabilistic modeling; fitting models; sequences and time series. Feature extraction from EEG and ECG; Fourier analysis and filtering; modeling. Noise/artifact removal. (Spring)

BME 6486. Clinical Medicine for Engineers. 3 Credits.
Overview of clinical medicine with emphasis on those areas most affected by engineering and technology. (Spring, Every year)

BME 6487. Rehabilitation Medicine Engineering. 3 Credits.
Cross-sectional view of those areas of medicine most involved with treatments for persons with disabilities; application of engineering theory and techniques to the rehabilitation of such persons. (Spring, Every year)

BME 6488. Cell and Molecular Imaging. 3 Credits.
Basics of optics, microscopy, spectroscopy, and fluorescence for imaging at the cellular and molecular level; advanced techniques for probing protein interactions and live cell functions; image processing algorithms and scientific visualization. Restricted to graduate students; advanced undergraduate students enrolled in the dual BS/MS in biomedical engineering degree program can be considered. Prerequisites: prior completion of coursework in basic biology and working skills in Matlab. Recommended background: Familiarity with computer programming. Same As: BME 4488. (Fall, Every year)

BME 6489. Telemedical Robotics and Machine Learning. 3 Credits.
Applies advanced robotic solutions to improving human lives through social, emotional, and interactive therapies. Social and behavioral therapies for children with autism spectrum disorder and emotional and rehabilitation assistance in elder care. Restricted to graduate students. Recommended background: Experience with computer programming. (Spring, Every year)

BME 6491. Microfabrication and Nanofabrication for Bioelectronics. 3 Credits.
Comprehensive introduction to the micro- and nanofabrication and processing methods to form the most important electronic and optical devices for bio-interfacing. Covers fundamental concepts to grow, deposit, pattern and integrate various materials.

BME 6492. Biology of Materials and Regenerative Medicine. 3 Credits.
Basic principles of biology, hematology and immunology directly related to biomaterials and regenerative medicine. Topics include blood cell physiology, organs-on-a-chip, cell viability assays, engineered blood vessels, and cancer immunoengineering. (Fall, Every year)

BME 6493. Medical Device Engineering Evaluation. 3 Credits.
The fundamentals of medical device engineering as it relates to regulatory evaluation. Students participate in projects and case studies with engineering standards using existing US and EU government databases. Restricted to graduate and advanced undergraduate students. Recommended background: engineering or science. (Fall, Every year)

BME 6830. Introduction to Medical Imaging Methods. 3 Credits.
Application of linear systems analysis methods to medical imaging techniques; basic properties of imaging systems; physics and instrumentation behind modalities; advantages, disadvantages, and primary applications of modalities. Recommended background: Knowledge of signal processing. (Spring, Every year)

BME 6840. Digital Image Processing. 3 Credits.
Properties of images and visual systems. Image acquisition, sampling, quantization. One- and two-dimensional image transform techniques; enhancement and restoration. Image coding and data compression. Segmentation, representation, boundary and shape, texture, matching. Image understanding. Prerequisites: ECE 6800. (Same as ECE 6840) (Spring, Odd years)

BME 6842. Image Engineering. 3 Credits.
Sensor/camera design and analysis as a system. Detection and noise processes underlying the sensing of optical radiation; the engineering and physics of image formation. Topics covered include radiometry/photometry, optics and image formation, device and camera characterization, and image quality metrics and system design trades. Prerequisites: ECE 6010 and ECE 6015. (Same as ECE 6842) (Fall, Every year)

BME 6850. Pattern Recognition and Machine Learning. 3 Credits.
Supervised learning: classification, regression. Bayes decision theory. Parametric, multivariate, nonparametric methods. Dimensionality reduction. Clustering, unsupervised learning. Decision trees. Perceptrons. Deep learning. Biomedical applications. Prerequisites: An undergraduate or graduate course in probability and in linear algebra; programming in any scientific language; or permission of instructor. Same As: ECE 6850. (Fall, Odd years)

BME 6885. Computer Vision. 3 Credits.
Image processing; edge detection, segmentation, local features, shape and region description in 2D and 3D. Insights from human vision studies. Representation for vision: object models, synthetic images, matching, gaps, algorithms. Interference, production system, syntactic networks. Planning spatial reasoning for robot vision. Prerequisites: CSCI 6511; and ECE 6850. Recommended background: Students in this course should have taken at least one prior course in artificial intelligence and/or pattern recognition; Acceptable courses include ECE 6850 (Pattern Recognition), or an equivalent course; If unsure, contact the instructor, and discuss the pre-requisite requirements. Same As: ECE 6885. (Spring, Even years)

BME 6998. Thesis Research. 3 Credits.
Thesis research.

BME 6999. Thesis Research. 3 Credits.
Thesis research.

BME 8999. Dissertation Research. 1-12 Credits.
May be repeated for credit. Restricted to doctoral candidates. (Fall, spring, and summer, Every year)