Biomedical Engineering Courses (BME)

BME Courses

This is a list of courses with the subject code BME. For more information, see Roy J. Carver Department of Biomedical Engineering (College of Engineering) in the catalog.

BME:1010 First-Year Forum 1 s.h.
Presentations by faculty, graduate students, collaborators from the Carver College of Medicine, and Colleges of Dentistry and Law; may include visits to laboratories and industries.

BME:2010 Professional Seminar: Biomedical Engineering 1 s.h.
Professional aspects of biomedical engineering presented through lectures and discussions by guest speakers, field trips, films, panel discussions. Requirements: sophomore or higher standing.

BME:2200 Systems, Instrumentation, and Data Acquisition 4 s.h.
Introduction to engineering art and science of modeling, acquisition, and analysis of data collected from living systems; modeling of physiological and biological systems; concepts of analog circuit design, with emphasis on circuits for collecting data for biomedical applications using operational amplifiers, active filters, conversion, and interface to microcomputers; patient safety; clinical circuits; analysis of data using time domain and Fourier domain techniques and models; time domain sampling, and Nyquist sampling theorem. Prerequisites: ENGR:2120. Corequisites: (HHP:3500 or HHP:2400 or BME:2260) and (BIOS:4120 or STAT:3510).

BME:2210 Bioimaging and Bioinformatics 4 s.h.
Introduction to bioinformatics and biomedical imaging; computer algorithms, machine learning, databases and SQL, the web and web servers, ethics, computer security, genome technology, public warehouses of biological data; medical imaging hardware and software for acquisition and analysis of medical images, especially those collected from X-ray, CT, MR, and ultrasound systems; medical imaging system physics, including interaction of energy with tissue, concepts of image spatial and temporal resolution; applications of filtering, enhancement, and image processing for analysis of medical images. Prerequisites: ENGR:1300 and BIOL:1411. Corequisites: BIOS:4120 or STAT:3510.

BME:2260 Quantitative Physiology 3 s.h.
Introduction to core concepts in human physiology, homeostatic regulation, and structure-function relationships across cellular and organ systems; emphasis on analytical and quantitative methods including topics from dynamical systems, systems analysis, feedback, and control; students use mathematical modeling and computational simulation (MATLAB) to explore sensitivity analysis and emergent phenomena in complex physiological systems. Prerequisites: CHEM:1120 and BIOL:1411 and MATH:2560 and ENGR:1300.

BME:2400 Cell Biology for Engineers 3 s.h.
Introduction to fundamental concepts in quantitative cell biology from an engineering perspective. Prerequisites: BIOL:1411. Corequisites: BIOS:4120 or STAT:3510.

BME:2500 Biomaterials and Biomechanics 4 s.h.
Introduction to mechanics and materials in biological systems; principles of mechanics (stress, strain, motion, fluid flow) presented and used to characterize behavior of biological entities (tendon/ligament, bone and cartilage, blood, blood vessels, heart); principles of material science; role of biomaterials (metals, polymers, ceramics) in medical devices. Prerequisites: ENGR:2110. Corequisites: (HHP:3500 or HPP:2400 or BME:2260) and (BIOS:4120 or STAT:3510).

BME:2710 Engineering Drawing, Design, and Solid Modeling 3 s.h.
Introduction to methods and principles used by engineers to define and describe geometry and topology of engineered components; use of Parametric Technology's Creo Pro (formerly ProEngineer) 3D computer-aided design software; emphasis on elements of design; basic commands used in parametric design to develop spatial visualization skills and the ability to create and understand 3D solid parametric design for assembly and 3D drawing documentation; creation of 3D assemblies and detailed drawings from art of design to part utilization of solid modeling techniques.

BME:3710 Medical Device Design: The Fundamentals 3 s.h.
Introduction to medical device design process; project-based; development of prototyping and fabrication skills needed for engineering design projects, safety, communication, and teamwork; focus on physical rehabilitation science and assistive technologies; preparation for senior design course sequence. Prerequisites: BME:2500 and BME:2710. Requirements: junior standing.

BME:3995 Undergraduate Research in Biomedical Engineering arr.
Research performed by a biomedical engineering student under mentorship of a faculty supervisor.

BME:3998 Individual Investigations: Biomedical Engineering arr.
Individual projects for biomedical engineering undergraduate students, such as laboratory study, engineering design projects, analysis and simulation of an engineering system, computer software development.

BME:4135 Health Monitoring of Structural and Mechanical Systems 3 s.h.
Measurements, structural modeling, structural analysis, stiffness method, trusses and frames, structural testing, modal analysis. Prerequisites: ENGR:2750. Same as CEE:4135, ME:4235.

BME:4310 Computational Biochemistry 3 s.h.
Introduction to biomolecular modeling and computer simulation techniques; biomolecular structure and molecular driving forces; principles of structural optimization and conformational sampling; applications to biomolecular phenotypes; scripting and molecular visualization in PyMol, setting up and running molecular dynamics simulations using VMD and NAMD, performing refinement of X-ray diffraction data sets using Phenix, and executing Poisson-Boltzmann electrostatic calculations using APBS. Prerequisites: (MATH:1560 or MATH:1860) and CHEM:1120. Recommendations: BMB:3110 or BMB:3120. Same as BMB:4310.

BME:4314 Introduction to Synthetic Biology in the Lab 4 s.h.
Introduction to theory and practice of large-scale design goals of synthetic biology in which various types of DNA instructions, known from decades of research and discovery on specific biological systems, are taken out of context and used to execute various novel tasks designed to solve real-world problems; basic laboratory instruction in standardized construction techniques for stringing together off-the-shelf DNA components that are then introduced into organisms capable of executing the instructional set; controlled experiments to investigate the degree of variability exhibited by engineered genetic constructs. Prerequisites: BIOL:1411. Same as BIOL:4314.

BME:4710 Medical Device Design Studio 3 s.h.
Intermediate medical device design geared towards electro-mechanical design and techniques; builds on foundational knowledge acquired in BME:3710 and BME:2200; focus on advanced prototyping skills including solid modeling, proper electrical component selection, integrating electrical components into hardware design, and testing electro-mechanical device against industry standards. Prerequisites: BME:2200 and BME:2500 and BME:2710 and BME:3710.

BME:4910 Biomedical Engineering Senior Design I 4 s.h.
Individual or group work on a creative design project involving current problems in biomedical engineering; interdisciplinary projects involving biomedical engineering and health sciences faculty members; first semester of a year-long senior capstone design project. Prerequisites: BIOS:4120 or STAT:3510. Requirements: senior standing.

BME:4920 Biomedical Engineering Senior Design II 4 s.h.
Second semester of a year-long senior capstone design project begun in BME:4910. Prerequisites: BME:4910.

BME:5010 Seminar in Biomedical Engineering 0 s.h.
Presentation of recent advances in biomedical engineering. Requirements: graduate standing.

BME:5101 Biomaterials and Implant Design 3 s.h.
Introduction to material and mechanical considerations underlying a broad range of medical implants; emphasis on understanding factors involved in orthopedic device design; major classes of biomaterials; considerations that underlie implant design, use, failure; contemporary areas of biomaterials and implant development. Prerequisites: ENGR:2750 and BME:2500.

BME:5200 Biomedical Signal Processing 3 s.h.
Application of signal processing methods (e.g., Fourier, Laplace, z-transforms) to biomedical problems, such as analysis of cardiac signals, circadian rhythm, the breathing cycle; computer simulation lab. Same as IGPI:5212.

BME:5210 Medical Imaging Physics 3 s.h.
Physics and data acquisition techniques of major medical imaging modalities (X-ray, CT, MR, ultrasound, PET, SPECT); physical interactions of energy with living tissue; principles and methods for acquiring imaging data and subsequent image construction; how individual modalities influence image quality; MATLAB programming required. Second in a medical imaging sequence. Prerequisites: BME:2200 and BME:2210. Same as ECE:5470, IGPI:5206.

BME:5240 Deep Learning in Medical Imaging (DLMI) 3 s.h.
Overview of deep learning architectures related to medical image analysis, including convolutional neural networks, auto-encoders, generative adversarial networks, and transformers; solve challenging medical imaging problems using image diagnosis, detection, segmentation, registration, and synthesis; use Python libraries including PyTorch, MONAI, SimpleITK, NumPy, and Matplotlib. Prerequisites: ENGR:3110. Requirements: practical knowledge of programming. Recommendations: ECE:5480, proficiency in Python, and comfortable with calculus, matrix algebra, and basic probability and statistics.

BME:5251 Advanced Biosystems 3 s.h.
Biological systems unique to systems analysis; operation under nonequilibrium conditions; tools for systems analysis developed from models of systems at equilibrium (i.e., mechanical systems); fundamental difference between biological and mechanical systems that impact systems analysis; expand knowledge of linear systems and begin work with nonlinear systems; various modeling and analysis approaches useful in biomedical and biomedical engineering research. Prerequisites: BME:2200. Same as IGPI:5251.

BME:5335 Computational Bioinformatics 3 s.h.
Introduction to computational methods used in genomics, genome analysis, biological sequence analysis, sequence database search, expression analysis, and biological network analysis; in-depth coverage of principal genome science challenges and contemporary solutions. Prerequisites: (BIOS:4120 or STAT:2020 or STAT:3510) and (CS:5110 or ENGR:1300).

BME:5340 Contemporary Topics in Biomedical Engineering 3 s.h.
New and emerging areas of biomedical engineering and related fields; specific content varies.

BME:5421 Cell Material Interactions 3 s.h.
Examine the current knowledge of cell and material interactions in terms of biomaterial science, the mechanobiology of native tissues and engineered analogs, and immunity. Prerequisites: BME:2400.

BME:5430 Biotransport 3 s.h.
Energy, mass, and momentum transport in living systems; processes essential for understanding how physiological systems function from molecular level through scale of tissues and organs; fluid mechanics and physiological flows, mass transport, biochemical kinetics and reactions, bioheat transfer; conservation laws; various biological applications. Prerequisites: BME:2500.

BME:5431 Biofabrication for Tissue Engineering 3 s.h.
Understanding the principles and approaches of advanced biofabrication for tissue engineering and regenerative medicine. Biofabrication relies on the use of biological materials and cells to create bioengineered tissue to regenerate or repair diseased or injured tissues and organs, such as respiratory bioengineering. Emphasis is on the fundamental mechanisms, processing conditions, and bioinspired strategies of biofabrication, additive approaches, the integration of molecular sciences, and tissue-level micro-physiological systems. Prerequisites: ENGR:2110 and BME:2400 and BME:2500.

BME:5435 Systems Biology for Biomedical Engineering 3 s.h.
Although systems biology is comprised of both experimental and computational aspects, focus is on computational aspects; introduction to deterministic models of biochemical reaction networks; development and application of mathematical models of reaction networks using systems of nonlinear ordinary differential equations; numerical techniques employed to study system stability and perform simulations in realistic biological contexts. Prerequisites: BME:2400 and BME:2200.

BME:5441 Numerical and Statistical Methods for Bioengineering 3 s.h.
Mathematics and computation as indispensable tools needed to model and explain complex phenomena relevant to biomedical engineering problems; introduction to concepts from linear algebra, differential equations, probability and statistics, nonlinear model regression, optimization, numerical integration, and other numerical methods, all using Matlab. Prerequisites: MATH:2560 and MATH:2550.

BME:5445 Stem Cells in Regenerative Engineering 3 s.h.
Discovery and history of stem cells, how they are defined and grouped, and various techniques for their isolation, creation, culture, and characterization; focus on current state of stem cells in medical research and treatment of human disease, as well as future outlook of their use; particular emphasis placed on practical knowledge that students may find useful as they pursue careers in cellular and tissue engineering. Prerequisites: BME:2400 or BIOL:2723.

BME:5451 Research Methods in Cellular Engineering 3 s.h.
Statistical approaches and principles of assays routinely used in cell engineering; design of experiments and statistical approaches commonly used to analyze biological data including t-tests and one- and two-way ANOVAs, taking into consideration the constraints of cellular engineering research; students design, execute, and analyze data collected from actual experiments; review of recently published literature and analysis of public data sets to understand how each assay and test contributes to understanding of cellular phenotype. Prerequisites: BIOL:1411 and (STAT:3510 or BIOS:4120).

BME:5460 Biomedical Micro Devices and Systems 3 s.h.
Micro-sized devices have impacted a variety of biomedical research and successfully entered the mainstreaming commercial markets, such as biochemical molecule sensing, single-cell transcriptomics, cell sorting, and high-throughput drug screening. These micro-devices include lab-on-a-chip, microfluidic, micro-electro-mechanical, micro total analysis systems, and beyond. Examine the history, theory, design, fabrication, and functional units of micro-sized devices; discuss the state-of-the-art technologies and real-life biomedical applications; fabricate and operate lab-on-a-chip devices. Prerequisites: BME:2500.

BME:5510 Cardiovascular Engineering 3 s.h.
Mechanics—forces and motion—at the heart of the cardiovascular system; fluid and solid mechanics inherent to the motion of the heart, valves, arteries, and veins, and how they facilitate the flow of blood; how to use mechanics to understand and diagnose the severity of cardiovascular disease states and to design implants and devices. Prerequisites: BME:2500.

BME:5525 Cardiopulmonary Design and Modeling 3 s.h.
Cardiac and pulmonary systems; physiologic fluid mechanics critical to tissue/organ function, transport, homeostasis, and disease progression; diseases that afflict cardiopulmonary system; focus on role of fluid mechanics in how diseases develop, progress, and are treated; use of computational modeling tools to simulate disease conditions and understand challenges of designing devices and interventions. Prerequisites: ENGR:2510 and BME:2500.

BME:5540 Quantitative Studies of Respiratory and Cardiovascular Systems 3 s.h.
Quantitative physiological aspects of respiratory and cardiovascular systems; classical linear and nonlinear models, including lumped and distributed parameter models to predict air and blood flows in branching tree structures; biomedical instrumentation for respiratory and cardiovascular measurements; computer models to simulate the behavior of the respiratory and cardiovascular systems in frequency and time domains, under conditions of health and disease; functional and quantitative imaging techniques for the respiratory and cardiovascular systems. Prerequisites: BME:2200.

BME:5610 Musculoskeletal Biomechanics 3 s.h.
Fundamentals of mechanical principles applied to analytical and experimental investigations of musculoskeletal systems, emphasizing biomechanical understanding of clinical problems in bones, tendons, ligaments, cartilages, and musculoskeletal joints. Prerequisites: BME:2500 and ENGR:2750.

BME:5620 Introduction to Applied Biomedical Finite Element Modeling 3 s.h.
Introduction to finite element modeling techniques, software, and analysis with particular emphasis on solid biomechanics applications. Topics include various modeling techniques (pre- and post-processing), element types, convergence, anatomic modeling, model verification and validation, and appropriate communication of finite element results. Prerequisites: ENGR:2750 and BME:2500.

BME:5630 Kinetics of Musculoskeletal Systems 3 s.h.
Principles of kinematic and kinetic analyses of multibody systems; multivariable calculus and vectors and matrices required for multibody kinetic analyses; examples of mathematical modeling and human musculoskeletal system. Prerequisites: ENGR:2710.

BME:5640 Ergonomics of Occupational Injuries 3 s.h.
Epidemiology, surveillance systems, ergonomics, biomechanics, physiology, psychology, legal aspects, and cost control. Prerequisites: BME:2500. Corequisites: ENGR:2750.

BME:5715 Advanced Medical Device Design Studio 3 s.h.
Continuation of BME:3710 and BME:4710; biomedical engineering project based; focus on advanced prototyping and manufacturing techniques of mechanical and electromechanical medical devices; implementation of design controls and testing to medical industry standards for quality and safety; development of project management skills and communication within a team; final course in medical device design sequence. Prerequisites: BME:2200 and BME:2500 and BME:2710 and BME:3710 and BME:4710.

BME:5720 Optimization of Structural Systems 3 s.h.
Advanced topics; optimization of structural topology, shape, and material; finite dimensional dynamic response optimization, sensitivity analysis, distributed parameter systems; projects. Same as CEE:5236.

BME:5998 Individual Investigations: Biomedical Engineering **arr.**
Individual projects for biomedical engineering graduate students, such as laboratory study, engineering design project, analysis and simulation of an engineering system, computer software development, research. Requirements: graduate standing.

BME:5999 Research: Biomedical Engineering MS Thesis **arr.**
Experimental and/or analytical investigation of an approved topic for partial fulfillment of the requirements for the MS with thesis in biomedical engineering. Requirements: graduate standing.

BME:6225 Communicating Science **3 s.h.**
Writing and speaking about biomedical engineering and science research; key principles of writing with clarity and cohesion; practice applying these principles on a piece of research writing students are currently working on; review of best practices for presenting research to peers and at conferences; students share their work with peers through writing and presentations.

BME:6230 Principles of Magnetic Resonance Imaging **3 s.h.**
MRI is a powerful and versatile imaging modality capable of providing a wide variety of contrast mechanisms and visualizing soft tissues in detail; principles of MRI from a signal processing perspective; MATLAB programming, literature readings, final project, visits to MRI research scanner facility, guest lectures from leading MRI experts; MRI concepts, interpretation of commonly used pulse sequences in clinical MRI, and emerging trends in MRI. Prerequisites: BME:5210 or BME:5200 or ECE:5460. Recommendations: familiarity with digital signal processing.

BME:6415 Advanced Biomechanics and Modeling of Soft Tissues **3 s.h.**
Application of continuum mechanics to the study of soft biological tissues and biomaterials; soft tissue mechanical behaviors such as nonlinear elasticity, viscoelasticity, and anisotropy; use of principles from continuum mechanics for characterizing three dimensional deformation of tissues and development of constitutive models to describe material behavior.

BME:7999 Research: Biomedical Engineering PhD Dissertation **arr.**
Experimental and/or analytical investigation of an approved topic for partial fulfillment of requirements for PhD with thesis in biomedical engineering.