Biomedical Engineering Courses (BME)

This is a list of all biomedical engineering courses. For more information, see Biomedical Engineering.

**BME:0000 Biomedical Engineering Internship/Co-op** 0 s.h.
Biomedical engineering students participating in the Cooperative Education Program register for this course during work assignment periods; registration provides a record of participation in the program on the student's permanent record. Requirements: admission to Cooperative Education Program.

**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:2110 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: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, 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: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, 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) 3-D CAD software; emphasis on elements of design; basic commands used in parametric design to develop spatial visualization skills and the ability to create and understand 3-D solid parametric design for assembly and 3-D drawing documentation; creation of 3-D assemblies and detailed drawings from art of design to part, utilization of solid modeling techniques.

**BME:3010 Leadership and Resourcefulness** 1 s.h.
Development of leadership skills and resourcefulness for real-world professional work and life. Requirements: completion of BME:1010 and two semesters of BME:2010.

**BME:3200 Systems Biology for Biomedical Engineers** 3 s.h.
Introduction to computational approaches relevant to systems biology; although systems biology is comprised of both experimental and computational aspects, the focus is on the latter, providing an introduction to the use of deterministic models to study biochemical reaction networks; computational models will be constructed using Wolfram Mathematica to provide insights into the complexities of biochemical systems and also serve to acquaint students with the types of modeling approaches used to study these systems. Prerequisites: BME:2110 and BME:2200.

**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. Corequisites: BME:4010. Requirements: junior standing.

**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, research.

**BME:4010 Biomedical Engineering Design Seminar** 1 s.h.
Information and presentations about possible projects; mentors available for senior design projects. Requirements: junior standing.
BME:4110 Principles of Regenerative Bioengineering 3 s.h.

Embryonic, fetal, and adult sources, human and nonhuman “stemness” of cells; references to biomaterials (i.e., those designed to direct organization, growth, and differentiation of cells in process of forming functional tissue by providing physical and chemical cues); biomarkers and nano-medicine; promises of bioinformatics in support tissue engineering, gene and protein sequencing, gene expression analysis, protein expression, and interaction analysis. Prerequisites: BIOL:1411. Corequisites: HHP:3500. Recommendations: BME:2110.

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: BIOC:3110 or BIOC:3120. Same as BIOC: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: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 IGPI:5206.

BME:5220 Digital Image Processing 3 s.h.

Mathematical foundations and practical techniques for digital manipulation of images; image sampling, compression, enhancement, linear and nonlinear filtering and restoration; Fourier domain analysis; image pre-processing, edge detection, filtering; image segmentation. Prerequisites: ECE:2400 or BME:2200. Same as ECE:5480, IGPI:5480.

BME:5230 Multidimensional Medical Imaging Process 3 s.h.

Algorithms developed to process and analyze large volumetric data sets; physics of CT, MRI, ultrasound, 3-D convolution and filtering, geometric transformations, shape features, surface segmentation, regional segmentation, surface tiling, surface reconstruction, volumetric registration. Third in a medical imaging sequence. Prerequisites: ENGR:1300.

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:5320 Bioinformatics Techniques 3 s.h.

Informatics tools and techniques applied to modern problems in biomedicine and basic life sciences; common tools, experience applying tools in contemporary problem settings; genomics and genetics, how to sequence a genome, transcription and expression, SNPs, Perl, BioPerl, Perl modules, Ensembl API, BLAST/BLAT, NCBI, UCSC, Ensembl Genome browsers, linkage, association, disease gene identification. Prerequisites: BIOL:1411 and (ENGR:2730 or CS:2110 or CS:2110 or CS:5110). Same as ECE:5210, IGPI:5321.

BME:5330 Computational Genomics 3 s.h.

Introduction to computational methods used in genome analysis and functional genomics; biological sequence analysis, sequence database search, microarray data analysis, biological network analysis; in-depth coverage of principal genome science challenges and recent solutions. Prerequisites: (BIOS:4120 or STAT:3510) and BME:5320 and (CS:5110 or ENGR:1300). Same as BIOL:5320, ECE:5220, GEN:5173, IGPI:5330.

BME:5340 Contemporary Topics in Biomedical Engineering 3 s.h.

New and emerging areas of biomedical engineering and related fields; specific content varies.

BME:5401 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:5415 Polymer Fundamentals 3 s.h.
Basic knowledge of polymers required as a foundation for other UI courses on polymers: basic polymer terminology, polymer groups, polymerization mechanisms, molecular weight determination. Five weeks. Same as CBE:5309.

BME:5421 Cell Material Interactions 3 s.h.
Current thought and techniques in the engineering and assessment of biomaterials. Prerequisites: BME:2110.

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: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:2110 and BME:2200 and BME:5430.

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:2110 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 BIOS:4120.

BME:5510 Cardiovascular Biomechanics 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:5520 Cardiovascular Fluid Mechanics 3 s.h.

BME:5530 Design of Circulatory Implants and Artificial Organs 3 s.h.
Exploration of current innovations and new technologies; examination of various devices currently on the market from a standpoint of design variables and objectives (i.e., stents, heart valves, dialyzers, VADs, artificial organs); biomedical engineers’ vital role in design and improvement of these implants. Prerequisites: BME:2500.

BME:5540 Quantitative Studies of Respiratory and Cardiovascular Systems 3 s.h.
Quantitative physiological aspects of respiratory and cardiovascular systems; classical models of these systems are considered including lumped element models, branching tree structures, and distributed parameter models to predict wave propagation in compliant walled tubes filled with compressible or incompressible fluids; development of extensive computer models to simulate the behavior of these systems in frequency- and time-domains, under various conditions of health and disease. Prerequisites: BME:2200 and HHP:3500.

BME:5550 Cardiovascular Tissue Mechanics 3 s.h.
Solid mechanics principles applied to understand behavior of tissues in the cardiovascular system; mechanical properties of ventricles, valves, and blood vessels, their normal function, how they are affected by disease states; solid mechanics of tissue-prosthesis interactions. Prerequisites: ENGR:2750 and BME:2500. Corequisites: BME:5510.

BME:5610 Musculoskeletal Biomechanics 3 s.h.
Principles of solid mechanics applied to analitical, experimental investigation of biological systems; emphasis on applications in kinesiology of human musculoskeletal system. Prerequisites: BME:2500 and ENGR:2750.

BME:5620 Introduction to Applied Biomedical Finite Element Modeling 3 s.h.
Introduction to finite element modeling as applied to biomechanics-related applications. Prerequisites: ENGR:2750 and BME:2500.

BME:5630 Kinetics of Musculoskeletal Systems 3 s.h.
Principles of kinematics, kinetics applied to analitical and experimental investigation of musculoskeletal systems; mathematical foundations for kinematic and kinetic analyses; examples of mathematical modeling of human movements. 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:5660 Intermediate Mechanics of Deformable Bodies 3 s.h.
Application of equilibrium analyses, strain-displacement relations, and constitutive relationships to practical structural systems and elementary plane elasticity problems. Prerequisites: ENGR:2750. Same as CEE:5540, ME:5150.
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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BME:5720</td>
<td>Optimization of Structural Systems 3 s.h.</td>
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<td>Advanced topics; optimization of structural topology, shape, and material; finite dimensional dynamic response optimization, sensitivity analysis, distributed parameter systems; projects. Same as CEE:5236, ME:5236.</td>
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<tr>
<td>BME:5910</td>
<td>Fast-Track Biomedical Engineering Design 1-A 3 s.h.</td>
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<td>Part A of first semester of year-long senior capstone design project; individual or group design project involving biomedical engineering problems. Corequisites: BME:5911. Requirements: senior standing.</td>
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<tr>
<td>BME:5911</td>
<td>Fast-Track Biomedical Engineering Design 1-B 1 s.h.</td>
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<td>Part B of first semester of year-long senior capstone design project; individual or group project involving biomedical engineering problems. Corequisites: BME:5910. Requirements: senior standing.</td>
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<tr>
<td>BME:5920</td>
<td>Fast-Track Biomedical Engineering Design 2-A 3 s.h.</td>
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<td>BME:5921</td>
<td>Fast-Track Biomedical Engineering Design 2-B 1 s.h.</td>
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<tr>
<td>BME:5998</td>
<td>Individual Investigations: Biomedical Engineering arr.</td>
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<td>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.</td>
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<tr>
<td>BME:5999</td>
<td>Research: Biomedical Engineering M.S. Thesis arr.</td>
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<td>Experimental and/or analytical investigation of an approved topic for partial fulfillment of the requirements for the M.S. with thesis in biomedical engineering. Requirements: graduate standing.</td>
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<tr>
<td>BME:6110</td>
<td>Mechanics of Cells and Cellular Systems 3 s.h.</td>
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<td>Mechanics of cells; focus on cellular mechanical properties, responses to mechanical stimuli, cellular forces and measurement, and computational tools; cellular environment considered with implication to disease pathologies and medical device design considerations.</td>
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<tr>
<td>BME:6225</td>
<td>Communicating Science 3 s.h.</td>
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<td>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.</td>
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<td>BME:6415</td>
<td>Advanced Biomechanics and Modeling of Soft Tissues 3 s.h.</td>
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<td>Application of continuum mechanics and modeling to study of biological tissues and biomaterials.</td>
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<td>BME:6515</td>
<td>Advanced Biological Soft Tissue Mechanics 3 s.h.</td>
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<td>Topics in vascular solid mechanics; study of vascular tissue from theoretical (constitutive modeling), experimental, and computational perspectives.</td>
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<td>BME:6520</td>
<td>Advanced Biofluid Mechanics 3 s.h.</td>
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<td>Hemodynamic theories of atherogenesis, Womersley models, steady and unsteady flows in curavature, bifurcation and branching arterial segments, flow dynamics past prosthetic implants, experimental and computational models, particulate and mass transport simulations in human circulation. Prerequisites: BME:5520.</td>
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<tr>
<td>BME:6610</td>
<td>Spine Mechanics 3 s.h.</td>
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<td>Biomechanics applied to mechanics of the human spine; clinical aspects; state-of-the-art in spine research; basic engineering principles for biomechanical analysis. Prerequisites: BME:5610.</td>
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<td>BME:6630</td>
<td>Human Response to Vibration 3 s.h.</td>
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<td>Exploration of the human body, a complex mechanism exposed to mechanical shock and vibration from many sources, under many conditions; interactions and applicable exposure standards, effects of whole-body and hand-arm vibration. Requirements: graduate standing in College of Engineering or College of Public Health.</td>
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<tr>
<td>BME:7999</td>
<td>Research: Biomedical Engineering Ph.D. Dissertation arr.</td>
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<td>Experimental and/or analytical investigation of an approved topic for partial fulfillment of requirements for Ph.D. with thesis in biomedical engineering.</td>
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