BIOMEDICAL ENGINEERING (BME)

NOTE: All prerequisites for Biomedical Engineering (BME) courses must be completed with a grade of "C-" or better.

Biomedical Engineering (BME) Courses

BME 1002. Introduction to Biomedical Engineering. (2-0) 2 Credit Hours.
Prerequisite: A grade of "C-" or better, or concurrent enrollment in BIO 1203, BIO 1201, and MAT 1213 (or MAT 1214 in previous catalogs). This course is an introduction to the interdisciplinary field of biomedical engineering. Topics covered include core biomedical engineering areas, fundamental concepts, ethics, professionalism, careers, and technical skills. Generally offered: Spring. Course Fee: LRE1 $20; STSE $25.

BME 2103. Physiology for Biomedical Engineering. (3-1) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BIO 1203 and BIO 1201; completion of or concurrent enrollment in MAT 1213 (or MAT 1214 in previous catalogs). Fundamental principles of general and organ systems physiology, including composition and concentration of cellular and other body fluids, types of transport (e.g., diffusion, membrane transporters), energy (e.g., thermodynamics, metabolism), enzymes, feedback control, and membrane potentials with engineering applications and mathematical modeling. This course includes a 3-hour lecture and a 1-hour recitation. (Same as CME 2113. Credit cannot be earned for both BME 2103 and CME 2113.) Generally offered: Fall. Course Fee: LRE1 $25; STSE $30.

BME 2203. Biomechanics I. (3-1) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in EGR 2302 or EGR 2323 and PHY 1943; completion of or concurrent enrollment in BME 3211 and EGR 3423. Introduction to fundamental engineering mechanics with a focus on the human body. This course includes a 3-hour lecture and a 1-hour recitation. (Same as CME 2803. Credit cannot be earned for both BME 2203 and CME 2803.). Course Fee: LRE1 $25; STSE $30; DL01 $75.

BME 3003. Biomaterials I. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 1002 and CHE 1113. Introduction to the fundamental science of natural and synthetic biomaterials used for repairing human tissues and organs. Topics include crystal structures, phase diagrams, and properties of materials. (Formerly listed as BME 2403 in previous catalogs. Credit cannot be earned for both BME 3003 and CME 3003.) This course has Differential Tuition. Course fee: DL01 $75.

BME 3013. Clinical Internship in Biomedical Engineering. (0-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3113 and BME 3121. This course will introduce students to the clinical environment, interacting with clinicians on current clinical problems, and engineering approaches. Generally offered: Summer. This course has Differential Tuition.

BME 3023. Biomedical Engineering Technology and Product Development. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3013 and BME 3303. This course will introduce students to current biomedical technologies and product development. (Formerly BME 3022. Credit cannot be earned for both BME 3023 and BME 3022.) This course has Differential Tuition. Course fee: DL01 $75.

BME 3033. Biomedical Engineering Internship. (0-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3023. Internship with a biomedical industry. May be repeated for credit, but no more than 3 semester credit hours will apply to a bachelor's degree. This course has Differential Tuition.

BME 3041. Biomedical Engineering Research. (0-0) 1 Credit Hour.
Prerequisite: Consent of instructor. Advanced laboratory practice and introduction to biomedical engineering research. This course may be counted as one of the courses to satisfy one of the BME tracks. May be repeated for credit, but no more than 3 semester credit hours will apply towards a bachelor's degree in Biomedical Engineering. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $10.

BME 3042. Biomedical Engineering Research. (0-0) 2 Credit Hours.
Prerequisite: Consent of instructor. Advanced laboratory practice and introduction to biomedical engineering research. This course may be counted as one of the courses to satisfy one of the BME tracks. May be repeated for credit, but no more than 3 semester credit hours will apply towards a bachelor's degree in Biomedical Engineering. This course has Differential Tuition.

BME 3043. Biomedical Engineering Research. (0-0) 3 Credit Hours.
Prerequisite: Consent of instructor. Advanced laboratory practice and introduction to biomedical engineering research. This course may be counted as one of the courses to satisfy one of the BME tracks. May be repeated for credit, but no more than 3 semester credit hours will apply towards a bachelor's degree in Biomedical Engineering. This course has Differential Tuition.

BME 3113. Cellular Biology for Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BME 2103. Introduction to concepts and principles in cell and molecular biology. Topics include the structure and function of biomolecules, the fundamentals of DNA synthesis and repair, gene expression, cell metabolism, cell signaling, the cytoskeleton, and the cell cycle. (Formerly BME 3114. Same as CME 3113. Credit can only be earned for one of the following: BME 3113, BME 3114, and CME 3113.) This course has Differential Tuition.

BME 3121. Cellular Biology for Biomedical Engineering Laboratory. (0-3) 1 Credit Hour.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 2103; completion of or concurrent enrollment in BME 3113 (formerly BME 3114). This laboratory course is designed to reinforce concepts from BME 3113 (formerly BME 3114) and provide students with the ability to use techniques and procedures commonly used in cell and molecular biology with biomedical engineering applications. This course has Differential Tuition. Course fee: L001 $30.

BME 3203. Biomechanics II: Cardiovascular. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203 and BME 3211. Continuation of fundamental biomechanics to include elasticity, viscoelasticity, deformation, stress analysis, blood flow in the systemic and pulmonary circulation, and fluid-structure interaction. (Same as CME 3803. Credit cannot be earned for both BME 3203 and CME 3803.) Generally offered: Fall. This course has Differential Tuition. Course Fee: DL01 $75.

BME 3211. Biomedical Engineering Laboratory I. (0-4) 1 Credit Hour.
Prerequisite: A grade of "C-" or better in BME 1002; completion of or concurrent enrollment in BME 2203, BME 3003, and either STA 1403 or STA 2303. A biomedical engineering lab in biomechanics and biomaterials. This lab-based course will emphasize the synthesis and characterization of mechanical properties as well as physical and chemical properties of biomaterials. (Formerly listed as BME 2211 in previous catalogs. Credit cannot be earned for both BME 3211 and BME 2211.) This course has Differential Tuition. Course Fee: L001 $30.

BME 3303. Bioinstrumentation. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203. Fundamental principles of bioinstrumentation used in clinical and research measurements will be covered. Topics include: principles of transducer operation, amplifiers and signal processing, recording and display. This course includes a 3 hour lecture and a 1 hour recitation. (Same as CME 3903. Credit cannot be earned for both BME 3303 and CME 3903.) Generally offered: Fall. This course has Differential Tuition. Course Fee: DL01 $75.

BME 3311. Biomedical Engineering Laboratory II. (0-4) 1 Credit Hour.
Prerequisite: Completion of or concurrent enrollment in BME 3303. A biomedical engineering lab in bioinstrumentation. This course will involve the design and testing of hardware and software for acquiring and analyzing biological signals. Generally offered: Fall. This course has Differential Tuition. Course Fee: L001 $30.

BME 3373. Modeling and Simulation Using MATLAB. (3-0) 3 Credit Hours.
Prerequisite: Junior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 2103, BME 2203, BME 3211, and EGR 3423, or permission by instructor; completion of or concurrent enrollment in BME 3311. Introduction to programming using MATLAB. Topics may include modeling biomedical phenomena, including neuronal action potentials, muscles, the heart and circulatory system, and problem-solving in biomechanics. This course has Differential Tuition.

BME 3413. Biocompatibility of Materials: Tissue-Biomaterial Interactions. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2103, BME 3003, BME 3113, and BME 3121. This course is an introduction to the interactions of cells and tissues with biomaterials. Blood composition and blood-material interactions, responses of the inflammatory and immune systems to biomaterials, the process of wound healing, protein structure and interactions with material surfaces, the mechanisms of cell interactions with extracellular matrix components, and cell/tissue responses to implant materials are reviewed in detail. Case studies of cardiovascular and orthopedic implants are discussed to illustrate that judicious selection of materials is a key aspect of implant design and a crucial choice for the success of various biomedical applications (e.g., in tissue engineering and biotechnology) which require regeneration of tissues. (Same as CME 3413 and BME 4423. Credit can only be earned for one of the following: BME 3413, BME 4423, or CME 3413). Generally offered: Fall. This course has Differential Tuition. Course Fee: DL01 $75.

BME 3503. Nanomaterials and Nanobiotechnology. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3003. This course will introduce an overview of nanomaterials and nanotechnology development. Topics may include biocompatible nanomaterials, microfabrication, microfluidics, lab-on-a-chip, and applications in biomedical engineering. (Formerly titled "Fundamentals of Nanobiotechnology.") (Same as CME 3513. Credit cannot be earned for both BME 3503 and CME 3513.) Generally offered: Spring. This course has Differential Tuition. Course fee: DL01 $75.

BME 3703. Biotransport Phenomena. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3303 and BME 3373. Corequisite: BME 3711. This course introduces the concepts of quantitative modeling of biological systems with respect to mass, momentum, and energy transport. We will study the use of conservation laws to model cardiopulmonary, renal, and thermal systems of the human physiology, and apply these principles to design artificial and extracorporeal devices and drug delivery systems for pharmacokinetic analysis. This course includes a 3 hour lecture and a 1 hour recitation. Generally offered: Spring. This course has Differential Tuition.

BME 3711. Biomedical Engineering Laboratory III. (0-4) 1 Credit Hour.
Corequisites: BME 3703. A biomedical engineering lab in biotransport phenomena. Experiments related to mass, momentum, and energy conservation in biological systems such as measurements of apparent viscosity in microcirculation, oxygen diffusivity, and thermal conductivity. Generally offered: Spring. This course has Differential Tuition. Course Fee: L001 $30.

BME 3803. Programming and Introductory AI for Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of “C-” or better in BME 1002 and BME 3373. Introduction to the Python language and emerging AI methodology in the context of biomedical applications. Use of Python packages and AI simulations to solve contemporary biomedical engineering problems. This course has Differential Tuition.

BME 3813. Machine and Deep Learning Theory to Solve Biomedical Engineering Problems. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of “C-” or better in MAT 1213. This course aims to provide students with the fundamentals of machine and deep learning. The topics include the mathematical derivations that transform these principles into practical algorithms. A course research project provides practical experiences in implementing and adjusting ML and DL frameworks to solve real-world biomedical challenges. This course has Differential Tuition.

BME 4203. Biomechanics III. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203. Topics may include elasticity, viscoelasticity, deformation, stress and strain analysis, stress and strain in tissue and organs, and problem solving and design in biomechanics using statics, mechanics of materials, kinematics, and/or dynamics concepts. This course has Differential Tuition. Course Fees: LRE1 $25; STSE $30.

BME 4213. Tissue Mechanics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203. Topics may include biomechanics characterization, modeling, and properties of regenerating tissues ranging from bone, cartilage, tendons, ligaments, skin, adipose tissue, nerves, bladder, eye, and pulmonary and cardiovascular tissues. This course has Differential Tuition.

BME 4233. Computational Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203, BME 3373, and EGR 3423, or consent from the instructor. This course will provide students with practical knowledge and tools to perform biomechanical analysis through computational modeling. The course applies fundamentals of mechanics of material and the methods of computational modeling such as the finite element method (FEM) to model biological systems and biomechanical components and simulate biomedical phenomena. Examples and problems may be solved analytically and with the use of commercially available FEM software. Some basic knowledge of computer programming is recommended. This course has Differential Tuition.

BME 4283. Impact Biomechanics. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 2203 or consent from the instructor. This course will cover the response of the human organism to impact loading. Topics will include dynamics, kinetics, injury mechanisms of the head, spine, thorax, abdomen, and extremities, human tolerance to impact, anthropomorphic test devices, mathematical models, and human subject testing. Impact scenarios covered will include automotive, aerospace, combat, and sports. Maybe repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. This course has Differential Tuition.

BME 4293. Topics in Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 2203. Specific topics in biomechanics. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4423. Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2103, BME 3003, BME 3113, and BME 3121. This course is an introduction to the current status of practice and advances in tissue engineering. Tissue engineering is the biomedical engineering discipline that applies science and technology to develop replacements for damaged and/or diseased tissues of the body. The course focuses on fundamental aspects of new tissue formation, specifically cells, biomaterials, biochemical cues, and biophysical stimuli, which are part of the physiological milieu. Applications of the latest advances in current knowledge of the aforementioned aspects in designing and formulating cell-containing constructs composed of natural and/or synthetic biomaterial scaffolds is necessary for successful outcomes in tissue engineering. Examples of applications in bone, cartilage, skin, and vascular tissues are reviewed in detail. Strategies which are used to address current challenges, pursue emerging opportunities, and explore new scientific directions are discussed. (Same as BME 3413 and CME 3413. Credit can only be earned for one of the following: BME 3413, BME 4423, or CME 3413). This course has Differential Tuition. Course Fee: DL01 $75.

BME 4433. Soft Materials. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3003 or CME 3003 and a junior or senior status in the program. A review of specific topics in soft biomaterials with an emphasis on the use of polymer matrices. Aspects of material synthesis and characterization will be addressed, along with their applications in nano- and micro-technologies, drug delivery, biosensing, and tissue engineering. This course has Differential Tuition.

BME 4443. Stem Cell Engineering. (3-0) 3 Credit Hours.
Prerequisite: BME 3003 or CME 3003, BME 3113 (BME 3114 in previous catalogs), BME 3121, and senior status in the program. A review of special topics and recent advancements in stem cell engineering. This course has Differential Tuition.

BME 4453. Fundamentals to Polymer Science and Engineering with Select Applications. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 3003 or equivalent. This course introduces the fundamentals of polymer chemistry and engineering, characterization of polymer properties, and polymer processing. Current applications of polymeric materials in materials engineering and bioengineering are highlighted and discussed in detail. (Same as CME 4713. Credit cannot be earned for both CME 4713 and BME 4453.) This course has Differential Tuition.

BME 4463. Cellular Mechanics and Mechanobiology. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 3113 and BME 3121. The goal of the course will be to teach how cells sense, process, and respond to mechanical forces; and to study how physical forces and changes in cells contribute to development, physiology, and disease. This course has Differential Tuition.

BME 4483. Topics in Biomaterials. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3003. Specific topics in biomaterials. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4493. Topics in Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3003, BME 3113 (BME 3114 in previous catalogs), and BME 3121. Specific topics in tissue engineering. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $30.

BME 4503. Biosensors. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3303. Basics to biological detection and in-depth view of device design and performance analyses. Topics may include optical, electrochemical, acoustic, piezoelectric, and nanobiosensors. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $30.

BME 4603. Biophotonics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in EGR 2323. This course will introduce the fundamental principles of biophotonics and will focus on their applications to address critical issues in the frontier of biomedical science and technology. Topics may include fundamentals of light interactions with molecules, cells, and tissues, optical imaging, optical biosensing, flow cytometry, photodynamic therapy, laser tweezers and laser surgery, and nanobiotechnology. Generally offered: Fall. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4613. Biomedical Imaging. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in EGR 2323. This course will examine, from a systems perspective, the techniques used in a variety of medical imaging modalities, which include x-ray imaging, computed tomography, magnetic resonance imaging, nuclear medicine, ultrasound imaging, and photoacoustic imaging. The fundamental principles and engineering underlying each imaging modality will be discussed and a performance analysis of each system will be examined. This course has Differential Tuition. Course fee: DL01 $75.

BME 4623. Biomedical Optics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in EGR 2323. This course will introduce the fundamental principles of modern and classical optics and their applications for biomedical research. State-of-the-art topics on cutting-edge research in the area of optics and lasers in medicine and biology will be covered. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $30.

BME 4713. Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisite: BME 3113 and BME 3121. This course focuses on the engineering of cell function for applications in biomedical engineering. Topics include cell conditioning, genetic engineering and gene therapy, basic principles of stem cell engineering, and translational applications of cell engineering. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4793. Topics in Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3113 (BME 3114 in previous catalogs), BME 3121, and EGR 2323. Specific topics in cellular engineering. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4803. Biomedical Data Science. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 1002, BME 3373, and BME 3803, or permission from the instructor. This course aims to provide students with the ability to use computational methods to understand and analyze biological data. Topics include a survey of high-throughput biomedical data analysis methods, modeling of signaling pathways, image analysis, and artificial intelligence methods. A course research project provides practical experience in applying computational tools to solve real-world biomedical challenges. This course has Differential Tuition.

BME 4813. Generative Modeling for Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 1002 and BME 3373. This course will introduce new methods in machine learning, bioinformatics, and artificial intelligence that support generative model building to design experiments and predict solutions to biomedical engineering problems. This course has Differential Tuition.

BME 4823. Data Analytics to Support Medical Decision Making. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in STA 1403 or STA 2303, BME 1002, and BME 3373. This course will leverage data science methods to support the development of models to understand complex problems in healthcare and inform decision and policy making. This course has Differential Tuition.

BME 4903. Senior BME Design I. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3023 and BME 3703. Development of project proposals and presentation of conceptual designs. Industrial collaboration and/or faculty sponsorship of these projects is encouraged. This course has Differential Tuition.

BME 4913. Senior BME Design II. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 4903. Continuation of the development of an instructor-approved design project, testing of the design project, and presentation of the findings. Industrial cooperation or faculty sponsorship of projects is encouraged. This course has Differential Tuition.

BME 4923. Orthopaedic Device Design. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 2203, or consent from the instructor. This course will educate students about current biomedical technologies and product development. Topics covered will include ideation, concept development, design methodologies, business plan basics, regulatory concepts for medical devices, and intellectual property management. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. This course has Differential Tuition.