**BIOMEDICAL ENGINEERING (BME)**

**Biomedical Engineering (BME) Courses**

**BME 1002. Introduction to Biomedical Engineering.** (2-0) 2 Credit Hours. Prerequisites: A grade of “C-” or better, or concurrent enrollment in BIO 1404 and MAT 1214. This course is an introduction to the interdisciplinary field of biomedical engineering. Topics covered include core biomedical engineering areas such as Biomechanics, Biomaterials and Bioimaging. Generally offered: Spring. Course Fees: LRE1 $20; STSE $20.

**BME 2103. Physiology for Biomedical Engineering.** (3-1) 3 Credit Hours. Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BIO 1404 and MAT 1214. 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 (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 a CME 2113. Credit cannot be earned for both BME 2103 and CME 2113.) Generally offered: Fall. Course Fees: LRE1 $20; STSE $30.

**BME 2203. Biomechanics I.** (3-1) 3 Credit Hours. Prerequisites: A grade of "C-" or better in PHY 1963. Corequisites: BME 3211 and EGR 2223. Introduction to the fundamental engineering mechanics with 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.) Generally offered: Spring. Course Fees: LRE1 $20; STSE $30.

**BME 3003. Biomaterials I.** (3-1) 3 Credit Hours. Prerequisites: A grade of "C-" or better, or concurrent enrollment 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. This course includes a 3-hour lecture and a 1-hour recitation. (Formerly BME 2403. Credit cannot be earned for more than one of the following: BME 3003, BME 2403, or CME 3003.) Differential Tuition: $165.

**BME 3013. Clinical Internship in Biomedical Engineering.** (0-0) 3 Credit Hours. Prerequisites: A grade of "C-" or better in BME 3003 and BME 3114. This course will introduce students to the clinical environment, interacting with clinicians on current clinical problems and engineering approaches. Generally offered: Summer. Differential Tuition: $165.

**BME 3023. Biomedical Engineering Technology and Product Development.** (3-0) 3 Credit Hours. Prerequisite: A grade of "C-" or better in 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.) Differential Tuition: $165.

**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. Differential Tuition: $165.

**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. Differential Tuition: $55.

**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. Differential Tuition: $110.

**BME 3114. Cellular Biology for Biomedical Engineering.** (3-4) 4 Credit Hours. Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BME 2103. Introduction to cell structure and function, energy conversions, protein sorting, signaling, cytokinesis, cell cycle, and mammalian genetics. A laboratory component will focus on techniques and procedures commonly used in cell and molecular biology with bioengineering applications. This class includes a 3-hour lecture and a 4-hour laboratory. (Formerly BME 2114. Same as CME 3113. Credit can be earned for only one of the following courses: BME 3114, CME 3113, BME 2114, or BME 3813/BIO 3822.) Differential Tuition: $220.

**BME 3203. Biomechanics II: Cardiovascular.** (3-0) 3 Credit Hours. Prerequisites: 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. Differential Tuition: $165.

**BME 3211. Biomedical Engineering Laboratory I.** (0-4) 1 Credit Hour. Prerequisite: A grade of "C-" or better in BME 1002. Corequisites: 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 BME 2211. Credit cannot be earned for both BME 3211 and BME 2211.) Differential Tuition: $55.

**BME 3303. Bioinstrumentation.** (3-1) 3 Credit Hours. Prerequisite: A grade of "C-" or better in BME 2203. Corequisite: BME 3311. 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. Differential Tuition: $165.
BME 3311. Biomedical Engineering Laboratory II. (0-4) 1 Credit Hour.
Corequisite: 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. Differential Tuition: $55.

BME 3403. Biomaterials II. (1-5) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3003. This course will emphasize materials used in medical applications, including modifications and characterization techniques. This course includes a 1 hour lecture and a 5 hour laboratory. Differential Tuition: $165.

BME 3413. Biocompatibility of Materials: Tissue-Biomaterial Interaction. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3003 and BME 3114. 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, and the mechanisms of cell interactions with extracellular matrix components as well as 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. Credit cannot be earned for both BME 3413 and CME 3413.) Generally offered: Fall. Differential Tuition: $165.

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. Differential Tuition: $165.

BME 3703. Biotransport Phenomena. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3303. 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 also apply these principles to design artificial and extracorporeal devices, drug delivery systems for pharmacokinetic analysis. This course includes a 3 hour lecture and a 1 hour recitation. Generally offered: Spring. Differential Tuition: $165.

BME 3711. Biomedical Engineering Laboratory III. (0-4) 1 Credit Hour.
Corequisite: BME 3703. A biomedical engineering lab in biortransport 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. Differential Tuition: $55.

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 analysis, strain measurement, and stress and strain in organs. Tissues covered may include heart, blood vessels, cartilage, and bone. Differential Tuition: $165.

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. Differential Tuition: $165.

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. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. Differential Tuition: $165.

BME 4293. Topics in 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. 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. Differential Tuition: $165.

BME 4403. Molecular Techniques for Cell-Biomaterials Interactions. (2-4) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3114. Advanced molecular techniques for characterizing cell-biomaterials interactions will be taught. Current understanding of topics in cell receptors and signaling mechanisms with application for biomaterial design will be emphasized. Topics will include receptor-ligand communication, methods of identification and quantification, and pathways involved for cell to material stress response. This course includes a 2 hour lecture and a 4 hour laboratory. Differential Tuition: $165.

BME 4423. Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3003 and BME 3114. 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 biological 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. Differential Tuition: $165.

BME 4483. Topics in Biomaterials. (3-0) 3 Credit Hours.
Prerequisites: 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. Differential Tuition: $165.

BME 4493. Topics in Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3003 and BME 3114. 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. Differential Tuition: $165.
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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

BME 4633. MATLAB for Biomedical Engineering. (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 is an introduction to programming in MATLAB. It covers basic programming concepts as well as MATLAB specific features that a biomedical engineer would need either in industry or research. This includes concepts of correctness, clarity, and efficiency. Maybe repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. Differential Tuition: $165.

BME 4703. Biomedical Engineering Thermodynamics. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3703. This course introduces the basics of engineering thermodynamics and applications in biomedical engineering. The course covers first and second laws, properties of pure substances and mixtures, phase rule, phase and chemical equilibria, and an introduction to statistical thermodynamics. This course includes a 3-hour lecture and a 1 hour recitation. Differential Tuition: $165.

BME 4713. Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3114 and EGR 2323. This course focuses on using engineering skills and principles in the analysis and design of cellular functions. The emphasis will be on protein biochemistry, cell metabolism, signaling and adhesion. Differential Tuition: $165.

BME 4793. Topics in Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3114 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. Differential Tuition: $165.

BME 4803. Fundamental Computational Bioengineering. (3-0) 3 Credit Hours.
Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BME 3303. This course will include fundamental knowledge and skills of mathematical modeling, computer simulation and visualization, with applications in biomedical engineering. Differential Tuition: $165.

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. Differential Tuition: $165.

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 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. Maybe repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. Differential Tuition: $165.