BIOMEDICAL ENGINEERING (BME)

Courses primarily for undergraduates:

BME 1040: Biomedical Engineering First-Year Learning Community
Credits: Required. Contact Hours: Lecture 1.
Curriculum and career planning; academic course support for first-year students. Restricted to BME majors. Offered on a satisfactory-fail basis only. (Typically Offered: Fall)

BME 1600: Biomedical Engineering Problems with Computer Applications Laboratory
Credits: 3.
Prereq: Credit or enrollment in MATH 1650 *or satisfactory (76+) score on mathematics placement exam*
Formulation and solution of engineering problems; significant figures; use of SI units; graphing and curve-fitting; flowcharting; introduction to material balances, statics, and electric circuits in the context of biomedical engineering problems; use of spreadsheet programs to solve and present engineering problems; solution of engineering problems using computer programming languages. Only one of ENGR 1600, ABE 1600, AERE 1600, BME 1600, CHE 1600, CE 1600, CPRE 1850, EE 1850, IE 1480, ME 1600 and SE 1850 may count towards graduation. (Typically Offered: Fall, Spring)

BME 2010: Faculty-guided Professional Development in Biomedical Engineering
Credits: Required. Contact Hours: Lecture 1.
Professionalism in the context of Biomedical Engineering. Examination and selection of emphasis areas and electives in collaboration with a faculty mentor. Discussion of internships and research opportunities within Biomedical Engineering. . Offered on a satisfactory-fail basis only. (Typically Offered: Spring)

BME 2200: Introduction to Biomedical Engineering
(Cross-listed with CHE 2200).
Credits: 3. Contact Hours: Lecture 3.
Prereq: BIOL 2120*; (*CHEM 1670 *or* CHEM 1770*); (*ABE 1600 *or* AERE 1600 *or* BME 1600 *or CE 1600 or* CHE 1600 *or* CPRE 1850 *or EE 1850 or* ENGR 1600 *or IE 1600 or ME 1600 or SE 1850);* MATH 1660*;* PHYS 2320
Engineering analysis of basic biology and engineering problems associated with living systems and health care delivery. The course will illustrate biomedical engineering applications in such areas as: biotechnology, biomechanics, biomaterials and tissue engineering, and biosignal and image processing, and will introduce the basic life sciences and engineering concepts associated with these topics. (Typically Offered: Fall, Spring)

BME 2700: Introduction to Biomedical Engineering Design
Credits: 2.
Prereq: ABE 1600*,* AERE 1600*,* BME 1600*,* CE 1600*,* CHE 1600*,* CPRE 1850*,* EE 1850*,* ENGR 1600*, IE 1480,* ME 1600*, or SE 1850*
Problem-based learning to introduce students to biomedical engineering design concepts, tools, and methodologies. Students will work in small groups and use computer-aided design (CAD), virtual design, and computational tools to propose and validate feasible solutions to real-world biomedical engineering problems with industrial and/or clinical relevance. (Typically Offered: Spring)

BME 3400: Computational Modeling in Biomedical Engineering
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*MATH 2670 *and* BME 2200*); credit or enrollment in* MATH 2650
Principles and techniques for computational analysis of biomedical engineering problems; computational methods for integration, differentiation, interpolation, curve fitting, data analysis, sampling and estimation, and error analysis; analysis of ordinary differential equations, symbolic computation, and scientific visualization. (Typically Offered: Fall)

BME 3410: BioMEMs and Nanotechnology
(Cross-listed with EE 3410).
Credits: 3. Contact Hours: Lecture 3.
Prereq: BME 2200
Overview of Micro-Electro-Mechanical-System (MEMS) technologies for bioengineering, fundamentals of microfluidic device design, fabrication, and characterization, survey of microfluidic functional building blocks for lab-on-a-chip applications including mixers, valves, channels, and chambers. Topics of nanotechnology in bioengineering, nanoscale building block technologies for bioengineering including self-assembling, surface chemical treatment, nano-imprinting, nano-particles, nano-tubes, nano-wires, and stimuli-responsive biomaterials.

BME 3500: Bioinstrumentation
Credits: 4. Contact Hours: Laboratory 4, Lecture 2.
Prereq: PHYS 2320*,* EE 4420*, and* BME 2700
Introduction to medical devices, sensors, lab equipment, wearable devices, and imaging equipment that are commonly used to measure and analyze biological systems. Fundamental principles of biology, electronics, physics, and engineering that are required to design and build these bioinstruments. Basic concepts of biomedical signal analysis for medical diagnosis and health monitoring. Measurements and analysis of bioelectrical, biomechanical, and biophotonic signals. Simple design of instruments to address a specific biomedical problem. (Typically Offered: Spring)

BME 3520: Cellular and Tissue Biomechanics
Credits: 3. Contact Hours: Lecture 3.
Prereq: BME 2200*;* MATE 2730
Introduction to fundamental engineering mechanics with a focus on the human body. Application of continuum mechanics to both living and non-living systems; anatomy of the musculoskeletal system and connective tissue; laws of motion, free-body diagrams and simple force analysis of musculoskeletal system; range of movement, joint dislocation, bone deformity and fracture; biomechanical response of soft and hard tissues with emphasis on microstructure and mechanical properties; introduction to cellular mechanics and viscoelastic properties; and applications to biomedical engineering design.

BME 3520L: Cellular and Tissue Biomechanics Lab
Credits: 1. Contact Hours: Discussion 1, Laboratory 2.
Prereq: Credit or enrollment in BME 3520*; Biomedical Engineering Major*
Laboratory exercises and design projects with an emphasis on acquiring and analyzing biomechanical measurements; measurement of deformation, fracture and mechanical properties on both hard and soft tissue as well as on cells and soft biomaterial environments for cells; fluid mechanics measurements on systems that mimic the circulatory or respiratory systems; introduction to statistical significance and its relationship to biological variability. (Typically Offered: Fall)

BME 3540: Biomaterials
(Cross-listed with MATE 3540).
Credits: 3. Contact Hours: Lecture 3.
Prereq: MATE 2160 *or* MATE 2730 *and credit or concurrent enrollment in* BIOL 2560 *or* BIOL 3350
Basic chemical and physical properties of biomaterials, with special emphasis on metallic, ceramic, polymeric, and composite biomaterials. Engineered biomaterials for incorporation into living systems. Role of microstructure and properties needed to select and design biomaterials used in medical devices, artificial organs, implants, and prostheses. Overview of medical science vis-à-vis materials science. (Typically Offered: Spring)

BME 3540L: Biomaterials Laboratory
Credits: 1. Contact Hours: Discussion 1, Laboratory 3.
Prereq: Biomedical Engineering Major and Credit or Enrollment in BME 3540/MATE 3540
Basic chemical and physical properties of biomaterials, with special emphasis on metallic, ceramic, polymeric, and composite biomaterials. Engineered biomaterials for incorporation into living systems. Role of microstructure and properties needed to select and design biomaterials used in medical devices, artificial organs, implants, and prostheses. Overview of medical science vis-à-vis materials science. (Typically Offered: Spring)

BME 3600X: Biotransport
Credits: 3. Contact Hours: Lecture 3.
Prereq: BME 2200
Introduction to momentum and mass transport within biomedical systems; introduction to internal fluid flow, viscosity, stress and strain, flow through membranes, diffusion and convection through cells and tissues. Topics in fluid mechanics and heat and mass transfer, considering the role of transport in health and disease and exploring opportunities in technological development and therapeutics. Role of transport across length scales in different topics across biomedicine. Contributions of different phenomena as assessed with non-dimensional quantities. (Typically Offered: Spring)

BME 4400: Biomedical Applications of Chemical Engineering
(Dual-listed with CHE 5400). (Cross-listed with CHE 4400).
Credits: 3. Contact Hours: Lecture 3.
Prereq: CHE 2100 *or* CHE 2200*,* MATH 2660 *or* MATH 2670*,* PHYS 2320
Applications of material and energy balances, transport phenomena, chemical reaction engineering, and thermodynamics to problems in biomedical engineering and applied physiology; survey of biomedical engineering; biomaterials; biomedical imaging.

BME 4470: Biomedical Design and Manufacturing
(Dual-listed with IE 5470). (Cross-listed with IE 4470).
Credits: 3. Contact Hours: Lecture 3.
Exploration of biology, materials, body mechanics, manufacturing, quality control, and ethics and the intersection of these subjects as they relate to biomedical manufacturing. Study of medical data (CT, MRI, etc.) processing, biomedical design, 3D bioprinting and additive manufacturing concepts.

BME 4500: Biosensors
(Cross-listed with EE 4500).
Credits: 3. Contact Hours: Lecture 3.
Prereq: BME 2200 *or Graduate Standing*
Overview of biosensors and bioanalytical challenges; designing for performance including various analytical problems, ion-selective membranes, characteristics of enzymes and basics of bioaffinity sensing; fundamentals of bioselective layers including depositing films and membranes, surfaces for immobilization and bioselective agents; survey of different biosensing technologies including electroanalytical, biomembrane, optical, and acoustic-wave based sensors.

BME 4500L: Biosensors Laboratory
(Cross-listed with EE 4500L).
Credits: 1. Contact Hours: Laboratory 3.
*Prereq: [*BME 2200 *and (Enrollment in* BME 4500 *or EE 4500)] or Graduate Standing*
Laboratory course accompanying BME 4500. Design, fabrication, and characterization of various electrical, chemical, polymer, optical and acoustic sensors.

BME 4560: Biomaterials
(Dual-listed with MSE 5560). (Cross-listed with MATE 4560).
Credits: 3. Contact Hours: Lecture 3.
Prereq: CHEM 1780 *and (*MATE 2160 *or* MATE 2730 *or* MATE 3920*)*
Presentation of the basic chemical and physical properties of biomaterials, with special emphasis on metallic, ceramic, polymeric, and composite biomaterials, as they are related to their manipulation by the engineer for incorporation into living systems. Role of microstructure and properties needed to select and design biomaterials used in medical devices, artificial organs, implants, and prostheses. Overview of medical science vis-à-vis materials science. (Typically Offered: Fall)

BME 4900: Independent Study
Credits: 1-6. Repeatable, maximum of 6 credits.
Prereq: Department Permission for Course
Investigation of biomedical engineering topics of special interest to student and supervising faculty member with a final written report. (Typically Offered: Fall, Spring, Summer)