BME - Biomedical Engineering

Note: For a course to be used as a prerequisite to BME courses, it must have been passed with a grade of C or better (generating 2.00 grade points or better).

Courses numbered 100 to 299 = lower-division; 300 to 499 = upper-division; 500 to 799 = undergraduate/graduate.

BME 115. Biomedical Engineering Seminar (0).
A zero-credit-hour course designed to introduce new, transfer and interested engineering students to the program and discipline of biomedical engineering. Includes activities such as research presentations from faculty and students, lab tours and activities, and presentations from alumni and industry representatives.

BME 2811. Noncredit Internship (0).
Complements and enhances the student's academic program by providing an opportunity to apply and acquire knowledge in a workplace environment as an intern. Prerequisite: departmental consent.

BME 335. Biomedical Computer Applications (3).
Introduces students to software packages and applications applicable to the biomedical engineering curriculum and discipline. Course content includes three-dimensional graphical computer aided design software (e.g., SolidWorks), mathematical programming software and applications (e.g., MATLAB), and data acquisition and analysis software (e.g., LabVIEW). Pre- or corequisite: MATH 242.

BME 425. Biomechanics (3).
Foundation of mechanics in addressing bioengineering problems. Introduces the basic concepts and methods of mechanics as applied to biological tissues. Introduces statics, dynamics and mechanics applied to the human body including the following: (1) vectors, moments, equilibrium, (2) kinetics and kinematics including displacement, rotation, acceleration and deformation, (3) stress and strain, (4) equations of motion, (5) impulse and momentum, and (6) mechanical properties of biological tissues. Prerequisites: MATH 243, AE 223.

BME 462. Introduction to Biofluids (3).
Introduces the conservation laws which form the foundation of fluid mechanics and their application to bioengineering related problems including blood flow in the vascular system and other biological flows within the human body. Topics include dimensional analysis, definition of system, conservation of mass and energy, and conservation of momentum. Prerequisites: AE 223, MATH 555. Pre- or corequisites: BIOL 223, ME 398.

BME 477. Introduction to Biomaterials (3).
Major classes of materials used in medical devices including polymers, metals, ceramics, composites and natural materials are discussed. Biocompatibility, host reactions to biomaterials, immune response, wound healing, biomaterial implantation and acute inflammation, thrombosis, infection, tumorigenesis and calcification of biomaterials, testing and degradation of biomaterials in vivo are covered. Specific biomaterials applications such as cardiovascular devices, drug delivery and tissue engineering are covered. Additionally, biomedical device design and regulatory issues are also discussed. Prerequisites: CHEM 211, PHYS 213 or 313.

BME 480. Bioinstrumentation (3).
Introduces engineering aspects of the detection, acquisition, processing, interpretation and display of signals from living systems; biomedical sensors for measurements of bio potentials, force, displacement, blood pressure, blood flow, heart sounds, respiration and temperature; biomedical devices; medical imaging instrumentation. Prerequisites: BME 335, EE 282, IME 254.

BME 481A. Cooperative Education (1).
Introduces engineering practice by working in industry in an engineering-related job. Provides a planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Intended for students who will be working full time on their co-op assignments and need not be enrolled in any other course. Repeatable for credit. Prerequisites: 30 credit hours toward Bachelor of Science in biomedical engineering and approval by the appropriate faculty sponsor.

BME 4811. Noncredit Internship (0).
Complements and enhances the student's academic program by providing an opportunity to apply and acquire knowledge in a workplace environment as an intern. Prerequisite: departmental consent.

BME 481N. Internship (1).
Complements and enhances the student's academic program by providing an opportunity to apply and acquire knowledge in a workplace environment as an intern. Prerequisite: departmental consent.

BME 481P. Cooperative Education (1).
Introduces engineering practice by working in industry in an engineering-related job. Provides a planned professional experience designed to complement and enhance the student's academic program. Individualized programs must be formulated in consultation with, and approved by, appropriate faculty sponsors and cooperative education coordinators. Students must enroll concurrently in a minimum of 6 credit hours of coursework including this course in addition to a minimum of 20 hours per week at their co-op assignment. Repeatable for credit. Prerequisites: 30 credit hours toward Bachelor of Science in biomedical engineering and approval by the appropriate faculty sponsor.

BME 482. Design of Biodevices (3).
Discusses the overview of device definitions, selection and use of materials in in-vitro medical devices and implantable medical devices, product development and documentation, regulation and testing of medical devices, reliability and liability, licensing and patents, manufacturing and quality control, biocompatibility, FDA and ISO 10993 biological evaluations. Provides an overview of the multiple issues in designing a marketable medical device, including the design process from clinical problem definition through prototype and clinical testing to market readiness. Design case studies are discussed. Students must be within three semesters of graduation in order to take this course. Prerequisites: BME 335 and program consent.

BME 497. Special Topics (3).
New or special topics presented on sufficient demand at the undergraduate level. Prerequisite: instructor's consent.

BME 585. Capstone Design I (3).
First course in a two-semester capstone design sequence. Focuses on the process of strategic clinical problem solving and innovation through evaluation of real-world diagnostic processes, current therapeutic approaches and clinical outcomes. Students work in teams to identify and critically evaluate unmet medical or clinical needs through the use of a bio design and innovation process, including clinical needs finding through on-site observations, stakeholder assessments, needs statement development and concept generation. Students and their results from this course transition to the next course in this sequence, BME 595, Capstone Design II. For undergraduate credit only. Students must be within three semesters of graduation in order to take this course. Prerequisites: BME 335 and program consent.
BME 590. Independent Study and Research (1-3).
Independent study or research directed by a faculty member affiliated with the biomedical engineering program. Repeated for credit. A maximum of 3 credit hours may be applied toward graduation. Prerequisite: consent of supervising faculty member.

BME 595. Capstone Design II (3).
Second course in a two-semester capstone design sequence. Uses design and engineering practice involving a team-based biomedical engineering analysis and design project, including discovering customer requirements, design requirements, biocompatibility, regulatory, ethical, societal, environmental and economic considerations, creativity, alternative approaches for solution, specific system analysis, project management, prototype construction and testing, and final report and presentation. For undergraduate credit only. Prerequisites: BME 482, 585.

BME 722. Introduction to Biorobotics (3).
Biorobotics combines human anatomy and physiology, electronics, mechanics and robotics technology using computer programming. It is being investigated for use in prosthetics, surgical and therapeutic devices. Course includes robotic principles, theories and control strategies used to manipulate various robotics devices through human physiological signals in real time. Covers topics on robotics in BME, prosthetics, biosignal processing, microcontroller programming, human sense of touch and virtual world communication. Fundamental knowledge of bioinstrumentation, rehabilitation, robotics and signal processing is demonstrated in the laboratory to create a human-machine-computer interface. Students gain hands-on experience with sensors, microcontrollers, actuators, haptic controllers, robotic arm, prosthetic hand and various MATLAB/Simulink toolboxes in order to implement biorobotics algorithms into 3D simulation and stationary/automobile robotic devices. Prerequisite: BME 480 or instructor's consent.

BME 735. Biocomputational Modeling (3).
Prepares students for engineering practice by introducing 3D multiphasic modeling software. Students use COMSOL multiphase simulation software linked with SolidWorks and MATLAB to solve engineering problems in complex 3D geometries such as the human body. Within the simulation software environment, students define the geometry, set boundary conditions, specify the physics, set material properties, mesh, simulate, and visualize their results. Topics include modeling of biofluid mechanics (e.g., stress and strain on arteries), heat and mass transfer (i.e., bioheat and drug delivery), and structural mechanics (i.e., stress and strain on bone). Computer simulation has become an essential part of science, medicine and engineering. Course gives students hands-on experience to meet those demands. Prerequisites: either BME 462 or ME 521, and BME 335 or its equivalent; or instructor's consent.

BME 738. Biomedical Imaging (3).
Prepares students with knowledge of imaging devices and gives hands-on experience with ultrasound imaging, dual-energy x-ray absorptiometry (DEXA), spectral imaging, and medical image processing labs. Covers medical imaging modalities such as planar x-ray, x-ray computed tomography (CT), DEXA, magnetic resonance imaging (MRI), nuclear medicine imaging—positron emission tomography and single-photon emission computed tomography, ultrasound imaging, and spectral imaging. Students gain hands-on experience with medical image processing software to import CT or MRI scans and construct 3D models of human anatomy. Introduces fundamental physical and engineering principles used in medical imaging and image processing, with a primary focus on physical principles, instrumentation methods, and image processing methods. Strengths, limitations, sensitivity and appropriate applications for each modality of imaging are also examined. Prerequisites: PHYS 314 and BME 335 or its equivalent; or instructor's consent.

BME 742. Biosensor Development (3).
Comprehensive introduction to the basic features and components of biosensors. Discusses different ways to evaluate the physiological state of cells in culture or a whole organism using various methods such as: optical detection, impedance measurements, aerometric measurements, potentiometric measurements and physical measurements using a scanning probe microscope. Primary focus is given to optical measurements and techniques used to explore surface chemistry such as: bioconjugation of biomolecules such as proteins, biomolecule attachment to transducer surfaces, DNA microarrays and bead-based assays. Case studies and analysis of commercially available biosensors are covered. Students perform a project for the design, fabrication and testing of a microfluidic-based biosensor. Students leave the course with a fundamental knowledge of biosensor design and development. Prerequisites: MATH 242 and either CHEM 532 or 533 or 536; or instructor's consent.

BME 743. Mechanobiology of Cells and Tissue (3).
Focuses on how the mechanical environment influences cell behavior and integrates principles from engineering, cell biology, physiology and biomedicine. Topics include, but are not limited to: (1) global/health importance of mechanobiology; (2) the role mechanical forces play in normal cell function and disease; (3) the role of the mechanical environment in regenerative medicine and tissue engineering applications; (4) how the extracellular matrix and biomimetic matrices alter cellular function; (5) how cells sense and respond to mechanical forces; (6) the mechanobiological feedback loop; (7) cell and tissue mechanics; (8) microscopy of cells and tissues; and (9) experimental methods to study cellular mechanobiology. Course emphasizes experimental design, data analysis, interpretation of data and results, and hands-on laboratories. In these laboratories, students gain firsthand experience with cell culture techniques; microscopy, and experimental and computational techniques in cell mechanobiology. Prerequisites: BIOL 210, BME 452 or equivalent, or instructor’s consent.

BME 747. Biochemical Engineering (3).
Prepares students for careers in the pharmaceutical industry as research scientists or process engineers. Students learn about designing scaffolds for tissues, molecular design for new drugs, in vitro testing of cells and in vivo testing of whole organisms. Students are guided through the process of transgenic organism production, production of pharmaceutical agents using bioreactors and downstream processing. Topics covered include the thermodynamics and kinetics for the biosynthesis or enzymatic degradation of various biological macromolecules. Students learn the application of engineering principles to analyze, design and develop processes using biocatalysts to enhance these processes. Processes covered include those that are involved in the formation of desirable compounds and products and in the transformation, or destruction of unwanted substances. Several in-class demonstrations are performed, and students design a micro-bioreactor. Prerequisites: MATH 242 and either CHEM 532 or 533 or 536; or instructor's consent.

BME 748. Biomolecular and Cellular Engineering (3).
Focuses on the molecules and mechanisms underlying cellular function from an engineering point of view. Emphasizes experimental methods, mathematical analysis and computational modeling, where hands-on laboratories complement lectures. Topics include, but are not limited to: (1) enzymes and biochemical kinetics; (2) cell signaling and modeling signaling pathways; (3) biophysical-based models of biological/biochemical systems; (4) gene expression and regulation; (5) ‘omic’ approaches to cell signaling including data analysis of high-throughput data; (6) system biology approaches — analysis
of complex biological systems across multiple temporal and spatial scales; (7) bioinformatics; and, (8) quantitative experimental methods related to biomolecular and cellular engineering. Applications to tissue engineering, regenerative medicine, biotechnology, bionanotechnology, drug and gene delivery, molecular medicine, and personalized medicine are discussed. Prerequisites: BIOL 420 or equivalent, or instructor’s consent.

**BME 752. Applied Human Biomechanics (3).**
Examines the biology, physiology, and structure of skeletal muscle, the mechanisms of skeletal muscle force generation, and the adaptations to muscle that arise from changes in muscle usage. Students learn to create biomechanical models and generate simulations of human movement based on data collected in a human biomechanics lab. Experimental design and data analysis and interpretation are emphasized. Prerequisites: BIOL 223 and BME 452 or its equivalent; or instructor's consent.

**BME 757. Clinical Biomechanics Instrumentation (3).**
2 Classroom hours; 2 Lab hours. Students learn to collect, process, analyze and interpret motion of the human body (e.g., running, walking, jumping, lifting, etc.), muscle force, muscle activity and acceleration data using various equipment in a human biomechanics lab. The equipment and techniques used are common to multiple fields and disciplines, including physical medicine and rehabilitation, orthopedics, physical therapy, prosthetics and orthotics, wearable biosensors, sports performance and medical/sport/safety equipment design. Prerequisite: BME 452 or instructor's consent. Corequisite: BME 757L.

**BME 760. Special Topics in Biomedical Engineering (3).**
Focuses on a contemporary biomedical engineering topic through traditional lecture, research and/or experiential learning activities. Content changes as new problems and research advances related to biomedical engineering attain prominence nationally and internationally. Repeatable for credit. Prerequisite: instructor's consent.

**BME 777. Biodegradable Materials (3).**
Comprehensive overview of biodegradable materials as it relates to their applications in the biomedical and health care fields. Covers in detail different classes of biodegradable materials including biodegradable polymers, ceramics and metals. Synthesis, characterization and degradation of these materials in the biological environment are covered. Biodegradation/biocorrosion mechanisms of these materials, the complexity of the response of the biological environment, and the experimental methods for monitoring the degradation process are discussed, as well as strategies for surface modification to control the degradation. Finally, specific applications are covered. Prerequisite: either BME 477 or ME 651; or instructor's consent.

**BME 779. Tissue Engineering (3).**
Introduces the strategies and fundamental bioengineering design criteria behind the development of tissue substitutes. Principles of engineering and the life sciences toward the development of biological substitutes that restore, maintain or improve tissue function are covered. Topics include stem cells, cell growth and differentiation, cell signaling, materials for scaffolding, scaffold degradation and modification, cell culture environment, cell nutrition, cryopreservation, bioreactor design, clinical applications, regulatory and ethics. Prerequisite: BME 477 or instructor's consent.

**BME 791BA. Badge: Muscle: Practical Blood Flow Restriction Applications (0.75).**
Explores the growing body of research around skeletal muscle as an endocrine organ that releases metabolites that affect other organs. Included in this study are the metabolic effects of various exercise approaches including practical Blood Flow Restriction (pBFR) as this approach can serve as an integral complement to a comprehensive strengthening program across the age and disability spectrum. Graded Bg/NBg. Prerequisite: instructor's consent.