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 2.000 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. Repeatable.

BME 281I. 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(s): 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(s): MATH 242.

BME 452. 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. Prerequisite(s): MATH 243, AE 223.

BME 462. Introduction to Biofluids (3).
Provides a background and introduction to 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. Elaborates on the application of fluid mechanics principles to major human organ systems. Prerequisite(s): AE 223, MATH 555. Pre- or corequisite(s): BIOL 223, ME 398. Corequisite(s): BME 462L.

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. Prerequisite(s): CHEM 211, PHYS 213 or 313. Corequisite(s): BME 477L.

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. Prerequisite(s): BME 335, ECE 282, IME 254.

BME 481A. Cooperative Education (1).
Academic program that expands a student's learning experiences through paid employment in a supervised educational work setting related to the student's major field of study or career focus. Intended for students who are working full time on their co-op assignments and do not need to be enrolled in any other course. Repeatable for credit. Prerequisite(s): 30 credit hours toward Bachelor of Science in biomedical engineering and approval by the appropriate faculty sponsor.

BME 481I. 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(s): 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(s): departmental consent.

BME 481P. Cooperative Education (1).
Academic program that expands a student's learning experiences through paid employment in a supervised educational work setting related to the student's major field of study or career focus. 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. Prerequisite(s): 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 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. Pre- or corequisite(s): BME 335.

BME 497. Special Topics (3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 497A, 497B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): 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. Prerequisite(s): BME 482 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(s): 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. Prerequisite(s): BME 585 and either PHIL 386 or PHIL 385.

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(s): 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 multiphasic 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. Prerequisite(s): 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 medical imaging 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. Prerequisite(s): BME 335 or its equivalent; 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. Emphasizes experimental design, data analysis, interpretation of data and results, and hands-on laboratories. Students gain firsthand experience with cell culture techniques, microscopy, and experimental and computational techniques in cell mechanobiology. Prerequisite(s): BIOL 210, BME 452 or equivalent, or instructor’s consent. Corequisite(s): BME 743L.

BME 746. Drug Delivery (3).
Understanding drug delivery approaches is critical for students who are interested in careers in healthcare, biotechnology and pharmaceutical industries. Students learn about controlled-release formulations, targeted delivery of compounds, and delivery of biologic drugs. Students are guided through an overview of drug delivery, various drug delivery systems, approaches to drug delivery, and the materials and systems utilized. Topics covered include route of administration, pharmacokinetics, bioavailability and modeling of specific delivery systems (e.g., nano- and microparticle formulations). Prerequisite(s): MATH 242 and either CHEM 531 or CHEM 533 or CHEM 535; 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. Prerequisite(s): 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. 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. Prerequisite(s): BIOL 210, BME 335 or equivalent, MATH 555; 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. Prerequisite(s): BIOL 223 and BME 452 or its equivalent; or instructor's consent.

BME 757. Clinical Biomechanics Instrumentation (3).
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(s): BME 452 or instructor's consent. Corequisite(s): BME 757L.

BME 758. Biomedical MEMS (3).
Biomedical microelectro mechanical systems (MEMS) is the application of MEMS technology in the fields of biomedical and health sciences which has seen tremendous growth in the past decade. Covers theoretical and experimental knowledge on biomedical MEMS technology, various microfabrication techniques that are commonly used in biomedical MEMS device fabrication (e.g. epidermal electronics, microfluidic devices, lab-on-a-chip and biosensors) and the underlying physical principles. Includes discussion of recent and future trends in biomedical MEMS. Students gain a broad perspective in the area of micro/nano systems for biomedical and chemical applications. Prerequisite(s): MATH 242 and BME 477; or instructor's consent.

BME 760. Special Topics in Biomedical Engineering (3).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 760A, 760B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Prerequisite(s): instructor's consent.

BME 760A. Brain-Computer Interfaces (3).
Covers theoretical and experimental knowledge on neuroengineering, neuroscience and neurorobotics systems currently being utilized for brain-computer interface (BCI) technology. Provides hands on learning experience using innovative hardware and software tools to acquire, process and analyze human brain signals and integrate robotics technology with current BCI models for real-time control of virtual environment and assistive/robotic devices. Students gain knowledge to perform BCI experiments in offline and online modes, understand signal processing and machine learning techniques to extract features, and design BCI-based human-machine interaction models for various assistive and/or rehabilitative technology. Prerequisite(s): BME 722 or instructor's consent.

BME 760C. Medical Image Processing (3).
Introduces medical image processing and gives students experience in working with MRI scan data sets and CT x-ray scan data sets using Materialise Interactive Medical Image Control System (MIMICS). Students learn how to perform image segmentation, learn how a part is created from a mask, perform threshold based segmentation to create a part, take measurements from the data set, segmentation of arteries using dynamic region growing, airway segmentation for modeling, translating a stack of 2D image data sets into 3D patient specific geometries, and work with DICOM data sets as medical image files. Prerequisite(s): BIOL 223 or instructor's consent.

BME 760E. Advanced Pharmaceutical Biotechnology (3).
Designed to emphasize the utilization of biological processes to solve therapeutic and diagnostic medical problems. A survey of topics is covered related to pharmaceutical biotechnology including: recombinant proteins as pharmaceutical agents; production, isolation and purification of recombinant proteins; physical, biochemical and spectroscopic methods for analysis of protein structure; advanced tissue engineering and regenerative medicine; molecular and genetic engineering; etc. Prerequisite(s): BIOL 420 or CHEM 661; or instructor's consent.

BME 760I. Introduction to Human Neuroimaging (3).
Provides an overview of the principles, methods and applications of human neuroimaging techniques. Topics include functional and structural imaging modalities such as fMRI, fNIRS and EEG. Students explore the physiological basis of neuroimaging, experimental design, data analysis, and clinical and research applications in neuroscience, psychology and biomedical engineering. Designed for undergraduate and graduate students interested in the interdisciplinary field of neuroimaging. Prerequisite(s): PHYS 314, BME 335 and IME 254; or instructor's consent.

BME 771. Polymer Processing and Technology (3).
Introduces the design and manufacture of polymer products emphasizing polymer processing and technology. Discusses fundamental polymeric concepts as they relate to polymer processing. Reviews topics related to solid-state properties, polymer viscoelasticity and polymer melt rheology. Industrial processing operations such as extrusion, injection molding, additive manufacturing, compression molding, polymer blending and mixing, and thermoforming foaming are discussed in detail, highlighting appropriate materials and processing methods for several engineering applications. Prerequisite(s): CHEM 211, and PHYS 213 or PHYS 313; or graduate standing.

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(s): 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(s): BME 477 or instructor's consent.

BME 791. Badge: Biomedical Engineering Topics (0.5-1).
An umbrella course created to explore a variety of subtopics differentiated by letter (e.g., 791A, 791B). Not all subtopics are offered each semester – see the course schedule for availability. Students enroll in the lettered courses with specific topics in the titles rather than in this root course. Graded Bg/NBg.

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(s): instructor's consent.

BME 791BB. Badge: Exercise as Medicine (0.5).
This badge course explores the foundations of molecular biology with exercise. It expands on the badge course, Muscle: Practical Blood Flow Restriction Applications (BME 791BA) to further explore the concept of the skeletal muscle as an endocrine organ and discusses the manipulation of metabolic pathways, the conformation changes of proteins including hemoglobin and ATPase, the biomolecular pathways of mitochondrial biogenesis, as well as muscle protein degradation due to immobilization, and the phenomenon of adaptive response. Graded Bg/NBg.