

BIOMEDICAL ENGINEERING (BME)

BME 100. Introduction to Biomedical Engineering for Summer Scholars. 3 Credit Hours.

This introductory course is designed to expose high school students to biomedical engineering. The program is designed for the exemplary high school student interested in applied mathematics and science. The students will be provided with an understanding and some hands-on experience on topics relative to the discipline of Biomedical Engineering. The course content changes throughout the 3-week duration and includes topics on lasers, medical imaging, biomaterials, bioelectricity and biomechanics. The students will be able to understand the challenges associated with the design, testing and FDA clearance of biomedical devices and the importance of the scientific methods in engineering. The laboratory and field trip experiences will deal with the design and testing of a bioelectric device. Summer Scholar Students only.

Components: LEC.

Grading: GRD.

Typically Offered: Summer.

BME 110. Introduction to Innovation: Learning About Innovation by Innovating. 3 Credit Hours.

Introduction to diverse methods and tools that promote and nurture student creativity, entrepreneurship, team-work, and skills for creating business plans that consider ethical, global and financial issues. Students will learn to use the Maker Space facility to implement their design ideas.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 111. Introduction to Engineering I. 3 Credit Hours.

Use of engineering tools for problem solving are discussed. Topics include the use of computer techniques for data acquisition, analysis, presentation, software design, computer aided drafting, and development of design skills through several design and building competitions. Introduction to professional ethics and intellectual property rights, the use of MATLAB, AutoCAD, and programming in C++.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 112. Introduction to Biomedical Engineering. 2 Credit Hours.

Introduction to Engineering II provides an introduction to biomedical engineering analysis, design, and manufacturing processes. Ethics, Regulatory Factors, and Biomedical Design Tools (mechanical, electrical, and computer tools) are introduced. Students will also be given lectures from both Biomedical Engineering researchers and industrial professionals concerning their experiences and the current trends within the field. Hands on experience is provided.

Prerequisite: BME 111.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 123. Explorations in Engineering. 3 Credit Hours.

Introduction to engineering for non-engineers with emphasis on real-world engineering systems and services which are changing the way we live, communicate, learn, play, and care for ourselves, our communities and our planet. Students will learn how to use modern tools to observe and design simple engineering systems.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 211. Introduction to Programming for Biomedical Engineers. 3 Credit Hours.

This course will provide a comprehensive introduction to programming using MATLAB. The students will learn MATLAB functions for importing, analyzing, visualizing and exporting data, numerical computation, modeling and solving biomedical engineering problems.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 265. Medical Systems Physiology. 3 Credit Hours.

Human physiological processes from a bioengineering and medical point of view. Pertinent aspects of anatomy, biophysics, biochemistry, and disease mechanisms are also included.

Prerequisite: BIL 150. And CHM 121.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 266. Human Physiology Laboratory. 1 Credit Hour.

This course provides a series of laboratory experiments to assist students to learn human physiology through noninvasive measurements by using the Powerlab Physiology Data Acquisition station. Following introductory lectures in the lab, students will assemble measurement probes, connect different devices, collect data under normal and stimulating conditions, and perform data analysis. Lab report is required for each experiment.

Prerequisite: Or Corequisite: BME 265.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 302. Cellular Engineering. 3 Credit Hours.

Cellular engineering addresses issues related to understanding and manipulating cell structure-function relationships. This course is intended to bridge between cell biologists and engineers, to understand quantitatively cell biological aspects. Central to biomaterial and tissue engineering is our use of cells and our understanding of their interactions with their environment. It is important to understand how cells respond to external signals from their substrata or their milieu, how they move, and what they need in order to perform their desired function. Students are provided with an introduction to engineering principles and modeling at the cellular level. Of particular interest are cytomechanics, receptor/ligand binding, genetic engineering, enzyme kinetics, and metabolic pathway engineering.

Prerequisite: BIL 150. And CHM 121.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 303. Cell Engineering Lab. 1 Credit Hour.

The principles of cell engineering will be presented in a hands-on laboratory experience. General techniques learned will include sterile methods, cell culture techniques, cell imaging, DNA cloning and cell transfection, microcontact printing. Cell engineering topics include cell cycle/metabolism, adhesion, signal transduction, and assessment and fabrication of 2D culture substrates.

Prerequisite: BIL 150 and BIL 151.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 305. Biomedical Technology. 3 Credit Hours.

Non-mathematical introduction to technical and clinical aspects of biomedical engineering. Biomedical signals and instrumentation, sensors, transducers, physiological measurements, laboratory instrumentation, implants, cardiac assist devices, radiology, ultrasound, CT, MRI, transmission, and scanning electron microscopy. Field trips to clinical and research laboratories are included. Open only to non-BME students.

Prerequisite: BIL 150 and CHM 121.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 310. Mathematical Analysis in Biomedical Engineering. 3 Credit Hours.

Mathematical modeling of physiological and other biomedical engineering systems and devices. Basic engineering principles and mathematical tools are covered for rigorous understanding of physiological regulation and control in biosystems.

Prerequisite: MTH 311.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 312. Biomedical Statistics and Data Analysis. 3 Credit Hours.

The course will provide a comprehensive introduction to biostatistical models and methods, with applications in clinical trials research, observational studies, physiology, genomics and public health. Various examples will be solved using statistical software and the results will be compared and discussed.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 320. The Evolution of Technology. 3 Credit Hours.

Organized and taught by an interdisciplinary team, this innovative course is designed for juniors and seniors. An experimental elective, the course uses multimedia to explore the ways in which innovation is driven by the needs of society and individuals, and nurtured by improvements in tools and production. Five broad subject areas will receive special attention: survival, communication, transportation, entertainment and medicine.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 330. Foundations of Medical Imaging. 3 Credit Hours.

Physical and biological principles of medical imaging, including ultrasound, X-ray, nuclear, magnetic resonance, electrical impedance and optical imaging. Propagation and interaction of ultrasonic waves, light waves, X-ray photons, and nuclear radiation in hard and soft biological tissue.

Corequisite: BME 310.

Prerequisite: PHY 222. And PHY 223. Or Pre/Corequisite: BME 310.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 335. Biomaterials. 3 Credit Hours.

Introduction to the field of Biomaterials. Review of materials science for four main types of biomaterials: ceramics, metals, polymers, and composites. Lectures on special topics given by guest lecturers who are active in their specific areas, under supervision of the instructor.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 375. Fundamentals of Biomechanics. 3 Credit Hours.

Application of solid and fluid mechanics to describe the mechanical behavior of human motion, mechanical behavior of soft and hard biological tissues, cells and biofluids. Review of fundamental concepts and techniques of mechanics (stress, strain, constitutive relations). Focus on mechanical properties of specific tissues, including tendon, skin, smooth muscle, heart muscle, cartilage, and bone. Cellular and biofluid mechanics will be presented.

Prerequisite: MTH 311. And PHY 221.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 399. Cooperative Education. 1 Credit Hour.

Practical application of classroom theory through alternating semester or summer employment with firms offering positions consistent with the student's field of study. May be repeated.

Components: THI.

Grading: GRD.

Typically Offered: Fall, Spring, & Summer.

BME 401. Biomedical Design. 3 Credit Hours.

Introduction to the clinical problem-based design for undergraduate biomedical engineering students. Focus will be on need identification, concept generation, prototype development and testing.

Junior standing.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 402. Senior Design I. 2 Credit Hours.

This course deals with the introduction phase of an individual or group project for seniors. Need identification, screening, technical and economic feasibility, proof of concept development and killer experiment will be performed by students working on teams. Scheduled individual or group report presentations are required.

Prerequisite: BME 401 And Senior standing.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 403. Senior Design II. 1 Credit Hour.

This course deals with the completion phase of an individual or group project for seniors. Concepts on projects related to the hypotheses/testing protocols, design limitations (constraints), and validation of the design in Biomedical Engineering will be discussed. Scheduled individual or group report presentations are required.

Prerequisite: BME 402.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 440. Biomedical Measurements. 4 Credit Hours.

Introduction to the principles of measurements in physiological and biological systems, as well as a discussion of measurable parameters, transducers, sensors, signal conditioning, and processing. Laboratory experiments are conducted in parallel with the course.

Prerequisite: ECE 201.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 450. Biomedical Transport Phenomena. 3 Credit Hours.

Fundamentals of transport phenomena in biological systems including diffusion, osmosis, convection, electrophoresis, and transport with binding. Applications to cell electrophysiology and drug delivery. Introduction to physiological fluid flow in tissues.

Prerequisite: BME 310.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 460. Introduction to Physiological Fluid Mechanics. 3 Credit Hours.

The role of transport processes in biological systems, mathematical modeling of physiological fluid transport, conservation of mass and momentum rheology of blood flow in large and small vessels, approximation methods for the analysis of complex physiological flow, fluid flow in the circulation and tissue. Basic engineering principles and mathematical tools are covered for rigorous understanding of physiological fluid flow.

Prerequisite: BME 310 and PHY 222.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 470. Biomedical Signal Analysis. 3 Credit Hours.

Time and frequency description, analysis and processing of biophysical and physiological signals. This course covers analytical and computational tools for measuring, manipulating and interpreting signals fundamental to biomedical engineering. Fourier analysis, Fourier transform, data acquisition, averaging, digital filter design, discrete Fourier transform, correlation, convolution, coherence are discussed.

Prerequisite: BME 211.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 480. Biomedical Instrumentation. 3 Credit Hours.

Analysis and design of systems and electronic circuits in biomedical instrumentation including modeling and simulation of dynamic measurement systems and implementation of analog signal processing. The functional principles, operation, clinical context and technological trends of medical instrumentation systems used in clinical and research applications will be discussed.

Prerequisite Or Corequisite: BME 440.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 495. Undergraduate Research in Biomedical Engineering. 1-3 Credit Hours.

Research and/or design projects consisting of an individual investigation of current problems under the mentorship of a faculty member. Requires department approval.

Components: THI.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 506. Computer Aided Design in Biomedical Engineering. 1 Credit Hour.

Laboratory course for computer based two and three dimensional drawing and design based on ProEngineer. Parametric design, parts, features, assemblies for complex modeling. Applications in biomedical engineering design.

Prerequisite: BME 112. And BME 211.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 507. LabView Applications for Biomedical Engineering. 1 Credit Hour.

Laboratory course for computer based instrumentation and design based on Labview. Virtual instrumentation, data acquisition and display, GPIB instrument control, biomedical applications in biosignal recording, and monitoring are discussed.

Prerequisite: BME 112. And BME 211.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 510. Introduction to Medical Robotics. 3 Credit Hours.

This course will discuss the basic principles of robotics and focus on its medical applications. The course integrates previously learned math, programming and imaging knowledge into an application platform to enable students to understand fundamentals of robotics methods in biology and medicine and to train students to build a robotics prototype through hands-on projects.

Prerequisite: BME 211. And BME 310. And BME 330.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 512. Regulatory Control of Biomedical Devices. 3 Credit Hours.

Regulatory agencies and requirements, Food and Drug Administration, 510(k) and premarket approval (PMA), international regulatory requirements, ISO 9000 series, CE, UL, product and process validation, quality engineering, quality improvement programs, rapid prototyping, packaging and sterilization, and project management are discussed.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 513. Biomedical Systems Engineering. 3 Credit Hours.

This course provides students with an understanding and appreciation of Biomedical Systems Engineering with emphasis on current day industrial project management and product development processes. The components of Systems Engineering to be presented include: functional system analysis, requirements analysis, translation of functions and requirements into a system and product architecture, and, finally, testing methods to verify the biomedical product meets all design requirements. Decision methodology, alternative concept analysis, trade-off studies, integration of human factors, manufacturability, reliability, maintainability, feasibility demonstration, and safety are all addressed as part of the product design system. The entire product development life cycle will be analyzed with relevant concepts from initial market evaluation, to requirement development, through final product manufacturing and product launch. The regulatory environment for biomedical devices will also be presented for both US FDA and international compliance. The lectures will provide detailed notes on the subjects; other articles as handouts or additional readings will also be assigned.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 520. Medical Imaging Systems: X-ray and CT. 3 Credit Hours.

Engineering and scientific principles of medical imaging systems. The physics concepts and engineering implementations for different medical imaging modalities are discussed. Topics include imaging fundamentals, radiographic imaging (X-ray) system, and computed tomography (CT) system.

Prerequisite: ECE 201. And BME 211. And BME 330.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 521. Medical Imaging Systems: MRI, NMI and Ultrasound. 3 Credit Hours.

Engineering and scientific principles of medical imaging systems. The physics concepts and engineering implementations for different medical imaging modalities are discussed. Topics include magnetic resonance imaging (MRI) system, nuclear medicine imaging (NMI) system, and ultrasound imaging system.

Prerequisite: ECE 201. And BME 211. And BME 330.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 522. Scanning Electron Microscopy for Engineers. 3 Credit Hours.

Physics of transmission and scanning electron microscopy including x-ray spectroscopic analysis. Students will learn to independently operate and use the SEM for imaging in its role in research and engineering. Each student will be responsible for several imaging assignments and an independent research project related to their field of interest.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 523. Neurosensory Engineering. 3 Credit Hours.

Biophysics of neural communication, quantitative electroencephalography and evoked potentials, sleep, seizure, anesthesia and intraoperative monitoring, neural stimulation, neural signal processing, cochlear and visual implants.

Prerequisite: BME 265 and BME 470.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 524. Neuromotor Engineering. 3 Credit Hours.

Advances in Neural Engineering have led to improved medical-device designs with novel functions. This course focuses on the fundamental engineering approaches, technical principles, neurophysiology, and applications of neuroprosthetics. We will cover Neural Engineering theory and applications from the perspectives of electronics design, neural signal analysis, and neurophysiology.

Prerequisite: BME 265 and BME 470.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 525. Special Topics. 1-3 Credit Hours.

Subject matter offerings based upon student demand and availability of faculty. Subtitles describing the topics to be offered will be shown in the printed class schedule, following the title "Special Topics".

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 526. Special Topics. 1-3 Credit Hours.

Subject matter offerings based upon student demand and availability of faculty. Subtitles describing the topics to be offered will be shown in the printed class schedule, following the title "Special Topics".

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 535. Advanced Biomaterials. 3 Credit Hours.

Applications of biomaterials in different tissue and organ systems. Relationship between physical and chemical structure of materials and biological system response are discussed as well as choosing, fabricating, and modifying materials for specific biomedical applications.

Prerequisite: BME 335.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 540. Microcomputer-Based Medical Instrumentation. 3 Credit Hours.

Principles and design of microcomputer-based biomedical instruments, analog and digital signal conversion, microcomputer hardware and software design, algorithm development for medical applications, medical signal processing with microcomputers, software safety in life support systems, and current applications are discussed.

Prerequisite: ECE 315. And ECE 304. Or ECE 211.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 541. Medical Electronic Systems Laboratory. 2 Credit Hours.

Laboratory course for BME 540/640. Design of medical instruments integrated with microcomputers and telemetry devices.

Pre/Corequisite: BME 540. Or BME 640.

Components: LAB.

Grading: GRD.

Typically Offered: Spring.

BME 545. Biomedical Optical Instruments. 3 Credit Hours.

Introduction to geometrical optics, light sources, detectors, and fiber optics with an emphasis on engineering aspects and medical applications. Fiber-optic delivery systems for medical applications, optics of the eye and visual instruments, and optical instruments used in medicine (microscopes, endoscopes, ophthalmic instruments) are discussed. Hands-on sessions in the laboratory are included.

Prerequisite: PHY 222. And PHY 223. And MTH 311.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 546. Medical Applications of Lasers. 3 Credit Hours.

Review of geometrical optics, fiber optics, wave optics, laser physics, and technology. Medical laser systems, optical properties of tissue, light propagation in tissue, laser-tissue interactions, and surgical applications of lasers are also covered. Hands-on sessions in the laboratory are included.

Prerequisite: PHY 222. And PHY 223. And MTH 311.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 555. Fundamentals of Computational Neuroscience. 3 Credit Hours.

Major concepts include neural signaling and communication from the single neuron to system of neural ensembles and the role of neural computation in engineering applications. Theory and principles of information processing in the brain are presented. Experimental data and computer simulations are used to provide real examples for students experimentation.

Prerequisite: BME 265 and Corequisite: BME 470.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 565. Principles of Cellular and Tissue Engineering. 3 Credit Hours.

Introduction to cellular and tissue engineering. Current therapeutic approaches for lost/damaged tissue or organ function, tissue engineering strategies to replace/repair tissue or function: infusion of cells, production and delivery of tissue-inducing substances, cells placed on or within biomaterial scaffolds, examples of tissue engineering applications: skin, heart muscle, blood vessels, and blood.

Prerequisite: BME 302. And BME 335.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 567. Tissue Engineering Lab. 1 Credit Hour.

The principles of tissue engineering will be presented in a hands-on laboratory experience. General techniques learned will include hydrogel spectroscopy analysis, swelling tests, permeability tests, rheological tests, cell culture techniques, cell imaging, cell culture in hydrogels. Cell & Tissue engineering topics include cell cycle/metabolism, adhesion, biomaterials synthesis and characterization, biocompatibility.

Prerequisite: BME 302 and BME 303. And Corequisite: BME 335 or BME 565.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 570. Advanced Biomedical Signal Processing. 3 Credit Hours.

This course provides an overview of advanced topics in biomedical signal processing with an emphasis on practical applications. Topics include quantitative description, analysis, on-line and real-time processing of biophysical and physiological signals (cardiovascular, neural, sensory, muscular, respiratory and other) using adaptive, learning, pattern recognition and data dimension reduction methods.

Prerequisite: BME 470.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 571. Introduction to Biosignal Processing Lab. 1 Credit Hour.

Laboratory course in conjunction with BME 570 course. Corequisite: BME 570.

Prerequisite: BME 570. Or Corequisite: BME 570.

Components: LAB.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 575. Tissue Mechanics. 3 Credit Hours.

Applications of linear and nonlinear viscoelastic concepts to the biomedical characteristics of biological tissues and structures at small and large deformations of blood flow, experimental methods of analysis, artificial organs, and life-support systems.

Prerequisite: BME 375. And BME 310.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 581. Radiation Biology and Physics. 3 Credit Hours.

The principles, methods, and results of radiation biology with physics applications in radiation therapy will be introduced in the course. The course will focus on mechanisms of radiation and biological system interaction, biological aspects of the foundation of radiation therapy, and mathematical models for radiobiological analysis.

Prerequisite: BME 265.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 582. Radiation Therapy Physics. 3 Credit Hours.

The principles and instrumentation of radiation dosimetry with focus on the applications in radiation therapy will be introduced in this course. The course will emphasize radiation dose computation algorithms and applications in treatment dose planning. The course will also cover a categorized dosimetric analysis of radiation therapy to different clinical conditions.

Prerequisite: BME 310. Or Pre/Corequisite: BME 581.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 583. Radiation Protection. 3 Credit Hours.

This course covers radiation safety principles for all areas of clinical medical physics, including regulatory requirements for personnel, equipment and facilities and detailed structural shielding design requirements for medical facilities. The student will become proficient in practical aspects of radiation safety objectives and regulatory requirements in clinical practice, including those for patients, members of the general public and staff. Students will learn the principles for designing and installing structural shielding in clinical facilities that satisfies both regulatory requirements and clinical needs.

Prerequisite: BME 581. Or Pre/Corequisite: BME 582.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 585. Immunoengineering. 3 Credit Hours.

Immunoengineering is a novel interdisciplinary field that combines biomaterial science and bioengineering design with immunology to develop cutting edge technology for the prevention, rapid diagnosis and treatment of infectious diseases, cancer, autoimmune and inflammatory diseases. The goal of this course is to provide a basic background in immunology that will allow understanding the need for immunoengineering and providing the tools to be able to design novel immunotherapy. Application of biomaterials for immunoengineering applications will be reviewed through lectures, reading assignments and group projects (design and journal clubs). This course will provide valuable knowledge of an emerging field that will impact both the academic and industrial world.

Prerequisite: BME 335.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 587. Finite Element Analysis for Engineers. 3 Credit Hours.

Introduction to the finite-element method. Hands-on applications of FEMLAB software to the analysis of structural, thermal, chemical, electromagnetic, optical, and fluid flow problems.

Prerequisite: MTH 311.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 595. Current Trends in Regenerative Medicine. 3 Credit Hours.

This team-taught course provides background, clinically-relevant applications and ethical aspects of regenerative medicine as it applies to multiple types of cell, tissues and organs. The course is divided into modules focused on one application of regenerative medicine and taught by an expert in that specific topic area. The course includes hands-on demonstrations of key techniques and problem-based group projects.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 599. Cooperative Education.. 1 Credit Hour.

Practical application of classroom theory through alternating semester or summer employment with firms offering positions consistent with the student's field of study. Course may be repeated. Periodic reports and conferences are required.

Components: THI.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 601. Biochemistry and Cellular Physiology for Engineers. 3 Credit Hours.

Treatment of the basic biological and medical elements in physiological systems. The anatomy, physiology, biophysics, biochemistry and certain aspects of clinical medicine are unified with an emphasis on cellular and subcellular systems. Not open to BME undergraduates.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 602. Human Physiology for Engineers. 3 Credit Hours.

Treatment of the basic biological and medical elements in physiological systems. The anatomy, physiology, biophysics, biochemistry, and certain aspects of clinical medicine are unified with an emphasis on cardiovascular, renal, digestive, endocrine, and reproductive systems. Not open to BME undergraduates.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 603. Neurophysiology for Engineers. 3 Credit Hours.

Treatment of the basic biological and medical elements in physiological systems. The anatomy, physiology, biophysics, biochemistry, and certain aspects of clinical medicine are unified with an emphasis on neural, sensory, and muscular systems. Not open to BME undergraduates.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 606. Computer Aided Design in Biomedical Engineering. 1 Credit Hour.

Laboratory course for computer based two and three dimensional drawing and design based on ProEngineer. Parametric design, parts, features, assemblies for complex modeling. Applications in biomedical engineering design.

Prerequisite: BME 112. And BME 211.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 607. LabView Applications for Biomedical Engineering. 1 Credit Hour.

Laboratory course for computer based instrumentation and design based on Labview. Virtual instrumentation, data acquisition and display, GPIB instrument control, biomedical applications in biosignal recording, and monitoring are discussed.

Prerequisite: BME 112. And BME 211.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 610. Introduction to Medical Robotics. 3 Credit Hours.

This course will discuss the basic principles of robotics and focus on its medical applications. The course integrates previously learned math, programming and imaging knowledge into an application platform to enable students to understand fundamentals of robotics methods in biology and medicine and to train students to build a robotics prototype through hands-on projects.

Prerequisite: BME 211. And BME 310. And BME 330.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 612. Regulatory Control of Biomedical Devices. 3 Credit Hours.

Regulatory agencies and requirements, Food and Drug Administration, 510(k) and premarket approval (PMA), international regulatory requirements, ISO 9000 series, CE, UL, product and process validation, quality engineering, quality improvement programs, rapid prototyping, packaging and sterilization, and project management are discussed.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 613. Biomedical Systems Engineering. 3 Credit Hours.

This course provides students with an understanding and appreciation of Biomedical Systems Engineering with emphasis on current day industrial project management and product development processes. The components of Systems Engineering to be presented include: functional system analysis, requirements analysis, translation of functions and requirements into a system and product architecture, and, finally, testing methods to verify the biomedical product meets all design requirements. Decision methodology, alternative concept analysis, trade-off studies, integration of human factors, manufacturability, reliability, maintainability, feasibility demonstration, and safety are all addressed as part of the product design system. The entire product development life cycle will be analyzed with relevant concepts from initial market evaluation, to requirement development, through final product manufacturing and product launch. The regulatory environment for biomedical devices will also be presented for both US FDA and international compliance. The lectures will provide detailed notes on the subjects; other articles as handouts or additional readings will also be assigned.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 620. Medical Imaging Systems: X-ray and CT. 3 Credit Hours.

Engineering and scientific principles of medical imaging systems. The physics concepts and engineering implementations for different medical imaging modalities are discussed. Topics include imaging fundamentals, radiographic imaging (X-ray) system, and computed tomography (CT) system.

Prerequisite: ECE 201, BME 211, BME 330 Or Permission of Instructor.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 621. Medical Imaging Systems: MRI, NMI and Ultrasound. 3 Credit Hours.

Engineering and scientific principles of medical imaging systems. The physics concepts and engineering implementations for different medical imaging modalities are discussed. Topics include magnetic resonance imaging (MRI) system, nuclear medicine imaging (NMI) system, and ultrasound imaging system.

Prerequisite: ECE 201. And BME 211. And BME 330. Or Permission of Instructor.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 622. Scanning Electron Microscopy for Engineers. 3 Credit Hours.

Physics and operating principles of scanning electron microscope (SEM), transmission electron microscope (TEM), and optical light microscope. Biological tissue preparation, storage, fixation and digital image storage. Each student will learn to use the SEM in the design and/or analysis of a biomedical device.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 623. Neurosensory Engineering. 3 Credit Hours.

Biophysics of neural communication, quantitative electroencephalography and evoked potentials, sleep, seizure, anesthesia and intraoperative monitoring, neural stimulation, neural signal processing, cochlear and visual implants.

Prerequisite: BME 265 and BME 470.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 624. Neuromotor Engineering. 3 Credit Hours.

Advances in Neural Engineering have led to improved medical-device designs with novel functions. This course focuses on the fundamental engineering approaches, technical principles, neurophysiology, and applications of neuroprosthetics. We will cover Neural Engineering theory and applications from the perspectives of electronics design, neural signal analysis, and neurophysiology.

Prerequisite: BME 265 and BME 470.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 625. Special Topics. 1-3 Credit Hours.

Subject matter offerings based upon student demand and availability of faculty. Subtitles describing the topics to be offered will be shown in the printed class schedule, following the title "Special Topics"

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 626. Special Topics. 1-3 Credit Hours.

Subject matter offerings based upon student demand and availability of faculty. Subtitles describing the topics to be offered will be shown in the printed class schedule, following the title "Special Topics".

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 635. Advanced Biomaterials. 3 Credit Hours.

Applications of biomaterials in different tissue and organ systems. Relationship between physical and chemical structure of materials and biological system response are discussed as well as choosing, fabricating, and modifying materials for specific biomedical applications.

Prerequisite: BME 335.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 640. Microcomputer-Based Medical Instrumentation. 3 Credit Hours.

Principles and design of microcomputer-based biomedical instruments, analog and digital signal conversion, microcomputer hardware and software design, algorithm development for medical applications, medical signal processing with microcomputers, software safety in life support systems, and current applications are discussed.

Prerequisite: ECE 315. And ECE 304. Or ECE 211.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 641. Medical Electronic Systems Laboratory. 2 Credit Hours.

Laboratory course for BME 540. Design of medical instruments integrated with microcomputers and telemetry devices.

Pre/Corequisite: BME 540. Or BME 640.

Components: LAB.

Grading: GRD.

Typically Offered: Spring.

BME 645. Biomedical Optical Instruments. 3 Credit Hours.

Introduction to geometrical optics, light sources, detectors, and fiber optics with an emphasis on engineering aspects and medical applications. Fiber-optic delivery systems for medical applications, optics of the eye and visual instruments, and optical instruments used in medicine (microscopes, endoscopes, ophthalmic instruments) are discussed. Hands-on sessions in the laboratory are included.

Prerequisite: PHY 222. And PHY 223. And MTH 311.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 646. Medical Applications of Lasers. 3 Credit Hours.

Review of geometrical optics, fiber optics, wave optics, laser physics, and technology. Medical laser systems, optical properties of tissue, light propagation in tissue, laser-tissue interactions, and surgical applications of lasers are also covered. Hands-on sessions in the laboratory are included.

Prerequisite: PHY 222. And PHY 223. And MTH 311.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 655. Fundamentals of Computational Neuroscience. 3 Credit Hours.

Major concepts include neural signaling and communication from the single neuron to system of neural ensembles and the role of neural computation in engineering applications. Theory and principles of information processing in the brain are presented. Experimental data and computer simulations are used to provide real examples for students experimentation.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 665. Principles of Cellular and Tissue Engineering. 3 Credit Hours.

Introduction to cellular and tissue engineering. Current therapeutic approaches for lost/damaged tissue or organ function, tissue engineering strategies to replace/repair tissue or function: infusion of cells, production and delivery of tissue-inducing substances, cells placed on or within biomaterial scaffolds, examples of tissue engineering applications: skin, heart muscle, blood vessels, and blood.

Prerequisite: BME 302. And BME 335.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 667. Tissue Engineering Lab. 1 Credit Hour.

The principles of tissue engineering will be presented in a hands-on laboratory experience. General techniques learned will include hydrogel spectroscopy analysis, swelling tests, permeability tests, rheological tests, cell culture techniques, cell imaging, cell culture in hydrogels. Cell & Tissue engineering topics include cell cycle/metabolism, adhesion, biomaterials synthesis and characterization, biocompatibility.

Co-requisite: BME 635 or BME 665.

Components: LAB.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 670. Advanced Biomedical Signal Processing. 3 Credit Hours.

This course provides an overview of advanced topics in biomedical signal processing with an emphasis on practical applications. Topics include quantitative description, analysis, on-line and real-time processing of biophysical and physiological signals (cardiovascular, neural, sensory, muscular, respiratory and other) using adaptive, learning, pattern recognition and data dimension reduction methods.

Prerequisite: BME 470.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 671. Introduction to Biosignal Processing Lab. 1 Credit Hour.

Laboratory course in conjunction with BME 570 course. Corequisite: BME 570.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 675. Tissue Mechanics. 3 Credit Hours.

Applications of linear and nonlinear viscoelastic concepts to the biomedical characteristics of biological tissues and structures at small and large deformations of blood flow, experimental methods of analysis, artificial organs, and life-support systems.

Prerequisite: BME 375. And BME 310.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 681. Radiation Biology and Physics. 3 Credit Hours.

The principles, methods, and results of radiation biology with physics applications in radiation therapy will be introduced in the course. The course will focus on mechanisms of radiation and biological system interaction, biological aspects of the foundation of radiation therapy, and mathematical models for radiobiological analysis. Corequisite or prerequisite: BME 502 or permission of instructor.

Corequisite: BME 602.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 682. Radiation Therapy Physics. 3 Credit Hours.

The principles and instrumentation of radiation dosimetry with focus on the applications in radiation therapy will be introduced in this course. The course will emphasize radiation dose computation algorithms and applications in treatment dose planning. The course will also cover a categorized dosimetric analysis of radiation therapy to different clinical conditions.

Prerequisite: BME 310. Or Pre/Corequisite: BME 681.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 683. Radiation Protection. 3 Credit Hours.

This course covers radiation safety principles for all areas of clinical medical physics, including regulatory requirements for personnel, equipment and facilities and detailed structural shielding design requirements for medical facilities. The student will become proficient in practical aspects of radiation safety objectives and regulatory requirements in clinical practice, including those for patients, members of the general public and staff. Students will learn the principles for designing and installing structural shielding in clinical facilities that satisfies both regulatory requirements and clinical needs.

Prerequisite: BME 681. Or Pre/Corequisite: BME 682.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 685. Immunoengineering. 3 Credit Hours.

Immunoengineering is a novel interdisciplinary field that combines biomaterial science and bioengineering design with immunology to develop cutting edge technology for the prevention, rapid diagnosis and treatment of infectious diseases, cancer, autoimmune and inflammatory diseases. The goal of this course is to provide a basic background in immunology that will allow understanding the need for immunoengineering and providing the tools to be able to design novel immunotherapy. Application of biomaterials for immunoengineering applications will be reviewed through lectures, reading assignments and group projects (design and journal clubs). This course will provide valuable knowledge of an emerging field that will impact both the academic and industrial world.

Prerequisite: BME 335.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 687. Finite Element Analysis for Engineers. 3 Credit Hours.

Introduction to the finite-element method. Hands-on applications of FEMLAB software to the analysis of structural, thermal, chemical, electromagnetic, optical, and fluid flow problems.

Prerequisite: MTH 311.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 695. Current Trends in Regenerative Medicine. 3 Credit Hours.

This team-taught course provides background, clinically-relevant applications and ethical aspects of regenerative medicine as it applies to multiple types of cell, tissues and organs. The course is divided into modules focused on one application of regenerative medicine and taught by an expert in that specific topic area. The course includes hands-on demonstrations of key techniques and problem-based group projects.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 699. Cooperative Education.. 1 Credit Hour.

Practical application of classroom theory through alternating semester or summer employment with firms offering positions consistent with the student's field of study. Course may be repeated. Periodic reports and conferences are required.

Components: THI.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 702. Organs on Chips. 3 Credit Hours.

This course provides a comprehensive introduction to engineering the living and non-living components of cellular systems in a dish. The first part of the course will focus on cell source, with an emphasis on human stem cell acquisition and differentiation. The second part of the course will focus on biomaterials and methods for engineering tissues. The final portion of the course will be a survey of tissue engineering in the clinic today and existing "Organ on Chip" platforms. Throughout the course, laboratory principles will be discussed, including cell culture and gene editing. Most of the assigned reading will be recent primary literature articles.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 706. Master's Project. 3 Credit Hours.

Comprehensive MS research or design project in biomedical engineering. Open only to students who are enrolled in the MS program. This course is a requirement for all MS students in biomedical engineering.

Components: LEC.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 713. Application of Computers in Medicine. 3 Credit Hours.

Applications in the clinical and medical research laboratories for physiological data acquisition, analysis, and management of patient records. Differences among computer systems and languages for clinical and research activities are also covered.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 722. Scanning Electron Microscopy Special Projects. 3 Credit Hours.

An advanced course for graduate students with basic skills in SEM. Course is open only to masters or Ph.D. students. Students will have an opportunity to do independent research under supervision of the instructor on special projects of interest that may be related to their field of study as long as it is not part of their thesis or dissertation.

Prerequisite: BME 522 Or BME 622.

Components: LEC.

Grading: GRD.

Typically Offered: Spring.

BME 725. Special Problems. 1-3 Credit Hours.

Research and/or design projects through an individual investigation of current problems under the mentorship of a faculty mentor. Requires department approval.

Components: THI.

Grading: GRD.

Typically Offered: Fall & Spring.

BME 728. Advanced Topics. 1-3 Credit Hours.

Subject matter offerings based upon student demand and availability of faculty. Subtitles describing the topics to be offered will be shown in parentheses in the printed class schedule, following the title "Advanced Topics".

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 729. Advanced Medical Imaging. 3 Credit Hours.

Analysis of contemporary medical imaging systems and the associated technologies. The course focuses on principles of advanced medical imaging systems. Topics include multimodality imaging, three-dimensional image reconstruction and visualization, clinical and research applications, and derivation and comparison of algorithms.

Prerequisite: BME 620 Or BME 621.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 731. Advanced Topics. 1-3 Credit Hours.

Subject matter offerings based upon student demand and availability of faculty. Subtitles describing the topics to be offered will be shown in parentheses in the printed class schedule, following the title "Advanced Topics."

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 732. Advanced Topics. 1-3 Credit Hours.

Subject matter offerings based upon student demand and availability of faculty. Subtitles describing the topics to be offered will be shown in parentheses in the printed class schedule, following the title "Advanced Topics."

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 735. Auditory and Visual Neural Systems. 3 Credit Hours.

Design and application of auditory and visual neural systems and devices for medical purposes. Methodologies and instrumentation using electrophysiological, psychophysical and other measurements are explored focusing on diagnostic and therapeutic applications.

Prerequisite: BME 603.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 740. Implantable Biomedical Devices. 3 Credit Hours.

Development and advances in implantable materials and devices especially those used as electrically driven prostheses. Topics include pacemakers, defibrillators, catheters, neurological stimulators, heart assist, bone repair, and other diagnostic and therapeutic devices. The historical, medical significance, business, economic, and technical aspects of these devices and the associated instruments for monitoring are discussed. Fundamentals of electrochemical corrosion and stimulation as well the technology of implantable power sources are reviewed.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 745. Biomedical Optical Imaging and Diagnostics. 3 Credit Hours.

Review of geometrical optics, fiber optics, and tissue optics. Introduction to physical optics: interference, diffraction, and polarization; optical imaging resolution limits, super-resolution imaging, advanced optical microscopy, and optical coherence tomography (OCT). Imaging through scattering tissue, imaging and diagnostics with polarized light, fluorescence, infrared, and Raman spectroscopy and applications are also discussed. Optical diagnostics using scattered light: laser Doppler flowmetry, and dynamic light scattering; and opto-chemical and evanescent wave sensors are also covered.

Prerequisite: BME 310.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 760. Stem Cell-Based Tissue Engineering. 3 Credit Hours.

Principles and advanced topics on cellular and tissue engineering. Topics include biodegradable and non-biodegradable biomaterials, cytokines, the traditional and stem cell-based tissue engineering approaches, bioreactors and special topics such as bone, cartilage and other tissues.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 761. Stem Cell Design. 3 Credit Hours.

Stem cell engineering is a relatively new field of research that focuses on using stem cells and tissue derived products to repair damaged or diseased tissues. This course will examine through the most recent publications the role of stem cells and tissue derived donors for tissue repair, wound healing, and as well as regeneration/repair. In addition, we will highlight the use of engineered products developed from tissue banks associated with the different type of cells for clinical application. The course will use a mix of lectures/article presentations and discussion format to effectively present relevant information.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 779. Biomedical Engineering Seminar Series. 1 Credit Hour.

A course for Biomedical Engineering doctoral students. Students will attend lectures and roundtable discussions with leading experts from both academia and industry.

Components: SEM.

Grading: SUS.

Typically Offered: Fall & Spring.

BME 780. Graduate Scholarship in Biomedical Engineering. 3 Credit Hours.

A course for Biomedical Engineering doctoral students. Students will learn to critically review scientific journal articles as well as NIH research proposals (i.e. R01, R03, F30/31 and R21). Students will also learn how to read federal grant application guidelines and determine what is required for a highly competitive written application. The students will have the opportunity to prepare their own research proposal in the form of an F31 NIH application on a biomedical engineering topic of interest. Students will also learn how to prepare and present their research findings at conferences.

Components: LEC.

Grading: GRD.

Typically Offered: Fall.

BME 781. Radiation Dosimetry and Physics. 3 Credit Hours.

Application of radiation physics in the field of radiation therapy. The course will cover the relevant subjects of modern physics, the basic modalities and basic instrumentations of radiation therapy, the principles of particle transport and radiation dose computation and quality assurance of radiation therapy instruments. The subject of radiation protection will also be discussed.

Prerequisite: BME 582. Or BME 682.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 783. Radiation Therapy Physics Clinical Rotation. 3 Credit Hours.

Students will observe clinical activities at a designated radiation therapy center for ten hours per week. Rotation includes observation of daily treatment, simulation, dose planning, physics quality assurance and routine physics support activities (special physics consultation, weekly physics chart check, monitoring radiation safety activities, support of brachytherapy procedures). Students will meet with the course instructor one and a half hours/week to discuss the schedule and the progress of the rotation activities. Students need to submit reports on each radiation therapy category.

Prerequisite: BME 682. And BME 781.

Components: THI.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 784. Medical Physics Journal Club. 1 Credit Hour.

The course aims to keep track of recent developments in the field of Medical Physics for therapeutic and diagnostic purposes in oncology through reading, discussion and presentation of identified scientific papers from the major journals of Medical Physics among enrolled students.

Components: LEC.

Grading: GRD.

Typically Offered: Offered by Announcement Only.

BME 810. Master's Thesis. 1-6 Credit Hours.

The student working on his/her master's thesis enrolls for credit, in most departments not to exceed six, as determined by his/her advisor. Credit is not awarded until the thesis has been accepted.

Components: THI.

Grading: SUS.

Typically Offered: Fall, Spring, & Summer.

BME 820. Research in Residence. 1 Credit Hour.

Used to establish research in residence for the thesis for the master's degree after the student has enrolled for the permissible cumulative total in BME 710 (usually six credits). Credit not granted. May be regarded as full time residence.

Components: THI.

Grading: GRD.

Typically Offered: Fall, Spring, & Summer.

BME 825. Continuous Registration--Master's Study. 1 Credit Hour.

To establish residence for non-thesis master's students who are preparing for major examinations. Credit not granted. Regarded as full time residence.

Components: THI.

Grading: GRD.

Typically Offered: Fall, Spring, & Summer.

BME 830. Pre-candidacy Doctoral Dissertation. 1-12 Credit Hours.

Doctoral dissertation credits taken prior to Ph.D. student's candidacy. The student will enroll for credit as determined by his/her advisor. Not more than 12 hours of BME 730 may be taken in a regular semester, nor more than six in a summer session.

Components: THI.

Grading: SUS.

Typically Offered: Fall, Spring, & Summer.

BME 840. Post-Candidacy Doctoral Dissertation. 1-13 Credit Hours.

Doctoral dissertation credits taken after Ph.D. student has been admitted to candidacy. The student will enroll for credit as determined by his/her advisor. Not more than 12 credits in BME 740 may be taken in a regular semester, nor more than six credits in a summer session.

Components: THI.

Grading: SUS.

Typically Offered: Fall, Spring, & Summer.

BME 850. Research in Residence. 1 Credit Hour.

Used to establish research in residence for the Ph.D., after the student has been enrolled for the permissible cumulative total in appropriate doctoral research. Credit not granted. May be regarded as full-time residence as determined by the Dean of the Graduate School.

Components: THI.

Grading: SUS.

Typically Offered: Fall, Spring, & Summer.