BME - Biomedical Engineering

BME 403/503 Introduction to Mathematical Modeling in Physiology (3 Credit Hours)
This course introduces model development and model formulation with differential equations in physiology. Students will learn how to use Matlab to solve differential equations and visualize their results. The physiological focus will be on cellular physiology, particularly ion channel dynamics and homeostasis.
Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211

BME 404/504 Introduction to Biomaterials (3 Credit Hours)
This course will introduce the properties of biomedical materials used as implants, prostheses, orthosis, and tissue-engineered materials as medical devices in contact with tissues and organs. Biocompatibility, immunological responses, wound healing, clotting cascade, surface compatibility and characterization of materials used for implantable medical devices will be introduced. Other topics such as ethical considerations and medical device regulatory mechanisms will be presented.
Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211

BME 405/505 Biomechanics (3 Credit Hours)
The purpose of this course is to achieve a broad overview of biomechanics, focused on the musculoskeletal system. Students will explore multiscale mechanics, including whole-body movement and mechanical properties of the structures in the musculoskeletal system. Additionally, students will survey the experimental methods and computational modeling techniques used in biomechanics research.
Prerequisites: BIOL 240 or BIOL 250, and MATH 212

BME 409/509 Introduction to Regenerative Medicine (3 Credit Hours)
This course will introduce fundamental knowledge in regenerative medicine including therapeutic applications of biomaterials, tissue and stem cell engineering, gene therapy and bioelectrics, with emphasis on structure-function relationships of biologic systems. In addition to lecture, students will have opportunities for group discussions and presentations on milestone work related to tissue regeneration. Students will leave with a thorough understanding of true mammalian regeneration, wound healing/repair processes, and medical device milestones as related to human tissue regeneration and repair.
Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211

BME 430/530 Therapy and Function Models for Medical Simulation (3 Credit Hours)
This course introduces students to the main Modeling & Simulation models. (1) Anatomical modeling based on robust medical image segmentation and meshing methodologies. (2) A therapy model to determine the impact of a medical intervention by synthesizing the effect of a therapy on the patient’s tissues. (3) A collision model, which interacts with anatomy and therapy models, is used for haptics-driven simulations. This course will also explore physiological simulation and the use of finite elements to model biomechanics.
Prerequisites: ECE 250 or CS 250 or CS 251 and CS 260 or equivalent

BME 454/554 Introduction to Bioelectrics (3 Credit Hours)
This course covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition ultra-short electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered.
Prerequisites: PHYS 111N or higher and MATH 200 or higher

BME 462/562 Introduction to Medical Image Analysis (3 Credit Hours)
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. Cross-listed with ECE 462/MSIM 462.
Prerequisites: a grade of C or better in MATH 212

BME 464/564 Biomedical Applications of Low Temperature Plasmas (3 Credit Hours)
This course is cross listed with ECE and Biology. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered.
Prerequisites: Senior standing

BME 495/595 Topics in Biomedical Engineering (1-3 Credit Hours)
This course explores specialized topics in biomedical engineering, providing an in-depth study of emerging trends, technologies, and applications in the field. Topics may vary by semester and are designed to enhance students' understanding of cutting-edge developments in biomedical engineering.
Prerequisites: Departmental approval

BME 497/597 Independent Study in Biomedical Engineering (1-3 Credit Hours)
This course allows students to pursue independent research or study in biomedical engineering under the guidance of a faculty mentor. Students will explore specific areas of interest, develop problem-solving skills, and gain hands-on experience in a focused topic. A written report or presentation may be required as part of the course. Supervised and approved by the advisor.
Prerequisites: Departmental approval

BME 503 Introduction to Mathematical Modeling in Physiology (3 Credit Hours)
This course introduces model development and model formulation with differential equations in physiology. Students will learn how to use Matlab to solve differential equations and visualize their results. The physiological focus will be on cellular physiology, particularly ion channel dynamics and homeostasis.
Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211

BME 504 Introduction to Biomaterials (3 Credit Hours)
This course will introduce the properties of biomedical materials used as implants, prostheses, orthosis, and tissue-engineered materials as medical devices in contact with tissues and organs. Biocompatibility, immunological responses, wound healing, clotting cascade, surface compatibility and characterization of materials used for implantable medical devices will be introduced. Other topics such as ethical considerations and medical device regulatory mechanisms will be presented.
Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211

BME 505 Biomechanics (3 Credit Hours)
The purpose of this course is to achieve a broad overview of biomechanics, focused on the musculoskeletal system. Students will explore multiscale mechanics, including whole-body movement and mechanical properties of the structures in the musculoskeletal system. Additionally, students will survey the experimental methods and computational modeling techniques used in biomechanics research.
Prerequisites: BIOL 240 or BIOL 250, and MATH 212

BME 509 Introduction to Regenerative Medicine (3 Credit Hours)
This course will introduce fundamental knowledge in regenerative medicine including therapeutic applications of biomaterials, tissue and stem cell engineering, gene therapy and bioelectrics, with emphasis on structure-function relationships of biologic systems. In addition to lecture, students will have opportunities for group discussions and presentations on milestone work related to tissue regeneration. Students will leave with a thorough understanding of true mammalian regeneration, wound healing/repair processes, and medical device milestones as related to human tissue regeneration and repair.
Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211

BME 530 Therapy and Function Models for Medical Simulation (3 Credit Hours)
This course introduces students to the main Modeling & Simulation models. (1) Anatomical modeling based on robust medical image segmentation and meshing methodologies. (2) A therapy model to determine the impact of a medical intervention by synthesizing the effect of a therapy on the patient's tissues. (3) A collision model, which interacts with anatomy and therapy models, is used for haptics-driven simulations. This course will also explore physiological simulation and the use of finite elements to model biomechanics.
Prerequisites: ECE 250 or CS 250 or CS 251 and CS 260 or equivalent

BME 554 Introduction to Bioelectrics (3 Credit Hours)
This course covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition ultra-short electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered.

BME 562 Introduction to Medical Image Analysis (3 Credit Hours)
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. Cross-listed with ECE 562/MSIM 562.

BME 564 Biomedical Applications of Low Temperature Plasmas (3 Credit Hours)
This course is cross listed with ECE and Biology. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered.
Prerequisites: Senior standing

BME 595 Topics in Biomedical Engineering (1-3 Credit Hours)
This course explores specialized topics in biomedical engineering, providing an in-depth study of emerging trends, technologies, and applications in the field. Topics may vary by semester and are designed to enhance students' understanding of cutting-edge developments in biomedical engineering.
Prerequisites: Departmental approval

BME 597 Independent Study in Biomedical Engineering (1-3 Credit Hours)
This course allows students to pursue independent research or study in biomedical engineering under the guidance of a faculty mentor. Students will explore specific areas of interest, develop problem-solving skills, and gain hands-on experience in a focused topic. A written report or presentation may be required as part of the course. Supervised and approved by the advisor.
Prerequisites: Departmental approval

BME 612 Digital Signal Processing I (3 Credit Hours)
This course covers fundamentals of digital signal processing. Topics include frequency domain analysis of discrete-time signals and linear systems, sampling and reconstruction of signals, the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), and digital filter design and implementations. Practical applications and examples will be discussed. Problem solving using MATLAB is required. Cross-listed with ECE 612.
Prerequisites: ECE 381 or equivalent

BME 695 Topics in Biomedical Engineering (3 Credit Hours)
This course will be offered as needed, depending upon the need to introduce special subjects to target specific areas of master's-level specializations in biomedical engineering.

BME 698 Master's Project (1-3 Credit Hours)
Individual project directed by the student's professor in major area of study.

BME 699 Master's Thesis (1-9 Credit Hours)
Directed research for the master's thesis.
Prerequisites: departmental approval

BME 700 Cardiovascular Physiology (4 Credit Hours)
This physiology course will focus solely on cardiovascular physiology. Lectures will focus on basic and advance cardiovascular principles. The laboratory will focus on the use of current cardiovascular research.

BME 702 Biomedical Sciences Journal Club (1 Credit Hour)
Review and discussion of current papers in the areas of biomedical sciences. Student presentation, discussions and readings in this field required.

BME 710 Advanced Cell Biology (3 Credit Hours)
This course will cover selected current topics in cell biology that reflect recent advances in the field. Major topics include membranes and transport, signal transduction, cell adhesion and motility, cell cycle, apoptosis, and specialized cell functions. Students will read current research papers that describe the latest innovations in microscopic and molecular analysis of cellular function. This course is built on previous coursework in cell biology by reinforcing key fundamental concepts and performing a more in-depth examination of cellular mechanisms.
Prerequisites: Course background in cell biology recommended

BME 711 Biological Mechanisms for Biomedical Engineers (3 Credit Hours)
This course is designed for students without a sufficient background in biology and physiology, providing them with the essential biological foundations needed for biomedical engineering. It equips students with a comprehensive understanding of biological and physiological systems, chemical building blocks of life (proteins, lipids, carbohydrates, nucleic acids), the structure and function of various human organs, cell structure and function, key concepts in cellular and molecular biology, molecular genetics and genetic engineering, human physiology relevant to biomedical applications, as well as pathophysiology and disease mechanisms. The course also introduces biological characterization techniques, such as cellular and molecular analyses and immunohistological characterization of tissues.

BME 712 Engineering Fundamentals in Biomedicine (3 Credit Hours)
This course introduces students without a sufficient engineering background to the essential mathematical and engineering principles needed for biomedical engineering. Students will build foundational knowledge in mathematical concepts and core engineering areas, such as mechanical and electrical engineering. This foundation will enable them to analyze, design, and implement engineering solutions to biomedical challenges. Emphasis is placed on problem-solving, critical thinking, and understanding the integration of engineering concepts within biological systems, equipping students with the insights needed for interdisciplinary work in biomedical engineering.

BME 714 Biomedical Sciences Laboratory (2 Credit Hours)
Three laboratory rotations (6 credits) are required by the curriculum.
Prerequisites: Approval of the Program Director

BME 720 Modern Biomedical Instrumentation (3 Credit Hours)
This course covers the design of modern biomedical instruments including select diagnostic, assistive, therapeutic, prosthetic, imaging, and virtual devices and systems. Techniques for mechanical, electrical, and chemical sensor and transducer design; stimulation and measurement; data acquisition; digital signal processing; and data visualization will be examined.

BME 721 Mathematical Modeling in Physiology (3 Credit Hours)
This course on mathematical modeling in human physiology emphasizes the development of mathematical models, their implementation, and the interpretation of simulation data. The course focuses on cellular physiology, including membrane channels, excitability, and calcium dynamics; it also covers intercellular communication and spatially distributed systems.

BME 726 Biomaterials (3 Credit Hours)
This course cover fundamental principles and properties of biomedical materials used as implants, prostheses, orthosis, and tissue-engineered materials as medical devices in contact with tissues and organs. Advanced concepts of biocompatibility and material characterization will be discussed. Physiological response factors associated with materials and implanted devices used in the human body will be presented, including immunological responses, wound healing, clotting cascade and surface compatibility. Other topics such as ethical considerations and medical device regulatory mechanisms will be discussed.

BME 730 Predoctoral Fellowship Grant Writing (1 Credit Hour)
This course is designed to guide predoctoral students through the process of developing and writing competitive fellowship grant applications. Students will work one-on-one with a mutually agreeable faculty mentor to identify funding opportunities, refine research proposals, and draft key components of their applications. Emphasis will be placed on understanding the expectations of funding agencies, writing clear and compelling narratives, and addressing reviewer criteria. By the end of the course, students may have a polished grant proposal.

BME 731 Finite Element Analysis (3 Credit Hours)
This course provides an understanding of the finite element method (FEM) as derived from an integral formulation perspective. It demonstrates the solutions of (1-D and 2-D) continuum mechanics problems such as solid mechanics, fluid mechanics and heat transfer. It also provides insight into the theoretical formulation and numerical implementation of finite element methods.

BME 740 Regenerative Medicine (3 Credit Hours)
This course explores the engineering principles and techniques applied to regenerative medicine. Topics include advanced engineering methods for scaffold development, material characterization techniques, and the evaluation of tissue-engineered constructs through in vitro and in vivo analysis. Students will gain a comprehensive understanding of how engineering tools are utilized to address challenges in regenerating tissues and organs, bridging the gap between biology and engineering in regenerative medicine.
Prerequisites: Either BIOL 240 or BIOL 250 and one of MATH 200 or MATH 205 or MATH 211

BME 741 Principles of Visualization (3 Credit Hours)
Well-designed graphical media capitalizes on human facilities for processing visual information and thereby improves comprehension, memory, inference, and decision making. This course teaches techniques and algorithms for creating effective visualizations based on principles and techniques from graphic design, visual art, perceptual psychology and cognitive science. Both users and developers of visualization tools and systems will benefit from this course.

BME 747 Responsible Conduct of Research (2 Credit Hours)
The course will introduce students to the responsible conduct of science and scientific research.

BME 751 Computational and Statistical Methods in Biomedical Engineering (3 Credit Hours)
This course covers the theoretical foundation and application of commonly used techniques in biomedical engineering. Topics include linear algebra, partial differential equations, regression analysis, applied probabilities, multivariate distributions, Bayesian statistics, hypothesis tests, multiple comparisons, ANOVA, solution of non-linear equations, numerical methods and optimization. Programming software will be used to perform simulations and analyze biomedical data.
Prerequisites: Graduate status

BME 754 Advanced Bioelectrics (3 Credit Hours)
Bioelectrics is a new field encompassing both the science and technology of applying electrical stimuli to biological systems. This course covers the pulsed power technology that is required to generate electrical stimuli as well as the biological responses they evoke in cells and tissues. Particular emphasis is placed on the medical applications of bioelectrics, including tumor ablation, gene electrotransfer, wound healing, decontamination with cold plasma, and treatment of cardiac arrhythmias.
Prerequisites: ECE 454 or ECE 554 or BIOE 454 or BIOE 554

BME 755 Biomembranes and Ion Channels (3 Credit Hours)
This course will give an overview of the structure and dynamics of biomembranes, the ion channels that are embedded in them, and the electrical properties of biomembranes. Topics include molecular dynamics modeling of biomembranes, membrane damage and repair, ion channel dynamics and their experimental assessment using patch clamping, and excitability in neurons and cardiomyocytes.
Prerequisites: ECE 454 or ECE 554 or BIOL 523

BME 760 Autonomous and Robotic Systems Analysis and Control (3 Credit Hours)
Kinematics, dynamics and control of complex non-linear electro-mechanical systems, particularly robotic manipulators.

BME 762 Applied Medical Image Analysis (3 Credit Hours)
Course explores hands-on exposure to state-of-the-art algorithms in medical image analysis, which builds on open-source software (Insight Segmentation and Registration Toolkit - ITK), as well as the principles of medical image acquisition in the modalities of clinical interest. Medical imaging modalities - X-rays, CT, and MRI/ITK image pipeline; image enhancement, feature detection; segmentation - basic techniques, feature-based classification and clustering, graph cuts, active contour and surface models; surface and volume meshing; registration - transformations, similarity criteria; shape and appearance models are all explored and discussed in this course.
Prerequisites: Knowledge of C++ and object-oriented programming

BME 770 Advanced Study in Biology (3 Credit Hours)
Under the guidance of members of the graduate faculty and with the approval of the program track coordinator, the student will carry out in-depth studies of selected topics relevant to the area of specialization. Extensive surveys and analyses of the literature. Written reviews, comprehensive and synoptic, and oral presentations are required of each student.

BME 775 Grant Writing in Biology (3 Credit Hours)
Provides students with the skills to write competitive grant proposals to both private and federal funding sources (emphasis on NIH and NSF). Students will learn how to find the most appropriate funding mechanisms and how to position themselves to be competitive. Different grant writing formats will be illustrated through proposal development projects.

BME 783 Digital Image Processing (3 Credit Hours)
Principles and techniques of two-dimensional processing of images. Concepts of scale and spatial frequency. Image filtering in spatial and transform domains. Applications include image enhancement and restoration, image compressing, biomedical imaging for diagnosis of disease, and image segmentation for computer vision.
Prerequisites: ECE 782 or ECE 882

BME 785 Advanced Manufacturing Technology (3 Credit Hours)
Treatment of the next generation of manufacturing technology. Topics include additive manufacturing; rapid prototypying; electronic manufacturing; micro and nanofabrication; process simulation; product life cycle management; and sustainable design and manufacturing.
Prerequisites: MAE 682 or permission of Program Director

BME 792 Biomechanics (3 Credit Hours)
The purpose of this course is to achieve a broad overview of biomechanics, focused on the musculoskeletal system. Students will explore multiscale mechanics, including whole-body movement and mechanical properties of the structures in the musculoskeletal system. Additionally, students will survey the experimental methods and computational modeling techniques used in biomechanics research.
Prerequisites: MATH 212 or equivalent

BME 794 Cellular Biomechanics (3 Credit Hours)
A broad introduction to the field of cellular biomechanics. Topics include overview of cell architecture, cytoskeleton, adhesion and molecular motors, biomolecular/biopolymer dynamics and mechanics, techniques to measure cell mechanical properties, techniques to mechanically stimulate cells, models of cell mechanical behavior, mechanobiology and mechanotransduction. Will include discussion of classic and current research articles. Course content will aim to cater to students with diverse backgrounds – students with biological science background will be exposed to physical science concepts and analysis; students with engineering/physical science background will be exposed to biological phenomena and concepts.
Pre- or corequisite: MATH 212

BME 795 Special Topics in Biomedical Engineering (1-3 Credit Hours)
Special courses covering selected graduate-level topics in biomedical engineering.

BME 797 Independent Study (1-3 Credit Hours)
This course allows students to develop specialized expertise by independent study (supervised by a faculty member).
Prerequisites: departmental approval

BME 800 Cardiovascular Physiology (4 Credit Hours)
This physiology course will focus solely on cardiovascular physiology. Lectures will focus on basic and advance cardiovascular principles. The laboratory will focus on the use of current cardiovascular research.

BME 802 Biomedical Sciences Journal Club (1 Credit Hour)
Review and discussion of current papers in the areas of biomedical sciences. Student presentation, discussions and readings in this field required.

BME 810 Advanced Cell Biology (3 Credit Hours)
This course will cover selected current topics in cell biology that reflect recent advances in the field. Major topics include membranes and transport, signal transduction, cell adhesion and motility, cell cycle, apoptosis, and specialized cell functions. Students will read current research papers that describe the latest innovations in microscopic and molecular analysis of cellular function. This course is built on previous coursework in cell biology by reinforcing key fundamental concepts and performing a more in-depth examination of cellular mechanisms.
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Prerequisites: Either BIOL 240 or BIOL 250 and one of MATH 200 or MATH 205 or MATH 211

BME 841 Principles of Visualization (3 Credit Hours)
Well-designed graphical media capitalizes on human facilities for processing visual information and thereby improves comprehension, memory, inference, and decision making. This course teaches techniques and algorithms for creating effective visualizations based on principles and techniques from graphic design, visual art, perceptual psychology and cognitive science. Both users and developers of visualization tools and systems will benefit from this course.

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Prerequisites: ECE 454 or ECE 554 or BIOL 523

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Prerequisites: Knowledge of C++ and object-oriented programming

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Prerequisites: ECE 783 and ECE 883

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Treatment of the next generation of manufacturing technology. Topics include additive manufacturing; rapid prototypying; electronic manufacturing; micro and nanofabrication; process simulation; product life cycle management; and sustainable design and manufacturing.
Prerequisites: MAE 682 or permission of Program Director

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Prerequisites: MATH 212 or equivalent

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Pre- or corequisite: MATH 212

BME 895 Special Topics in Biomedical Engineering (1-3 Credit Hours)
Special courses covering selected graduate-level topics in biomedical engineering.

BME 897 Independent Study (1-3 Credit Hours)
This course allows students to develop specialized expertise by independent study (supervised by a faculty member).
Prerequisites: departmental approval

BME 899 PHD Dissertation Research (1-9 Credit Hours)
Directed research for the doctoral dissertation.

BME 999 Doctoral Graduate Credit (1 Credit Hour)
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.