BIOMEDICAL ENGINEERING (EGRB)

EGRB 101. Biomedical Engineering Practicum. 2 Hours.
Semester course; 2 lecture hours. 2 credits. Enrollment is restricted to students in the biomedical engineering department and requires permission of course coordinator. This course involves the introduction of clinical procedures and biomedical devices and technology to biomedical engineering freshmen. Students will tour medical facilities, clinics and hospitals and will participate in medical seminars, workshops and medical rounds. Students will rotate among various programs and facilities including orthopaedics, cardiology, neurology, surgery, otolaryngology, emergency medicine, pharmacy, dentistry, nursing, oncology, physical medicine, ophthalmology, pediatrics and internal medicine.

EGRB 102. Introduction to Biomedical Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 151, MATH 200, MATH 201 or a satisfactory score on the math placement exam. Biomedical engineering is a multidisciplinary STEM field that combines biology and engineering, applying engineering principles and materials to medicine and health care. This course provides students with an introduction to biomedical engineering, beginning with a framework of core engineering principles, expanding to specializations within the field of biomedical engineering and connecting the concepts to real-world examples in medicine and health care.

EGRB 104. Introduction to Biomedical Engineering Laboratory. 1 Hour.
Semester course; 3 laboratory hours. 1 credit. Enrollment is restricted to biomedical engineering majors. This laboratory course introduces students to practical laboratory skills required for biomedical engineering. Following successful completion of this course, students will be able to construct and design simple mechanical-electric prototypes; solder electrical components to a breadboard; construct a bridge measurement circuit in order to measure a physiological signal; use a digital multimeter to analyze a circuit. This course is also a writing-intensive course and will provide students with the skills necessary to analyze and write up the results of their experiments. Non-technical skills that will be introduced in this course include how to set up and maintain a laboratory notebook; record and analyze data in Excel, including how to use Excel formulas, create pivot tables and generate graphs; how to plan and execute an experiment; how to read and write a laboratory report in IMRD format; how to write a design concept paper; oral presentation.

EGRB 105. Successes and Failures in Biomedical Technologies. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course will look at successes and failures in biomedical engineering and technologies through case studies, as well as consider the ethical implementations and framework for developing evidence-based reasoning. Origins and recent advances in biomedical engineering and technologies will be explored, including applications of biomechanics, bio- and nanotechnologies, medical imaging, rehabilitation engineering and biomaterials.

EGRB 111. Introduction to Biological Systems in Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 151, MATH 200, MATH 201 or a satisfactory score on the math placement exam; and CHEM 100 with a minimum grade of B, CHEM 101, CHEM 102 or a satisfactory score on the chemistry placement exam. The cell is the principle unit of the human body. In this course, students will explore how the cell works from an engineering perspective. Students will learn the essential functions of cells, the components of cells and terminology related to cell biology. The course will also introduce key concepts in engineering, and students will learn how to apply these concepts to mammalian cells.

EGRB 203. Statics and Mechanics of Materials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 201 and PHYS 207, both with a minimum grade of C. Enrollment is restricted to biomedical engineering majors. The theory and application of engineering mechanics applied to the design and analysis of rigid and deformable structures. The study of forces and their effects, including equilibrium of two- and three-dimensional bodies, stress, strain and constitutive relations, bending, torsion, shearing, deflection, and failure of materials.

EGRB 209. Applied Physiology for Biomedical Engineers. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: MATH 200 with a minimum grade of C. Corequisite: EGRB 111. Enrollment is restricted to biomedical engineering students. This course introduces the concepts of mathematical models and describes physiological systems using applied mathematics and engineering principles. Physiological systems will include a comprehensive study of muscle, nervous, cardiovascular, respiratory, renal and endocrine, beginning with applied biophysical concepts in cell anatomy and physiology leading into the various physiological systems. This course also incorporates a laboratory that uses the knowledge-based tools gained through lecture and implements them in practice using exercises in biochemical and physiological calculations, osmosis, electrical network simulation of diffusion, EEG, blood pressure, ECG and spirometry.

EGRB 215. Computational Methods in Biomedical Engineering. 3 Hours.
Semester course; 3 lecture/recitation hours. 3 credits. Prerequisite: MATH 201 with a minimum grade of C. Corequisite: MATH 301, MATH 310 or permission of instructor. Enrollment is restricted to students with sophomore standing in biomedical engineering. The goal of this course is to enhance students' software skills for subsequent biomedical engineering courses and laboratories, as well their careers. The course covers the basic fundamentals of programming in Python as well as data analysis of biomedical data. An important component of this course is developing problem-solving skills.

EGRB 301. Biomedical Engineering Design Practicum. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 101, EGRB 102, EGRB 203, EGRB 209, EGRB 215, EGRE 206 (or equivalent), each with a minimum grade of C. Restricted to students with junior standing in the biomedical engineering program. Explores the professional and ethical responsibilities of a biomedical engineer. Emphasis will be placed on design issues associated with biomedical engineering, teamwork, regulatory issues and human and animal subjects.

EGRB 303. Biotransport Processes. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 209, MATH 301 and MATH 310, each with a minimum grade of C. Course involves the study of fundamental principles of fluid mechanics and mass transport as well as application of these principles to physiological systems. Fluid mechanics principles covered will include conservation of mass and momentum, laminar and turbulent flow, Navier-Stokes equations, dimensional analysis, Bernoulli's equation, and boundary layer theory. Mass transport principles will include diffusion, convection, transport in porous media and transmembrane transport. Concepts will be applied to studying diffusion in biological tissues, electrolyte transport, vascular transport, blood flow mechanics and cardiovascular flow. The course will also cover organ-specific transport processes, including oxygen transport in the lungs and blood and mass transport in the kidney.

EGRB 307. Biomedical Instrumentation. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: EGRB 102 and EGRB 209; EGRB 215 or CMSC 210; and EGRE 206, all with minimum grades of C. A study of the physical principles, design and clinical uses of biomedical instrumentation. Analysis and design of low frequency electronic circuits, which are most frequently used in biomedical instruments, will be conducted. Analysis of biosensors, biopotential electrodes, the measurements of biopotential signals including electrocardiogram, electroencephalogram and electromyogram, blood pressure, blood flow, and respiratory system will be conducted. Laboratory work on basic biomedical electronics and instrumentation will be performed.

EGRB 308. Biomedical Signal Processing. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: EGRB 102 and EGRB 209; EGRB 215 or CMSC 210; EGRB 307; EGRE 206; and MATH 301 and MATH 310, all with a minimum grade of C. Explores the basic theory and application of digital signal processing techniques related to the acquisition and processing of biomedical and physiological signals including signal modeling, AD/DA, Fourier transform, Z transform, digital filter design, continuous and discrete systems.

EGRB 310. Biomechanics. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: EGRB 203 and EGRB 209; EGRB 215 or CMSC 210; and MATH 200 and MATH 201, all with a minimum grade of C. Corequisites: MATH 301 and MATH 310. A study of the forces, stresses and strains in the human body during normal function. Emphasis is placed on the mechanics of various components of the body including hard (bone) and soft (skin, vessels, cartilage, ligaments, tendons) tissues from a structure-function perspective. Stress and strain relationships for these biomaterials will be analyzed based upon the fundamentals of engineering mechanics. In addition, the distinctive features of biological materials will be studied with respect to their differences from nonliving materials and elaborated upon in laboratory exercises using material evaluation protocols.

EGRB 315. Device Design Methods. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisites: EGRB 203; EGRB 215 or CMSC 210; EGRB 307; MATH 301; and MATH 310, all with a minimum grade of C. The main goal of the course is to introduce a variety of design and prototyping methods for biomedical devices. The focus will be on: (1) using first approximations and Solidworks for mechanical design and (2) using Arduino microcontrollers for controlling sensors and actuators.

EGRB 401. Biomedical Engineering Senior Design Studio. 3 Hours.
Semester course; 9 laboratory hours. 3 credits. Prerequisites: EGRB 301 and EGRB 315, each with a minimum grade of C. Corequisite: STAT 441. Enrollment is restricted to students with senior standing in the Department of Biomedical Engineering or by permission of instructor. A minimum of nine laboratory hours per week is dedicated to the design, development and execution of the senior design (capstone) project for biomedical engineering under the direction of a faculty research adviser in biomedical engineering or an acceptable substitute as determined by the course coordinator. Tasks include team meetings (for team projects), brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects. Monthly progress reports are due to the research adviser and course coordinator. At the end of the first semester, each team will orally present to the BME faculty project background information and discuss potential technical approaches and deliverables.

EGRB 402. Biomedical Engineering Senior Design Studio. 3 Hours.
Semester course; 9 laboratory hours. 3 credits. Prerequisites: Completion of EGRB 401 with a minimum grade of C. A minimum of nine laboratory hours per week is dedicated to the design, development and execution of the senior design (capstone) project for biomedical engineering under the direction of a faculty research adviser in biomedical engineering or an acceptable substitute as determined by the course coordinator. Tasks include team meetings (for team projects), brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects. Monthly progress reports are due to the research adviser and course coordinator. Final project reports must be submitted before the end of the semester. All design teams must participate in the College of Engineering public poster session. At the end of the semester and conclusion of the two-semester design process, teams must present their final designs and deliverables before the BME faculty.

EGRB 403. Tissue Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 209 with a minimum grade of C or permission of instructor. Enrollment is restricted to students with junior standing in engineering. Study of the design, development and clinical application of tissue engineered components for use in the human body. Analysis of biology, chemistry, material science, engineering, immunology and transplantation as pertains to various tissue engineered components including blood vessels, bone, cartilage, pancreas, liver and skin.

EGRB 405. Finite Element Analysis in Solid Mechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 310 and MATH 301, each with a minimum grade of C. Finite element analysis as presented in this course is a numerical procedure for solving continuum mechanics problems that cannot be described by closed-form mathematical solutions. Emphasis will be placed on understanding the theoretical basis for the method, using a commercial software program, and understanding the volume of information that can be generated. Applications to both one- and two-dimensional problems in solid mechanics and biomechanics will be explored.

EGRB 406. Artificial Organs. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 209, EGRB 303, EGRB 307 and EGRB 310, each with a minimum grade of C, or permission of instructor. This course explores the design, operating principles and practices regarding artificial organs and their use in the human body. Analysis of dialysis systems for kidney replacement, artificial hearts and heart assist devices, cardiac pacemakers, sensory organ assist and replacement devices, and artificial liver and pancreas devices. Design aspects, legal ramifications, regulatory issues and clinical implantation issues will be addressed.

EGRB 407. Physical Principles of Medical Imaging. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: PHYS 208 with a minimum grade of C. Enrollment is restricted to students with junior standing in the College of Engineering. A study of the physical principles and basic clinical uses of medical imaging. Analysis of radiation and interaction of radiation, generation and control of X-rays, X-ray diagnostic methods, X-ray computed tomography (CT), magnetic resonance imaging (MRI) and ultrasonic imaging will be conducted. Basic principle of radionuclide imaging also will be introduced.

EGRB 408. Advanced Biomedical Signal Processing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 308. This course will briefly review the basic theory of discrete-time signal processing techniques in biomedical data processing. Advanced signal processing techniques including adaptive signal processing, wavelets, spectral estimation and multirate signal processing will be employed. Specific examples utilizing electrocardiogram (ECG) and other biological signals are provided. Topics covered are alternance phenomenon in biological systems, late potential in ECG, intrapotential in ECG and coherence analysis.

EGRB 409. Microcomputer Applications in Biomedical Engineering. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: EGRB 307. Covers microcomputer applications (hardware and software) as applied to biomedical science and biomedical engineering. Basic hardware components of a microcomputer are discussed with particular reference to configurations needed for analyzing biomedical events. Software applications including data encoding, data storage, graphical interfaces and real-time processing are explored for analysis of physiological and biomedical signals. Students will develop algorithms using LabView and MatLab to solve problems in biomedical engineering in the laboratories.

EGRB 410. Cellular Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 209 with a minimum grade of C. This course will be a detailed study of the structure and function of the cell from an engineering perspective. Fundamental molecular biology, cell biology and biochemistry topics (cellular structure, signal transduction, cell adhesions, cytoskeleton) will be introduced. Engineering principles (kinetics, transport, mechanics, thermodynamics, electrochemical gradient) will be applied to these topics. Emphasis is placed on methods to disrupt, enhance or mimic in vivo cellular function in biomedical applications.

EGRB 411. Cell Mechanics and Mechanobiology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 310 and EGRB 410 with minimum grades of C or permission of instructor. Focusing on cellular-extracellular matrix interactions, students will gain a quantitative understanding of the way cells detect, modify and respond to the physical properties within the cell environment. Coverage includes the mechanics of single-molecule polymers, polymer networks, two-dimensional membranes, whole-cell mechanics and mechanobiology. Mechanobiology topics include cancer and development, pulmonary system, cardiovascular system, and the nervous system. Students will gain understanding of techniques in cellular manipulation and quantification of cellular forces.

EGRB 412. Regenerative Engineering and Medicine. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 209 or equivalent with minimum grade of C. Students will apply fundamental concepts of cell and molecular biology, biochemistry, medicine and pathology, as well as material science and engineering principles to design novel strategies for cell and drug delivery, tissue engineering and regenerative medicine. Emphasis will be placed on designs and methods to solve current complex biomedical problems.

EGRB 413. Computational and Experimental Models of Cellular Signal Transduction. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 215 and EGRB 410 with minimum grades of C. Students will study the process by which an extracellular protein binding event is transduced and interpreted as an incoming signal into a cell. Students will learn the biology of cellular signal transduction and will also learn how to apply computational models and experimental techniques to predict and investigate these pathways. Students will follow the course of a protein within a signal transduction cascade, from binding to a receptor, activating intracellular pathways, inducing new transcription and translation and targeting of the protein to its final location. Students will develop MATLAB-based mathematical models to predict signal transduction dynamics, and then will study experimental techniques that are used to both disrupt and measure signal transduction.

EGRB 415. Cellular and Molecular Engineering Techniques. 3 Hours.
Semester course; 1 lecture and 6 lab hours. 3 credits. Prerequisite: EGRB 209 with a minimum grade of C. Cell and tissue culture techniques are becoming increasingly important in academic laboratories and companies involved in regenerative medicine. This laboratory-based course is designed to introduce basic, hands-on cell culture concepts and techniques needed for academia and industry. Students will be expected to learn molecular engineering techniques by designing and purifying plasmids for mammalian cell transfection. Students will apply mathematics to predict outcomes for culture conditions. Lectures will reinforce basic concepts in cell culture and bioengineering, while the laboratory will be used to practice concepts learned in lecture.

EGRB 420. Assistive Technology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 315 with a minimum grade of C. Enrollment is restricted to biomedical engineering students or by permission of the instructor. This course explores the principles and practice regarding the development of assistive technology for individuals with disabilities. The course will address the human user considerations that need to be taken into account in developing technology for individuals with different disabilities or multiple disabilities. This will include the use of participatory design as the design process and considering human factors based on human physiology and psychology. The course will also provide a general overview of current technologies and methods used in the design of assistive technology. It will further develop and apply engineering design skills relevant to assistive technology design.

EGRB 421. Human Factors Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 209 and EGRB 310, both with a minimum grade of C. This course explores the principles and practices regarding ergonomics and human factors engineering and the interaction of biomedical engineering with human function. Analysis of the functions of the human body regarding motion, sensory mechanisms, cognition and interaction with the environment will be included. Interactions of the human body with technology, workplaces, equipment and computers will be examined. Design of workplaces for optimal human performance will be discussed. Analysis of the design and arrangement of controls and displays will be covered.

EGRB 422. Human Performance Measurement Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 209, EGRB 307, EGRB 308 and EGRB 421, each with a minimum grade of C. Enrollment is restricted to biomedical engineering majors or with permission of instructor. Course explores the principles and practices of human performance measurement including direct and indirect measurement techniques and analysis. Course addresses the subjective, psychophysical and physiological methods related to the measurement, analysis and quantification of human performance.

EGRB 423. Rehabilitation Engineering and Prostheses. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 203 and EGRB 209, both with a minimum grade of C. Enrollment is restricted to biomedical engineering majors or with permission of instructor. This course explores the principles and practices regarding the development of rehabilitation therapy devices and prostheses. The course will further address the human user and factors that must be considered when developing devices and engineering solutions for individuals with different therapy and prosthetic needs. The course will also provide a general overview of current technologies and the engineering principles behind these designs.

EGRB 427. Biomaterials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 209 with a minimum grade of C. Enrollment is restricted to students with junior standing in biomedical engineering or with permission of the instructor. Principles of materials science as it relates to the use of materials in the body. Characterization of biomaterials. Study of the properties of biomedical materials used as implants, prostheses, orthosis and as medical devices in contact with the human body. Analysis of physical, chemical, thermal and physiological response factors associated with materials and implant devices used in the human body.

EGRB 491. Special Topics. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. May be repeated with different topics. Advanced study of a selected topic in biomedical engineering. See the Schedule of Classes for specific topics to be offered each semester and prerequisites, corequisites or restrictions.

EGRB 506. Artificial Organs. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 209 or permission of instructor. This course explores the design, operating principles and practices regarding artificial organs and their use in the human body. Analysis of dialysis systems for kidney replacement, artificial hearts and heart-assist devices, artificial heart valves, cardiac pacemakers, and sensory organ-assist and -replacement devices. Design aspects, legal ramifications, regulatory issues and clinical implantation issues will be addressed.

EGRB 507. Biomedical Electronics and Instrumentation. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Fundamental principles and applications of electronics and instrumentation as related to biomedical sciences.

EGRB 509. Microcomputer Technology in the Biomedical Sciences. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Microcomputer applications to the acquisition and manipulation of data in the biomedical laboratory.

EGRB 511. Fundamentals of Biomechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: Calculus and ordinary differential equations (MATH 200-201, MATH 301 or equivalent). Presents basic mechanical properties of materials, describes methods of material testing and introduces techniques for analyzing the solid and fluid mechanics of the body. Considers topics such as stress/strain relationships, particle mechanics, and force balances.

EGRB 513. Cellular Signal Processing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. In this course students will study the process by which an extracellular protein binding event is transduced and interpreted as an incoming signal into a cell. Students will learn the biology of cellular signal transduction, as well as how to apply computational models and experimental techniques to predict and investigate these pathways. The course will follow the course of a protein within a signal transduction cascade, from binding to a receptor, activating intracellular pathways, inducing new transcription and translation, and targeting of the protein to its final location. Students will develop MATLAB-based mathematical models to predict signal transduction dynamics and then study experimental techniques that are used to both disrupt and measure signal transduction.

EGRB 515. Manufacturing of Biomaterials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment is restricted to engineering students with junior class standing or above, or with permission of the instructor. This course introduces the concepts/ principles underlying different fabrication techniques of biomaterials and correlates the manufacturing techniques to different types of biomaterials and their applications in medicine. The areas of biomedical research and clinical practice that have benefited from each type of manufacturing technique are discussed. Specifically, the course focuses on three major material manufacturing techniques: additive manufacturing, surface treatments and coatings, and scaffold processing.

EGRB 517. Cell Mechanics and Mechanobiology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: previous course in biomechanics and a previous cell biology course, or permission of instructor. Graduate-level students will gain a quantitative understanding of cellular mechanics and the way cells detect, modify and respond to the physical properties within the cell environment. Students will gain a thorough understanding of relevant primary literature and mathematical models. Both experimental and theoretical approaches toward cell mechanics and mechanobiology will be addressed. Emphasis will be placed upon cells from the nervous, cardiovascular and pulmonary systems. Cancer cell mechanotransduction will also be addressed.

EGRB 521. Human Factors Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Students enrolling in this course should have completed a class in human and/or quantitative physiology (or equivalents), differential equations, statistics and/or have consent of the instructor. Course explores the principles and practices of ergonomics and human factors with respect to effective design and decision-making. Course addresses the physical and cognitive aspects of user-centered design, including factors related to the sensory systems, human memory, movement control and control systems, physical and mental workload, decision-making, mathematical modeling, environmental factors, simulation, usability testing, task analysis, eye tracking, display systems, and controls.

EGRB 523. Rehabilitation Engineering and Prostheses. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 203 and EGRB 209, both with a minimum grade of C. Enrollment is restricted to biomedical engineering majors or with permission of instructor. This course explores the principles and practices regarding the development of rehabilitation therapy devices and prostheses. Students will learn how to perform a dynamic analysis of human movement toward the design of rehabilitation therapies, devices and prostheses. The course will further address deficits in neuromuscular control that must be considered when developing engineering solutions for individuals with different therapy and prosthetic needs. The course will also provide a general overview of current technologies and the engineering principles behind these designs.

EGRB 524. Assistive Technology Design. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 255 or EGRE 245. Smartphones are prevalent in their use as a platform for assistive technology for individuals with disabilities. This course will consider the product development cycle for assistive technology. Students will also learn key aspects of programming Android phones, which are relevant for most assistive technology applications. Students will also have a group design project.

EGRB 525. Modeling and Simulation of Human Movement. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRB 203 and EGRB 209, both with a minimum grade of C. Enrollment is restricted to biomedical engineering majors or with permission of instructor. This course explores the principles and practices regarding musculoskeletal modeling and simulation of human movement. Students will learn the components of musculoskeletal models and how these models are developed and validated. The course will cover computer algorithms that are used to develop simulations of human movement and how simulations can be applied to develop new technologies, devices and understanding. Learning is achieved through a series of lectures, tutorials, reading, webinars and computer simulation exercises.

EGRB 527. Physical Principles of Medical Imaging. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment is restricted to students in the College of Engineering. A study of the physical principles and basic clinical uses of medical imaging. Analysis of radiation and interaction of radiation, generation and control of X-rays, X-ray diagnostic methods, X-ray computed tomography, magnetic resonance imaging and ultrasonic imaging will be conducted. Basic principle of radionuclide imaging also will be introduced.

EGRB 528. Fundamentals and Applications of Artificial Intelligence in Medical Imaging. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 225; and CLSE 115, CMSC 210, CMSC 254, EGRB 215 or EGRE 246. This course is designed to provide students with a comprehensive understanding of the intersection between artificial intelligence and medical imaging. Basic understanding of machine learning and image processing is recommended but not mandatory. Students will learn how AI techniques can be applied to various aspects of medical and biological imaging, including image analysis, feature extraction, disease diagnosis and treatment planning. The course will cover both theoretical concepts and hands-on practical applications, preparing students for careers in health care, research and AI development.

EGRB 534. Artificial Intelligence in Rehabilitation Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 215. Enrollment is restricted to engineering majors or with permission of instructor. This course offers a comprehensive study and application of the cutting-edge field of applying artificial intelligence to rehabilitation engineering. Students will gain an understanding of the innovative ways AI is revolutionizing the design and delivery of rehabilitation and prediction of patient outcomes. The course covers fundamental concepts in both AI and rehabilitation engineering. Through lectures, hands-on projects and case studies, students gain practical experience in developing AI algorithms in specific applications including: markerless motion capture that utilizes cloud-based data and machine learning, classification of human movement intent, speech classification from neural signals, and machine learning to predict outcomes of brain stimulation. By the end of the course, students are equipped with the knowledge and skills to contribute to the ongoing advancement of AI in rehabilitation engineering and improve patient care in this vital field.

EGRB 591. Special Topics in Biomedical Engineering. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. Enrollment is restricted to students with senior or graduate standing in the School of Engineering or by permission of the instructor. Lectures, tutorial studies, library assignments in selected areas of advanced study or specialized laboratory procedures not available in other courses or as part of research training. See the Schedule of Classes for special topics to be offered each semester.

EGRB 601. Numerical Methods and Modeling in Biomedical Engineering. 4 Hours.
Semester course; 4 lecture hours. 4 credits. Prerequisite: MATH 301 or equivalent. Enrollment is restricted to graduate students. The goal of this course is to develop an enhanced proficiency in the use of computational methods and modeling, to solve realistic numerical problems in advanced biomedical engineering courses and research, as well careers. The course will discuss and students will develop advanced technical skills in the context of numerical data analysis and modeling applications in biology and medicine. An important component of this course is developing problem-solving skills and an understanding of the strengths and weaknesses of different numerical approaches applied in biomedical engineering applications.

EGRB 602. Biomedical Engineering Systems Physiology. 4 Hours.
Semester course; 4 lecture hours. 4 credits. Prerequisite: EGRB 601. Enrollment restricted to graduate students. Biomedical engineering requires a foundational understanding of organ systems in the body as well as an advanced understanding of how to apply engineering principles and mathematical models to those systems. In this course, students will learn the basic physiology of major organ systems while also identifying and implementing mathematical modeling approaches to simulate and better understand these organ systems. Students will also learn how to apply engineering concepts, such as fluid dynamics, thermodynamics, structural mechanics and mass transport to better understand organ system physiology.

EGRB 603. Biomedical Signal Processing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: Calculus and differential equations (MATH 301 or equivalent), including Laplace and Fourier Transforms. Explores theory and application of discrete-time signal processing techniques in biomedical data processing. Includes discrete-time signals and systems, the Discrete/Fast Fourier Transforms (DFT/FFT), digital filter design and implementation, and an introduction into processing of discrete-time random signals.

EGRB 604. Biomechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 201, MATH 301 or permission of instructor. Presents fundamental principles and conservation laws governing solid and fluid mechanics which are then applied to the mechanics of living systems. This enables an understanding of normal biomechanical function as compared with variations present in dysfunctional states. The objectives of this course are to introduce the student to the general mechanical function of a variety of biological materials and structures, linkage to structure-function relationships, and how these can be studied and represented mathematically.

EGRB 605. Grant Writing in Biomedical Engineering. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Enrollment is restricted to graduate students. Students will learn about the typical components in a scientific grant, the review process for grants and approaches for developing such grants. Students will also acquire tools to improve their scientific writing skills by approaching scientific writing from the reader's perspective. Students will develop and write a complete grant proposal during the course that will be reviewed by department faculty in an interactive mock grant review panel.

EGRB 610. Microprocessor Interfacing for Biomedical Instrumentation. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisite: EGRB 509 or permission of instructor. Principles and applications of microprocessor interfacing for biomedical instrumentation. Topics include microprocessor architecture, assembly language, programming and debugging techniques, EPROM programming and bus structure and interfacing.

EGRB 611. Cardiovascular Dynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Concurrent prerequisite: PHIS 501 or PHIS 502. Analyzes and models the cardiovascular system in health and disease through studies on the properties of heart and vascular tissue, the mechanics of blood flow and the application of engineering methods to the diagnosis and treatment of cardiovascular pathologies.

EGRB 612. Structural Biomechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRB 511. Treats mechanical functions of the human body as an engineering structure used to assist and supplement these functions. Includes movement of the musculoskeletal system, joint reaction forces, stresses and strains developed within bones, function and design of orthopedic prostheses and braces, effect of vibration and impact on the body, mathematical and other models of the body.

EGRB 613. Biomaterials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: Undergraduate material science or permission of the instructor. Primary and secondary factors determining the performance of materials used for implants in the human body. Topics will include metallurgy of stainless steel, cobalt-chromium alloys, titanium alloys, biocompatibility of implant materials, mechanical and physical properties of biomaterials, corrosion of biomaterials and medical polymers.

EGRB 614. Tissue Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. In this course, students will learn and apply fundamental and novel concepts of biology, physiology, chemistry, physics, material science, biomaterials and engineering principles to design novel strategies for stem cell engineering and therapy and tissue engineering. Emphasis will be placed on designs and methods to solve current complex biomedical problems.

EGRB 615. Medical Imaging. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: Calculus and college physics. Covers the physical principles and techniques of medical imaging modalities such as ultrasound, X-ray and nuclear magnetic resonance. Includes generation and detection of images, consideration of system design and qualitative image analysis.

EGRB 616. Cell Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course will cover the cell and its engineering principles with an emphasis on current research techniques. Topics covered include the organization and structure of the cell, cell signaling, and application of cell biology to biomedical research. Advanced methods are taught enabling students to interpret and present findings from primary literature.

EGRB 618. Regenerative Engineering and Medicine. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: undergraduate or graduate level physiology or permission of instructor. Study of the design, development and clinical application of regenerative medicine strategies. Analysis of molecular and cellular engineering, biomaterials and tissue engineering, stem cell biology, and immunology as they pertain to pre-translational and clinically used regenerative medicine therapies, as well as the regulatory and ethical considerations of their implementation.

EGRB 619. Computational and Experimental Models of Cellular Signal Transduction. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Corequisite: EGRB 616 or permission of instructor. In this course students will study the process by which an extracellular protein binding event is transduced and interpreted as an incoming signal into a cell. Students will learn the biology of cellular signal transduction, as well as how to apply computational models and experimental techniques to predict and investigate these pathways. The course will follow the course of a protein within a signal transduction cascade, from binding to a receptor, activating intracellular pathways, inducing new transcription and translation, and targeting of the protein to its final location. Students will develop MATLAB-based mathematical models to predict signal transduction dynamics and then study experimental techniques that are used to both disrupt and measure signal transduction.

EGRB 635. Modeling for Biomedical Engineers. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: Permission of instructor. Applies mathematical modeling techniques to biomedical systems. Covers linear and nonlinear systems, deterministic and random systems, large systems, ecosystems, numerical techniques, graph theoretical approaches and simulation packages. Utilizes examples of biochemical, physiological and pharmacokinetic systems throughout.

EGRB 670. Advanced Molecular Modeling Theory and Practice. 3 Hours.
Semester course; lecture and laboratory hours. 3 credits. Prerequisite: MEDC 641, EGRB 641 or permission of the instructor. Examines the principles and applications of computational chemistry and molecular graphics to current problems in drug design. Lectures focus on the application of specific computational methods and techniques to solve problems in drug/molecular design. Workshop sessions provide hands-on experience using state-of-the-art hardware and software for molecular modeling.

EGRB 690. Biomedical Engineering Research Seminar. 1 Hour.
Semester course; 1 lecture hour. 1 credit. May be repeated for a maximum of four credits. Presentation and discussion of research reports and topics of current interest to the program seminar or special group seminar. Graded as satisfactory/unsatisfactory.

EGRB 691. Special Topics in Biomedical Engineering. 1-4 Hours.
Semester course; 1-4 credits. Lectures, tutorial studies, library assignments in selected areas of advance study, or specialized laboratory procedures not available in other courses or as part of the research training.

EGRB 697. Directed Research in Biomedical Engineering. 1-15 Hours.
Semester course; 1-15 credits. Research leading to the M.S. degree or elective research projects for other students.