

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Professor and chair

[biomedical.egr.vcu.edu \(https://egr.vcu.edu/departments/biomedical/\)](https://egr.vcu.edu/departments/biomedical/)

The Department of Biomedical Engineering offers programs at the baccalaureate, master's and doctoral level.

Biomedical engineering provides in-depth study in a variety of specialization areas including biomedical imaging systems, orthopaedic biomechanics, tissue and cellular engineering, biomaterials, artificial organs, human-computer interfaces, cardiovascular devices, rehabilitation and human factors engineering. The programs allow students to participate in cutting-edge research in one of the nation's most advanced engineering facilities. The department has ongoing collaborations with numerous industries, federal laboratories, the VCU science departments, the university's MCV Campus, the Hunter Holmes McGuire Veterans Affairs Medical Center, the Virginia BioTechnology Research Park and numerous biomedical and clinical programs throughout the VCU Medical Center's MCV Hospitals.

- Biomedical Engineering, Doctor of Philosophy (Ph.D.) (<http://bulletin.vcu.edu/graduate/school-engineering/biomedical-engineering/biomedical-engineering-phd/>)
- Biomedical Engineering, Master of Science (M.S.) (<http://bulletin.vcu.edu/graduate/school-engineering/biomedical-engineering/biomedical-engineering-ms/>)

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 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 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 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. Pre- or corequisite: 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 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. Presentation and discussion of research reports and topics of current interest to the program seminar or special group seminar.

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.