

BIOMEDICAL ENGINEERING

CU Boulder's Biomedical Engineering program offers students a flexible degree program to achieve their degree and research goals. Biomedical engineering is an exciting, multidisciplinary field that lies at the intersection of medicine, biology and engineering.

With a cross-listed curriculum and an interdisciplinary faculty roster, the BME program delivers a multi-faceted and rigorous education in biomedical engineering. Our department consists of 40+ faculty members from multiple backgrounds and disciplines. They conduct research in the areas of biomechanics, tissue engineering, biomaterials, drug delivery, molecular imaging, image-guided therapy, point-of-care diagnostics, biosensors, prosthetics, bioastronautics, systems biology and many more.

Our program offers students the opportunity to take courses in any of the following areas:

- Biomechanics and mechanobiology
- Imaging and diagnostics
- Medical devices
- Therapeutics

The BME program is directed by Dr. Corey Neu. For more information, visit the Biomedical Engineering Program (<https://www.colorado.edu/bme/>) website.

Course code for this program is BMEN.

Master's Degree

- Biomedical Engineering - Master of Science (MS) (<https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/biomedical-engineering/biomedical-engineering-master-science-ms/>)

Doctoral Degree

- Biomedical Engineering - Doctor of Philosophy (PhD) (<https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/biomedical-engineering/biomedical-engineering-doctor-philosophy-phd/>)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Ahmed, Alaa A. (https://experts.colorado.edu/display/fisid_144736/)
Assistant Professor; PhD, University of Michigan

Alistar, Mirela (https://experts.colorado.edu/display/fisid_164177/)
Assistant Professor; PhD, Technical University of Denmark

Allen, Mary Ann (https://experts.colorado.edu/display/fisid_149077/)
Research Associate Professor; PhD, University of Colorado Boulder

Borden, Mark A. (https://experts.colorado.edu/display/fisid_148514/)
Associate Professor; PhD, University of California, Davis

Bottenus, Nick (https://experts.colorado.edu/individual/fisid_165371/)
Assistant Professor; PhD, Duke University

Bruns, Carson J. (https://experts.colorado.edu/display/fisid_159851/)
Assistant Professor; PhD, Northwestern University

Calve, Sarah (https://experts.colorado.edu/individual/fisid_165779/)
Associate Professor; PhD, University of Michigan

Cha, Jennifer N. (https://experts.colorado.edu/display/fisid_151746/)
Professor; PhD, University of California, Santa Barbara

Clark, Torin K. (https://experts.colorado.edu/display/fisid_155959/)
Assistant Professor; PhD, Massachusetts Institute of Technology

Davis, Robert H. (https://experts.colorado.edu/individual/fisid_113653/)
Associate Faculty Director; PhD, Stanford University

Del Rio Flores, Antonio
Assistant Professor; PhD, University of California, Berkeley

Ding, Xiaoyun (https://experts.colorado.edu/display/fisid_158563/)
Assistant Professor; PhD, Pennsylvania State University

Dowell, Robin D. (https://experts.colorado.edu/display/fisid_147779/)
Professor; DSc, Washington University

Enoka, Roger M. (https://experts.colorado.edu/display/fisid_110122/)
Professor; PhD, University of Washington

Ferguson, Virginia L. (https://experts.colorado.edu/display/fisid_110131/)
Associate Professor; PhD, University of Colorado Boulder

Fox, Jerome Michael (https://experts.colorado.edu/display/fisid_156682/)
Assistant Professor; PhD, University of California, Berkeley

Gopinath, Juliet T. (https://experts.colorado.edu/display/fisid_147075/)
Associate Professor; PhD, Massachusetts Institute of Technology

Grabowski, Alena Marie (https://experts.colorado.edu/display/fisid_149727/)
Associate Professor; PhD, University of Colorado Boulder

Hayman, Allison P. (https://experts.colorado.edu/display/fisid_156275/)
Assistant Professor; PhD, Massachusetts Institute of Technology

Hind, Laurel (https://experts.colorado.edu/individual/fisid_165642/)
Assistant Professor; PhD, University of Pennsylvania

Huang, Shu-Wei (https://experts.colorado.edu/display/fisid_159847/)
Assistant Professor; PhD, MIT, Cambridge

Jayaram, Kaushik (https://experts.colorado.edu/display/fisid_165370/)
Assistant Professor; PhD, University of California-Berkeley

Layer, Ryan M. (https://experts.colorado.edu/display/fisid_163567/)
Assistant Professor; PhD, University of Virginia

Lynch, Maureen Ellen (https://experts.colorado.edu/display/fisid_163404/)
Assistant Professor; PhD, Cornell University

McLaughlin, Jessica (https://experts.colorado.edu/individual/fisid_167401/)
Teaching Assistant Professor; PhD, Northeastern University

McLeod, Robert R. (https://experts.colorado.edu/display/fisid_107547/)
Professor; PhD, University of Colorado Boulder

Mukherjee, Debanjan (https://experts.colorado.edu/individual/fisid_164181/)
Assistant Professor; PhD, University of California, Berkeley

Murray, Todd W. (https://experts.colorado.edu/display/fisid_146549/)
Professor; PhD, Johns Hopkins University

Myers, Chris (https://experts.colorado.edu/display/fisid_167168/)
Professor; PhD, Stanford University

Neu, Corey P. (https://experts.colorado.edu/display/fisid_156210/)
Associate Professor; PhD, University of California, Davis

Park, Won (https://experts.colorado.edu/display/fisid_122676/)
Associate Professor, Associate Chair; PhD, Georgia Institute of Technology

Piestun, Rafael (https://experts.colorado.edu/display/fisid_118538/)
Professor; PhD, Israel Instit of Tech (Israel)

Regueiro, Richard A. (https://experts.colorado.edu/display/fisid_134705/)
Associate Professor; PhD, Stanford University

Rentschler, Mark E. (https://experts.colorado.edu/display/fisid_146091/)
Associate Professor; PhD, University of Nebraska-Lincoln

Sankaranarayanan, Sriram (https://experts.colorado.edu/display/fisid_147413/)
Associate Professor; PhD, Stanford University

Shields, C. Wyatt IV (https://experts.colorado.edu/individual/fisid_165173/)
Assistant Professor; PhD, Duke University

Spencer, Sabrina Leigh (https://experts.colorado.edu/display/fisid_154911/)
Associate Professor; PhD, Massachusetts Institute of Technology

Sprenger, Kayla (https://experts.colorado.edu/individual/fisid_165650/)
Assistant Professor; PhD, University of Washington

Tan, Wei (https://experts.colorado.edu/display/fisid_141464/)
Associate Professor; PhD, University of Illinois at Chicago

Welker, Cara (https://experts.colorado.edu/display/fisid_168549/)
Assistant Professor; Ph.D., Stanford University

Xu, Nicole (https://experts.colorado.edu/display/fisid_172095/)
Assistant Professor; PhD, Stanford University

Yeh, Tom (https://experts.colorado.edu/display/fisid_151584/)
Associate Professor; PhD, Massachusetts Institute of Technology

Zhang, Yide
Assistant Professor; PhD, University of Notre Dame

Courses

BMEN 5110 (3) Regenerative Biology and Tissue Repair

Presents the regenerative biology behind tissue systems, along with the regenerative medicine of that tissue with an emphasis on engineering principles, using the assigned reading as a guideline. Follows lectures with class discussions of current papers on the regenerative biology of the same tissue system. In the final 1 & 2 classes assigned to this topic, individual graduate students give 20 min presentations on a relevant regenerative medicine/engineering-focused paper.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 5110, BMEN 4110, and MCEN 4110

Requisites: Restricted to any College of Engineering and Applied Science graduate students or to Biomedical Engineering undergraduate majors only.

BMEN 5111 (3) Introduction to Microfluidics

Microfluidics deals with the behavior of fluids in small scale. It is a highly multidisciplinary field at the intersection of engineering, physics, chemistry, biology, medicine, nanotechnology, and biotechnology. This course covers the fundamentals and fabrication of microfluidic devices and their applications, particularly in lab-on-a-chip. Includes lectures, literature discussion, team presentations, and possibly one lab on microfluidic devices. Enhances your understanding of microfluidic technologies and their broad applications.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 5111 and MCEN 4111 and BMEN 4111

Requisites: Restricted to any College of Engineering and Applied Science graduate students or to Biomedical Engineering undergraduate majors only.

BMEN 5113 (3) Mechanics of Cancer

Cancer is considered to be an organ or an ecosystem, in which a critical component of the tumor microenvironment is mechanical forces. This course will cover the role of mechanics in cancer and cancer-related processes, with a focus on solid mechanics and fluid mechanics. In this course, you will apply engineering principles to come away with an appreciation of how mechanics influences cancer and its etiology as well as the development of future treatments.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 5113 and BMEN 4113 and MCEN 4113

Requisites: Restricted to any College of Engineering and Applied Science graduate students or to Biomedical Engineering undergraduate majors only.

BMEN 5117 (3) Anatomy and Physiology for Biomedical Engineering

The main objective of this multidisciplinary course is to explore human physiological function from the viewpoint of an engineer. It provides an introduction to human anatomy and physiology with a focus on learning anatomical structures, biological signaling, physiological and pathological conditions, as well as fundamental biomedical engineering concepts that apply quantitative analyses (mass transfer, fluid dynamics, mechanics, modeling) and engineering concepts (e.g., device design to restore defective physiological functions) to understand physiology and pathology. Graduate students will be required to present a primary literature review and lead discussion during a class period, as well as take the lead on the final project: a mock NIH grant proposal.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 4117 or MCEN 5117 BMEN 4117

Requisites: Restricted to graduate Biomedical Engineering students only.

BMEN 5127 (3) Biomedical Ultrasound

Covers the design of ultrasound systems for medical imaging and therapy, including the physics of wave propagation, transducers, pulse-echo imaging, flow, tissue characterization, and microbubble contrast, with an emphasis on current topics in biomedical ultrasound. Includes lectures on theory, practice and special topics; a laboratory on wave propagation; oral presentations on current literature; signal processing exercises; and a team project. Some experience with MATLAB is strongly encouraged for exercises throughout the course.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 5127 and MCEN 4127 and BMEN 4127

Requisites: Restricted to graduate students only.

Grading Basis: Letter Grade

BMEN 5133 (3) Intro to Tissue Biomechanics

Focuses on developing an understanding of the fundamental mechanical principles that govern the response of hard and soft biological tissue to mechanical loading. Specifically, covers mechanical behavior of biological materials/tissues, classical biomechanics problems in various tissues, the relationship between molecular, cellular and physiological processes and tissue biomechanics and critical analysis of related journal articles.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 4133 and MCEN 5133

Requisites: Restricted to any College of Engineering and Applied Science graduate students or to Biomedical Engineering undergraduate majors only.

BMEN 5157 (3) Modeling of Human Movement

Human movement analysis is used in physical rehabilitation, sport training, human-robot interaction, animation, and more. Course provides a systematic overview of human movement on multiple levels of analysis, with an emphasis on the phenomenology amenable to computational modeling. Covers muscle physiology, movement-related brain areas, musculoskeletal mechanics, forward and inverse dynamics, optimal control and Bayesian inference, learning and adaptation. Inspires students to see and appreciate the complexities of movement control in all aspects of daily life.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 5157 and MCEN 4157 and BMEN 4157

Requisites: Restricted to graduate students in the College of Engineering and Applied Science or undergraduate Biomedical Engineering (BMEN) majors with 57+ credits (Junior or Senior).

BMEN 5171 (3) Biofluids on the Micro Scale

Introduces fundamental physical concepts and basic mechanisms of biological fluids in microscale. Elaborates on the application of fluid mechanics principles to major biological systems, including human organ systems and animal locomotion in microscale. Covers physiologically relevant fluid flow phenomena on the cellular level and the underlying physical mechanisms from an engineering perspective. Related state-of-art technologies such as organ-on-a-chip and micro/nano fabrication will be emphasized. Will enhance your understanding of organ-on-a-chip technologies and their broad applications.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 5171 and MCEN 4171 and BMEN 4171

Requisites: Restricted to any College of Engineering and Applied Science graduate students or to Biomedical Engineering undergraduate majors only.

BMEN 5195 (3) Bioinspired Robotics

Bioinspired design views the process of how we learn from nature as an innovation strategy translating principles of function, performance, and aesthetics, from biology to human technology. The creative design process is driven by interdisciplinary exchange among engineering, biology, medicine, art, architecture and business. Diverse teams of students will collaborate on, create, and present original bioinspired design projects in the ITLL.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 4195, BMEN 4195, and MCEN 5195

Requisites: Restricted to graduate students in the College of Engineering and Applied Science or undergraduate Biomedical Engineering (BMEN) majors with 57+ credits (Junior or Senior).

BMEN 5231 (3) Computational Fluid Dynamics

This course is an in-depth introduction to the basic principles and applications of computational fluid dynamics (CFD). Students learn about fundamental CFD concepts such as discretization, meshing, error and accuracy; and focus on computational solutions of flow and transport problems using the finite element method. Students conduct multiple hands-on simulation-based activities and exercises on canonical and realistic engineering flow/transport problems. Final project for the course culminates in a mini-conference/symposium where students present their work.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 5231 and MCEN 4231 and BMEN 4231

Requisites: Restricted to any College of Engineering and Applied Science graduate students or to Biomedical Engineering undergraduate majors only.

BMEN 5292 (3) Materials and Devices in Medicine

The main objective of this multidisciplinary course is to provide students with a broad survey of biomaterials and their use in medical devices for restoring or replacing the functions of injured, diseased, or aged human tissues and organs. The topics to be covered include: evolution in the medical device industry, a broad introduction to the materials used in medicine and their chemical, physical, and biological properties, discovery of medical problems, potential impacts of treatment innovations, existing devices and design considerations for several major physiological systems (cardiovascular, neuromuscular, skeletal, pulmonary, renal, dermal), materials interaction with the human body, basic mechanisms of wound healing, biocompatibility issues, testing methods and techniques in accordance with standards and relevant regulations, biofunctionalities required for specific applications, as well as state-of-the-art approaches for the development of new regenerative materials targeting cellular mechanisms. Sam

Requisites: Requires prerequisite course of MCEN 4117 or MCEN 5117 (minimum grade C-). Restricted to any College of Engineering and Applied Science graduate students or to BMEN undergraduate majors only.

BMEN 5840 (1-6) Independent Study

Provides opportunities for independent study at the graduate level.

Subject and/or project agreed upon by the student and instructor to fit the needs of the student.

Repeatable: Repeatable for up to 30.00 total credit hours.

Requisites: Restricted to graduate Biomedical Engineering students only.

BMEN 5939 (1-6) Biomedical Engineering Internship

Grants credit to international graduate students for conducting research via professional research opportunities in the biomedical engineering field. Students are responsible for securing their own internships.

Repeatable: Repeatable for up to 6.00 total credit hours.

Requisites: Restricted to graduate students only.

BMEN 6519 (1-3) Special Topics in Biomedical Engineering

Credit hours and subject matter to be arranged.

Repeatable: Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

BMEN 6949 (1) Master's Candidate for Degree

Credit hours and subject matter to be arranged.

BMEN 6950 (1-6) Master's Thesis

Work with a faculty advisor on a masters thesis.

Repeatable: Repeatable for up to 6.00 total credit hours.

Requisites: Restricted to graduate Biomedical Engineering students only.

BMEN 7840 (1-6) Independent Study

Provides opportunities for independent study at the graduate (PhD) level.

Subject and/or project agreed upon by the student and instructor to fit the needs of the student.

Repeatable: Repeatable for up to 10.00 total credit hours. Allows multiple enrollment in term.

Requisites: Restricted to Biomedical Engineering BMEN-PhD students only.

BMEN 8990 (1-10) Doctoral Dissertation

Work with a faculty advisor on a doctoral dissertation.

Repeatable: Repeatable for up to 60.00 total credit hours.

Requisites: Restricted to Biomedical Engineering (BMEN) Ph.D. graduate students only.