

BIOENGINEERING

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Overview

The Department of Bioengineering bridges engineering and medicine with a core mission of applying engineering principles and analyses to improving human health. The department will fulfill this mission by providing opportunities for training, research, and service in bioengineering to faculty, students, and residents of Colorado and the greater Rocky Mountain region.

Program Objectives

The Department of Bioengineering offers high-quality training in bioengineering that is both flexible and multidisciplinary. A design-based focus permeates every aspect of our training philosophy which can be summarized by the following question: what does the user want and how can I best utilize my bioengineering training to achieve this need? Our academic instruction focuses on developing core competencies in life sciences, quantitative methods, technology, and research methods.

Undergraduate Information

The program offers a Bachelor of Science (BS) degree in bioengineering. All undergraduate students begin the program on the CU Denver (Auraria) campus. In consultation with faculty advisors, each student chooses elective courses, training pathways, and research to fit talents, preparation, and career plans.

The BS in bioengineering degree will prepare students for careers in the biomedical industry, in hospital, government, or academic research labs, in regulatory agencies such as the FDA, and for further education in graduate school, medical school, or other advanced health sciences program.

The minimum of 128 semester hours is required to earn the BS degree, including 58 credits in bioengineering and prerequisite coursework and 24 credits in general education core at the Denver campus. This training is complemented by 46 credits in the upper-level bioengineering major and technical elective courses at the CU Anschutz Medical Campus.

Students can transition to the Anschutz Medical Campus in the fall semester once they have completed all MATH, BIOL, CHEM, PHYS and lower-division BIOE prerequisite coursework with a C- or higher and are in good academic standing.

BS/MS option

For full-time undergraduate CU Denver bioengineering students in the major, the bioengineering BS/MS option provides students the opportunity to begin graduate work while completing the undergraduate degree. Students are able to take six credits toward the Master of Science during the last year in the major as part of the Bachelor of Science

technical electives, accelerating the time to obtain a graduate degree. Visit our website or contact us at bioengineering@ucdenver.edu.

Programs

- Bioengineering, BS (<http://catalog.ucdenver.edu/cu-denver/undergraduate/schools-colleges-departments/college-engineering-design-computing/bioengineering/bioengineering-bs/>)

Faculty

Professors:

Keith Neeves, PhD

Email: keith.neeves@cuanschutz.edu

Specialties: Hematology and oncology

Robin Shandas, PhD

Email: robin.shandas@cuanschutz.edu

Specialties: Novel methods for translational bioengineering

Associate Professors:

Richard Benninger, PhD

Email: richard.benninger@cuanschutz.edu

Specialties: Optical microscopy, pancreatic islet biology and biophysics, diabetes

Cathy Bodine, PhD

Email: cathy.bodine@cuanschutz.edu

Specialties: Assistive technology, rehabilitation engineering

Emily Gibson, PhD

Email: emily.gibson@cuanschutz.edu

Specialties: Microfluidics technology, optical microscopy, and spectroscopy

Kendall Hunter, PhD

Email: kendall.hunter@cuanschutz.edu

Specialties: Soft tissue mechanics, vascular and cardiac imaging diagnostics, translational biomechanics

Jeffrey Jacot, PhD

Email: jeffrey.jacot@cuanschutz.edu

Specialties: Stem cells and heart tissue engineering

Daewon Park, PhD

Email: daewon.park@cuanschutz.edu

Specialties: Biomaterials, drug delivery, tissue engineering and regenerative medicine

Assistant Professors:

Chelsea Magin, PhD

Email: chelsea.magin@cuanschutz.edu

Specialties: regulatory affairs, pulmonary engineering

Bradford Smith, PhD

Email: bradford.smith@cuanschutz.edu

Specialties: Lung structure-function relationships, optimized mechanical ventilation, and high performance computing

Instructors:

Mary Bevilacqua, PhD Candidate

Email: mary.bevilacqua@cuanschutz.edu

Specialties: Global Health and Design

Steven Lammers, PhD

Email: steven.lammers@cuanschutz.edu

Specialties: 3D printing & design, bioprintable materials, tissue engineering of 3D cellularized scaffolds

Eric Roth, PhD

Email: eric.roth@cuanschutz.edu (steven.lammers@cuanschutz.edu)

Specialties: lab safety and compliance, design projects

Associate Research Professors:**Richard Weir, PhD**

Email: richard.weir@cuanschutz.edu

Specialties: Neural engineering, biomechatronic design, and rehabilitation engineering

Assistant Research Professors:**Brisa Pena-Castellanos, PhD**

Email: brisa.penacastellanos@cuanschutz.edu

Specialties: Material science, atomic force microscopy, cardiac tissue engineering, and miRNA delivery

Affiliated Faculty

Students receive instruction from affiliate faculty in the University of Colorado system, including CU Boulder and the CU School of Medicine. Faculty research areas include Imaging and Biophotonics; Cardiovascular Biomechanics and Hemodynamics; Orthopedic Biomechanics; Surgery; Ophthalmology; and Neuroscience Engineering.

Bioengineering (BIOE)

BIOE 1010 - Bioengineering Design and Prototyping I (3 Credits)

BIOE 1010 introduces students to bioengineering, and provides an introduction to possible careers and research topics in bioengineering. Students also learn human anatomy by understanding how to incorporate visual human data sets into computer prototyping and design tools.

Repeatable. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 3.

Typically Offered: Fall.

BIOE 1020 - Bioengineering Design and Prototyping II (3 Credits)

BIOE 1020 extends work from BIOE 1010 by introducing students to practical skills around computer-aided design (CAD), modeling and prototyping with focus on project-oriented work aimed at design, prototyping and metrology of specific medical devices. Prereq: BIOE 1010 with a C- or higher. Max hours: 3 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 3.

Prereq: BIOE 1010 with a C- or higher.

Typically Offered: Spring.

BIOE 2010 - Introduction to Programming for Bioengineers (2 Credits)

Digital computers are the primary tools of modern engineers. This class introduces the undergraduate to general computing concepts, computer languages, and programming techniques. Prereq: MATH 1401 with a C- or higher or permission from instructor. Max Hours: 2 Credits.

Grading Basis: Letter Grade

Prereq: MATH 1401 with a C- or higher.

BIOE 2020 - Introduction to Computational Methods for Bioengineers (2 Credits)

A modern engineer is required to solve problems involving the physical world not only on paper, but also using numerical tools implemented on digital computers. This class introduces the students a first set of numerical algorithms for the solution of calculus-based engineering problems. Prereq: MATH 2411 with a C- or higher or permission from instructor. Max Hours: 2 Credits.

Grading Basis: Letter Grade

Prereq: MATH 2411 with a C- or better.

BIOE 2840 - Independent Study in Bioengineering (1-6 Credits)

Covers topics which students may wish to pursue on their own initiative with guidance from department faculty. Credit is awarded upon completion of a project. Department consent required. Restriction: Restricted to BIOE-BS majors. Repeatable. Max Hours: 6 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

Department Consent Required. Restriction: Restricted to BIOE-BS majors.

BIOE 3010 - Bioinstrumentation (3 Credits)

This course is intended for junior bioengineering students to facilitate their development into bioengineering investigation. The course has been designed to introduce fundamental principles of circuit theory, analog and digital electronics and biological instrumentation techniques commonly used in biomedical research. Prereq: BIOE 1020, 2020; PHYS 2331/2341; CHEM 3411/3418, MATH 2421, 3195, and BIOL 2061/2081 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 1020, 2020; PHYS 2331,2341; CHEM 3411,3418, MATH 2421, 3195; BIOL 2061,2081 with a C- or higher.

BIOE 3020 - Introduction to Biomechanical Analysis (3 Credits)

This course will offer an overview of solid and fluid mechanics, as applied to biomechanical systems. After completing this course, students should have enough understanding of biomechanics to: (1) perform and interpret basic analytical of biomech. systems: (2) analytically reason through a design: (3) and choose a specialty. Prereq: BIOE 1020, 2020; PHYS 2331/2341; CHEM 3411/3418, MATH 2421, 3195 and BIOL 2061/2081 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 1020, 2020; PHYS 2331,2341; CHEM 3411,3418, MATH 2421, 3195; BIOL 2061,2081 with a C- or higher.

BIOE 3030 - Introduction to Biomaterials (3 Credits)

This course will cover different kinds of biomaterials in biomedical applications, and their physiological response in the biological environment. In addition, it will cover material properties, host response, and characterization techniques. Prereq: BIOE 1020, 2020; PHYS 2331/2341; CHEM 3411/3418, MATH 2421, 3195, and BIOL 2061/2081 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 1020, 2020; PHYS 2331,2341; CHEM 3411,3418, MATH 2421, 3195; BIOL 2061,2081 with a C- or higher.

BIOE 3040 - Physiology for Bioengineering (3 Credits)

This course will introduce students to central concepts in human physiology. This includes the structure, function and homeostatic role of key organs within the body; the engineering principles governing these systems and processes; and designing engineering-based solutions to overcome dysfunction in disease. Prereq: BIOE 1020, 2020; PHYS 2331/2341; CHEM 3411/3418, MATH 2421, 3195, and BIOL 2061/2081 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 1020, 2020; PHYS 2331,2341; CHEM 3411,3418, MATH 2421, 3195; BIOL 2061,2081 with a C- or higher.

Typically Offered: Fall.

BIOE 3050 - Systems Biology (3 Credits)

This course focuses on the quantitative description of biomolecular and cellular dynamics. The building and application of mechanistic models of biological processes will be covered including receptor-ligand binding, enzymatic reactions, signal transduction pathways, gene expression, cell growth and death, and pharmacokinetics. Mathematical and computational approaches of dynamical systems are used to analyze and design complex biological networks. Prereq: ENGR 1100, BIOE 2020, CHEM 2031/2038, CHEM 2061/2068, MATH 1401, MATH 2411, MATH 2421, MATH 3195, and BIOL 2020/2021 with a C- or higher. Max hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: ENGR 1100, BIOE 2020, CHEM 2031/2038, CHEM 2061/2068, MATH 1401, MATH 2411, MATH 2421, MATH 3195, and BIOL 2020/2021 with a C- or higher.

BIOE 3051 - Cell & Molecular Bioengineering Lab (1 Credit)

Laboratory experience in cellular and molecular biology techniques. Experimental methods will be performed including protein, RNA, DNA purification and quantification, ligand binding, enzyme kinetics, polymerase chain reaction technology, and recombinant DNA technology. Prereq: BIOE 3010, 3020, 3030, and 3040 with a C- or higher. Co-req: BIOE 3050. Max Hours: 1 Credit.

Grading Basis: Letter Grade

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher. Co-req: BIOE 3050

BIOE 3060 - Biostatistics, Measurement and Analysis (3 Credits)

Students will learn and apply parametric statistics, including t-tests, ANOVA, and regression methods, using commercially available statistical software to the analysis of clinical and/or biological data. Further, they will be introduced to measurement error and the propagation of error technique. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Typically Offered: Spring.

BIOE 3070 - Bioengineering Lab I (3 Credits)

Core bioengineering lab required of all major students. This lab introduces students to experimental techniques in the areas of Biomaterials, Biomedical Instrumentation, and Biomechanics. Prereq: BIOE 1020, 2020; PHYS 2331/2341; CHEM 3411/3418, MATH 2421, 3195, and BIOL 2061/2081 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 1020, 2020; PHYS 2331,2341; CHEM 3411,3418, MATH 2421, 3195; BIOL 2061,2081 with a C- or higher.

BIOE 3071 - Bioengineering Lab II (3 Credits)

Lab sequence 2 of 2. A series of modules focused on quantitative techniques relative to Bioengineering. Modules will include Physiological data acquisition and analysis, Medical Imaging and Assistive Technologies. Prereq: BIOE 3070 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3070 with a C- or higher.

BIOE 3090 - Introduction to BioDesign (3 Credits)

BioDesign I is the first course in a three sequence design process that provides students with a framework for identifying medical needs through clinical observation, environment analysis and product screening. Prereq: BIOE 3010, 3020, 3030, and 3040 with a C- or higher. Max hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher.

BIOE 3939 - Undergraduate Internship (1-6 Credits)

Department of Bioengineering Internship. Credit may be applied toward technical electives in the BS in Bioengineering degree. Department consent required. Restriction: Restricted to BIOE-BS majors. Repeatable. Max Hours: 3 Credits. Semester Hours: 1 to 3

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

Department Consent Required. Restriction: Restricted to BIOE-BS majors.

BIOE 4035 - Undergraduate BioDesign II (3 Credits)

This represents the second semester of the core undergraduate Biodesign sequence. Students gain experience around Design and Prototyping, Verification and Validation, and evaluation of key components around biomedical technology development. Prereq: BIOE 3090. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3090 with a C- or higher.

BIOE 4039 - Mechatronics and Embedded Systems (3 Credits)

The course focuses on the design and construction of microprocessor-controlled electro-mechanical systems. Lectures review critical circuit topics (Ohm's law, RLC circuits, DC and AC signals, diode and transistor circuits, operational amplifiers, and digital signals), introduce microprocessor architecture and programming, discuss sensor and actuator component selection, robotic systems, and design strategies for complex, multi-system devices. Lab work reinforces lectures and allows hands-on experience with robotic and embedded systems design. Students must design and build an embedded systems device related to assistive technology. Cross-listed with BIOE 5039. Max hours: 3 Credits. Grading Basis: Letter Grade

BIOE 4045 - BioDesign III (3 Credits)

This course represents the capstone culmination of the core undergraduate Biodesign experience. Students finalize all design, prototyping, testing and validation components, and present the project per professional standards to professionals and peers. Prereq: BIOE 4035 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 4035 with a C- or higher.

BIOE 4053 - Optics and Microscopy in Biomedical Research (3 Credits)

Undergraduate overview of optical imaging, ranging from classical microscopy to advanced, non-linear techniques and includes theory, technology and applications in biomedical sciences. This will prepare students for developing and applying state-of-the-art optical imaging in their research. Cross-listed with BIOE 5053. Prereq: BIOE 3010, 3020, 3030, and 3040 with a C- or higher. Restriction: Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher.

BIOE 4054 - Regulatory Affairs (3 Credits)

This course covers standards of quality assurance and regulatory pathways that guide biomedical engineering industry. Cross-listed with BIOE 5054. Max hours: 3 Credits.

Grading Basis: Letter Grade

BIOE 4057 - Rehabilitation and Assistive Technology (3 Credits)

This course provides students with an overview of technologies and their use by and for persons with disabilities. Cross-listed with BIOE 5057. Max hours: 3 Credits.

Grading Basis: Letter Grade

BIOE 4058 - Intro to Design, Disability, and Aging (3 Credits)

This course provides an introduction to the topic of disability and aging and the application of bioengineering principles for persons living with functional impairment(s) across the lifespan. Cross-listed with BIOE 5058. Max hours: 3 Credits.

Grading Basis: Letter Grade

BIOE 4063 - 3D Modeling for Bioengineers (3 Credits)

This course instills in the 3D modeling skills specific to the biomedical industry. Topics include computer aided design (CAD), medical imaging, image processing, patient specific image to three-dimensional (3D) model reconstruction, non-uniform rational b-spline (NURBS) surfaces, finite element and computational fluid dynamics (FEA/CFD) analyses and physical modeling using rapid prototyping. Prereq: 3010, 3020, 3030, and 3040 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher.

Typically Offered: Fall, Spring.

BIOE 4064 - Advanced MatLab For Bioengineers And Life Scientists (3 Credits)

MatLab programming for undergraduate bioengineers and life scientists. Topics include MatLab syntax and optimization as well as techniques for working with scalars, time-series, images and multi-dimension datasets. Surface/Curve fitting, modeling, automation and classification will be covered. Cross-listed with BIOE 5064. Prereq: BIOE 3010, 3020, 3030, and 3040 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher.

BIOE 4067 - Human Factors and Usability Testing for Bioengineers (3 Credits)

This course provides an introduction to human factors testing and evaluation in the context of medical devices and assistive technology (AT). Particular focus will be given towards designing and applying usability testing to inform product design decisions or improvements. Topics include human factor considerations for aging and disabled populations (and their care providers), usability techniques, user experience data collection and interpretation, etc. Students will engage in hands-on human factors assessments such as contextual inquiry of surgery patients, cognitive walkthroughs with simulating disability, and product usability testing and iteration. Max hours: 3 Credits.

Grading Basis: Letter Grade

BIOE 4068 - Introduction to Medical Imaging (3 Credits)

This course will introduce undergraduates to the basic physics, technologies, and clinical methodologies underlying Ultrasound, MRI, CT, PET and SPECT imaging systems. The course will include lectures, and visits to campus hospital and research imaging systems as well as hands on ultrasound labs. Cross-listed with BIOE 5068. Max Hours: 3 Credits.

Grading Basis: Letter Grade

BIOE 4069 - Advanced Biomechanics for Undergraduates (3 Credits)

This course covers advanced topics such as blood flow dynamics, introduction to non-linear finite deformation techniques, blood rheology, and computational techniques. Cross-listed with BIOE 5069. Max Hours: 3 Credits.

Grading Basis: Letter Grade

BIOE 4073 - Neural Interfaces and Bionic Limbs (3 Credits)

This course will introduce undergraduates to topics in neural interfaces (Brain machine interfaces, peripheral nerve interfaces etc), the issues involved in the design of mechatronic limb systems and the decoding algorithms used to map the neural interface to the mechatronic limb. Cross-listed with BIOE 5073. Prereq: BIOE 3010, 3020, 3030, and 3040 with a C- or higher or instructor permission. Max hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher.

BIOE 4083 - Polymers in Biomedical Applications (3 Credits)

This course will introduce undergraduate students to fundamental synthetic method and basic characteristics of various polymeric biomaterials and their crucial roles in different biomedical applications. It will also cover how the polymers can be modified to enhance biomedical applications. Cross-listed with BIOE 5083. Prereq: BIOE 3010, 3020, 3030, and 3040 with a C- or higher. Max Hours: 3 Credits.

Grading Basis: Letter Grade

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher.

BIOE 4085 - Tissue Engineering (3 Credits)

This course covers tools, techniques, characterization and applications in modern tissue engineering. Cross-listed with BIOE 5085. Max Hours: 3 Credits.

Grading Basis: Letter Grade

BIOE 4100 - Image Processing for BIOEs (3 Credits)

This course provides an overview of basic and advanced image processing algorithms from both a theoretical and a practical perspective with special emphasis in Bioengineering. Topics to be covered include quantization, filtering, texture analysis, Fourier transform, wavelets, morphological operations, image registration, segmentation, machine learning, deep learning, and principal component analysis (PCA). Cross-listed with BIOE 5100. Max hours: 3 credits.

Grading Basis: Letter Grade

Typically Offered: Spring.

BIOE 4400 - Genetic Engineering (3 Credits)

Laboratory experience in genetic engineering including molecular cloning, gene delivery, and genome editing. Students will work on open ended projects that may include the expression of recombinant proteins, silencing RNA, or the knockdown or insertion genes into the genome. Prereq: Requires prerequisite courses of CHEM 2031 and 2038 and 2061 and 2068 and 3411 and 3418 and BIOL 2020 and 2021 (all minimum grade D-). Cross-listed with BIOE 5400. Max hours: 3 Credits.

Grading Basis: Letter Grade

Requires prerequisite courses of CHEM 2031 and 2038 and 2061 and 2068 and 3411 and 3418 and BIOL 2020 and 2021 (all minimum grade D-).

BIOE 4420 - Special Topics in Bioengineering (1-5 Credits)

Special topics of particular interest to undergraduate senior in the Bioengineering program. Registration requires departmental approval. Prereq: BIOE 3010, 3020, 3030, and 3040 with a C- or higher or instructor permission. Repeatable. Max Hours: 9 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 9.

Prereq: BIOE 3010, 3020, 3030, 3040 with a C- or higher.

Typically Offered: Spring.

BIOE 4840 - Independent Study in Bioengineering (1-6 Credits)

Covers advanced topics which students may wish to pursue on their own initiative with guidance from department faculty. Credit is awarded upon completion of a project. Department Consent Required. Restriction: Restricted to BIOE-BS majors. Repeatable. Max Hours: 6 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

Department Consent Required. Restriction: Restricted to BIOE-BS majors.

BIOE 4929 - Undergraduate Research Project (1-6 Credits)

Department of Bioengineering Research Project. Credit may not be applied toward the BS in Bioengineering degree. Department consent required. Restriction: Restricted to BIOE-BS majors. Repeatable. Max Hours: 6 Credits.

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

Department Consent Required. Restriction: Restricted to BIOE-BS majors.