Bioengineering (BIOE)

BIOE 1990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOE 2000. Introduction to Engineering Co-op Education. 1 Hour.
Seeks to prepare students for the first co-op experience. Focuses on skills that provide a basis for successful co-op engagement including expectations and requirements, an introduction to professional credentials, résumé construction, self-assessment and goal setting, interviewing, professional and co-op ethics, issues of diversity in the workplace community, academic planning and decision making, and an introduction to career portfolios.

BIOE 2060. Special Topics in Bioengineering. 4 Hours.
Focuses on topics of timely interest to students of science and engineering. Topic varies from semester to semester. When appropriate, the course takes advantage of unique opportunities afforded by visiting faculty and guests. May be repeated up to three times.

BIOE 2350. Biomechanics. 4 Hours.
Designed to acquaint students with concepts of stress, strain, and constitutive laws as applied to problems in biomechanics. Introduces rigid body and deformable body mechanics. Focuses on basic foundations of solid mechanics using vectors and tensors. Illustrative examples from tissue and cell biomechanics are given where appropriate.

BIOE 2355. Quantitative Physiology for Bioengineers. 4 Hours.
Introduces engineering and science students to core knowledge and understanding of physiological systems and processes. Focuses on quantitative analysis of human physiological systems. Topics include the physical and chemical foundations of physiology; coupled forces and flows; electrical, mechanical, and chemical potentials and their conjugated fluxes; and the physiology of excitable tissue. Examines cell structure, function, and homeostasis with a particular focus on membrane transport, osmotic pressure, cell signaling, and cellular energetics.

BIOE 2365. Bioengineering Measurement, Experimentation, and Statistics. 4 Hours.
Introduces the fundamentals of biomedical data acquisition and statistical analysis. Engineering statistics topics include descriptive statistics, probability distributions, hypothesis testing, analysis of variance, and experiment design. Applies these statistical topics by analyzing data obtained from laboratory exercises in BIOE 2366. Laboratory exercise topics include cell culture, mechanical testing, modeling medical imaging data, 3D printing, and bioprinting. Emphasizes using MATLAB software to analyze data on the computer.

BIOE 2366. Lab for BIOE 2365. 1 Hour.
Offers associated laboratory exercises for BIOE 2365. Requires lab reports from all students.

BIOE 2990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOE 3000. Professional Issues in Engineering. 1 Hour.
Offers students an opportunity to reflect on both academic and co-op experiences in the context of planning for the senior year and beyond. Topics include professional and ethical issues; resolving ethical conflicts; awareness of engineers as professionals in a diverse world; strengthening decision-making skills; career portfolios; and lifelong learning needs, goals, and strategies. Students reflect upon issues of diversity from their experience in the university and in their cooperative education placements. Explores the role of different work and learning styles and diverse personal characteristics in the workplace and the classroom. Professional issues include impact of the cultural context, both in the United States and around the world, on the client, government relations, and workplace.

BIOE 3210. Bioelectricity. 4 Hours.
Discusses principles of circuits, signals, and systems in the context of operating principles of bioelectrical systems at multiple physiological scales. Offers students an opportunity to obtain the fundamental background required to interface biological systems with circuits and sensors for measurements. Covers fundamentals of structure and function of electrically active tissue including nerves, brain, and muscle, including heart.

BIOE 3310. Transport and Fluids for Bioengineers. 4 Hours.
Covers the fundamental principles of processes and systems in which mass, energy, and momentum are transported in typical biological problems. Emphasizes momentum transport for incompressible and compressible fluids (fluid flow) and energy transport. The methods taught are relevant to the analysis of physiological systems, processing, and separation of biological materials.

BIOE 3380. Biomolecular Dynamics and Control. 4 Hours.
Focuses on the principles of thermodynamics and kinetics applied to the analysis and design of biomolecular systems. Covers foundational topics—such as mass and energy balances, chemical equilibria, and enzyme kinetics—in a biological context. Introduces the role of feedback and feed-forward control in biomolecular networks, emphasizing basic analytical and computational methods, including the use of MATLAB, for analyzing how these regulatory structures affect the dynamics of small-scale, prototypical networks.

BIOE 3990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOE 4790. Capstone Design 1. 4 Hours.
Offers students an opportunity to apply design principles to create a device or process to solve a relevant bioengineering problem. Teams develop, construct, and evaluate prototypes under real-world fiscal, regulatory, and safety conditions. Progress is monitored through a series of oral presentations in design gate review meetings. Requires a thorough written report and working prototype for course completion.

BIOE 4970. Junior/Senior Honors Project 1. 4 Hours.
Focusses on in-depth project in which a student conducts research or produces a product related to the student’s major field. Combined with Junior/Senior Project 2 or college-defined equivalent for 8-credit honors project. May be repeated without limit.

BIOE 4971. Junior/Senior Honors Project 2. 4 Hours.
Focusses on second semester of in-depth project in which a student conducts research or produces a product related to the student’s major field. May be repeated without limit.
BIOE 4990. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOE 4991. Research. 4 Hours.
Offers an opportunity to conduct research under faculty supervision. May be repeated without limit.

BIOE 4992. Directed Study. 1-4 Hours.
Offers theoretical or experimental work under the direction of members of the department under a chosen topic. Course content depends on instructor. May be repeated without limit.

BIOE 5050. Special Topics in Bioengineering. 4 Hours.
Focuses on topics of timely interest to students of science and engineering. Topic varies from semester to semester. When appropriate, the course takes advantage of unique opportunities afforded by visiting faculty and guests. May be repeated once.

BIOE 5100. Medical Physiology. 4 Hours.
Designed to provide bioengineering students with a working knowledge of the integrated behavior of organs and systems in the human body. As such, the student is provided with a comprehensive and intense immersion in each physiological subsystem with the expectation that he or she display knowledge of each at the level equivalent to that of a second-year medical student following his or her exposure to physiology. The specific subsystems covered are muscle physiology, cardiovascular physiology with ECG interpretation, pulmonary physiology with gas exchange mechanics and ventilation/perfusion, renal physiology and water balance, regulation of pH, gastrointestinal physiology, temperature regulation and energy balance, endocrine systems, and reproductive systems. The course does not cover neurophysiology. Requires prior completion of BIOL 1117 or equivalent.

BIOE 5235. Biomedical Imaging. 4 Hours.
Presents the foundations of modern medical imaging, including imaging principles, imaging mathematics, imaging physics, and image-generation techniques. Includes X-ray, ultrasound, computed tomography, and magnetic resonance imaging.

BIOE 5250. Design, Manufacture, and Evaluation of Medical Devices. 4 Hours.
Covers engineering design challenges intrinsic to the development of biomedical devices, including clinical evaluation, manufacture, and testing of medical devices and the constraints that FDA regulations place on these processes. Topics include quality systems, design control, cybersecurity concerns, the role of standards in global device regulation, and the design process. Students are asked to form teams and to carry out a semester-long conceptual design project to develop a design overview, design plan, design input specifications, and verification test procedures for a novel medical device.

BIOE 5320. Advanced Biomedical Measurements and Instrumentation. 4 Hours.
Offers a comprehensive analysis of the principles underlying biomedical instrumentation, including ECG, EEG, CAT scanning, MRI imaging, and other biomedical laboratory tools. Includes associated laboratory exercises within the course material.

BIOE 5380. Advanced Biomolecular Dynamics and Control. 4 Hours.
Applies the foundational principles of thermodynamics and kinetics to the analysis and design of biomolecular systems. Briefly reviews mass and energy balances, chemical equilibria, and enzyme kinetics. Emphasizes more advanced topics, such as the effect of external fields (e.g., mechanical forces, electrical potential) on biomolecular reaction equilibria and kinetics, the spatiotemporal dynamics of reactions in the context of mass transport, and the effect of spatial compartmentation on biomolecular propagation of information. Examines the role of feedback and feedforward control in biomolecular networks, focusing on analyzing how these regulatory structures affect adaptation and oscillatory behavior of small- and large-scale networks. Intended for students in the College of Engineering and in the College of Science. Students from other disciplines are invited to enroll—requires prior knowledge of differential and integral calculus, systems of ordinary differential equations and linear algebra, coding in Matlab, and familiarity with chemical kinetics and thermodynamics.

BIOE 5410. Molecular Bioengineering. 4 Hours.
Introduces the fundamentals of molecular structure and function that underpin engineering of biological macromolecules. Builds on this base with the application of design concepts for molecules and methods of structural and functional analyses and strategies for design and redesign of therapeutic molecules. Projects seek to provide students with experience in conceptual design to create strategies to address significant health concerns.

BIOE 5420. Cellular Engineering. 4 Hours.
Analyzes the techniques that form the foundation of molecular cell engineering, including recombinant DNA, cloning and genomics, prokaryotic and eukaryotic gene regulation and single-cell gene expression, structure, dynamics of gene regulatory networks, metabolism and cellular energetics, cell structure, cytoskeleton and cellular motors, synthetic gene circuits, and metabolic engineering.

BIOE 5430. Principles and Applications of Tissue Engineering. 4 Hours.
Applies the principles of biology and biomedical engineering to the creation of artificial organs for transplantation, basic research, or drug development. Requires integration of knowledge of organic chemistry, cell biology, genetics, mechanics, biomaterials, nanotechnology, and transport processes to create functional organs. Reviews basic cell culture techniques, structure function relationships, cellular communication, natural and artificial biomaterials, and the basic equations governing cell survival and tissue organization.

BIOE 5630. Physiological Fluid Mechanics. 4 Hours.
Analyzes biofluids and their mechanics, including cardiovascular fluid mechanics. Examples are taken from biotechnology processes and physiologic applications, including the cardiovascular, respiratory, ocular, renal, musculoskeletal, and gastrointestinal systems. Topics include dimensional analysis, particle kinematics in Eulerian and Lagrangian reference frames, constitutive equations and Newtonian/non-Newtonian biofluid models, flow and wave propagation in flexible tubes, and oscillatory and pulsatile flows.

BIOE 5650. Multiscale biomechanics. 4 Hours.
Seeks to help students develop and apply scaling laws and continuum mechanics to biomechanical phenomena at different length scales starting from a single molecule, moving up to the cellular and tissue levels. Topics include structure of tissues and the molecular basis for macroscopic properties; chemical and electrical effects on mechanical behavior; cell mechanics, motility, and adhesion; biomembranes; biomolecular mechanics and molecular motors; and experimental methods for probing structures at the tissue, cellular, and molecular levels.
BIOE 5810. Design of Biomedical Instrumentation. 4 Hours.
Investigates the principles of biology and engineering underlying the design and use of biomedical instrumentation. Topics include design of a broad range of instrumentation and monitoring devices, sensors, and integrated systems.

BIOE 5820. Biomaterials. 4 Hours.
Offers a broad overview of the field of biomaterials (materials used in medical devices that interact with living tissues). Introductory lectures cover biomaterials and their translation from the laboratory to the medical marketplace. Discusses important biomaterials terminology and concepts. Emphasizes material structure-property-function-testing relationships and discusses specific materials used in medical devices and drug delivery. Concludes with introductions to topics in the field, such as biomaterials-tissue interactions, tissue engineering, and regulatory requirements. Considers principles of device design as related to the selection and application of biomaterials.

BIOE 5850. Design of Implants. 4 Hours.
Studies the use of cell-matrix control volumes; stress analysis in design processes; anatomical fit, shape, and size of implants; biomaterials; surgical implantation procedures; testing for safety and efficacy; and design of clinical trials. Covers applications to orthopedic devices, soft tissue implants, artificial organs, and dental implants.

BIOE 6000. Principles of Bioengineering. 1 Hour.
Covers the fundamentals of bioengineering research topics and methodology for master’s-level bioengineering students. Internal and external speakers discuss general topics in bioengineering, including the medical device qualification and regulatory environment, tissue engineering, cell engineering, mechanobiology, drug delivery, bioimaging, neuromotor control, and effective design of experiments. Each student is expected to read, critically evaluate, and present research in a peer-reviewed bioengineering journal article.

BIOE 6962. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOE 6964. Co-op Work Experience. 0 Hours.
Provides eligible students with an opportunity for work experience. May be repeated without limit.

BIOE 6965. Co-op Work Experience Abroad. 0 Hours.
Provides eligible students with an opportunity for work experience abroad. May be repeated without limit.

BIOE 7000. Principles of Bioengineering. 4 Hours.
Designed to introduce new graduate bioengineering students to the fundamentals of bioengineering research topics and methodology. Includes outside speakers to discuss general topics in bioengineering. Examples of course topics include the medical device qualification and regulatory environment, tissue engineering, cell engineering, mechanobiology, drug delivery, bioimaging, neuromotor control, and effective design of experiments, writing research proposals for the National Institutes of Health (NIH) and how to evaluate and write a peer-reviewed journal article, etc. Expects students to read, critically evaluate, and present the research in a bioengineering journal article. Students are then expected to extend their article into a hypothesis-driven proposal in NIH format with an oral defense of the proposal.

BIOE 7001. Biomaterials. 4 Hours.
Introduces biomaterials science. Reviews the design of medical implants, artificial organs, and engineered matrices. The development of modern day biomaterials is tracked by introducing the student to first-, second-, and third-generation biomaterials. Students are guided from the earliest ad-hoc materials to advanced tissue-engineered constructs. Examines the challenges of implantation of materials, including developing an understanding of the material design requirements and an understanding of the host response. Covers regulatory standards for the design of materials for use in vivo. Studies the molecular and cellular interactions with biomaterials designed to act as scaffolds for later implantation into host systems.

BIOE 7100. Special Topics in Biomedical Imaging and Signal Processing. 4 Hours.
Offers various topics of interest in biomedical imaging and signal processing for advanced study depending on the interests of the faculty and students. May be repeated up to two times.

BIOE 7200. Special Topics in Cell and Tissue Engineering. 4 Hours.
Offers various topics of interest in cell and tissue engineering for advanced study depending upon the interests of the faculty and students. May be repeated up to two times.

BIOE 7300. Special Topics in Biomechanics. 4 Hours.
Offers various topics of interest in biomechanics for advanced study depending upon the interests of the faculty and students. May be repeated up to two times.

BIOE 7347. Special Topics in Bioengineering. 4 Hours.
Offers topics of interest to the staff member conducting the course for advanced study. Undergraduate students may take this class with permission of instructor. May be repeated without limit.

BIOE 7390. Seminar. 0 Hours.
 Presents topics of an advanced nature by staff, outside speakers, and students in the graduate program. This course must be attended every semester by all full-time graduate students. May be repeated without limit.

BIOE 7400. Special Topics in Biomedical Devices. 4 Hours.
Offers various topics of interest in biomedical devices for advanced study depending upon the interests of the faculty and students. May be repeated up to two times.

BIOE 7890. Master’s Project. 4 Hours.
Offers analytical and/or experimental work leading to a written report and a final short presentation by the end of the semester.

BIOE 7962. Elective. 1-4 Hours.
Offers elective credit for courses taken at other academic institutions. May be repeated without limit.

BIOE 7978. Independent Study. 1-4 Hours.
Offers theoretical or experimental work under individual faculty supervision. May be repeated for up to 16 total credits.

BIOE 7990. Thesis. 4 Hours.
Offers analytical, research, and/or experimental work conducted under the auspices of the department. May be repeated once.

BIOE 7996. Thesis Continuation. 0 Hours.
Continues thesis work conducted under the supervision of a departmental faculty.

BIOE 8960. Exam Preparation—Doctoral. 0 Hours.
Offers students an opportunity to prepare for the PhD qualifying exam under faculty supervision. Intended for students who have completed all required PhD course work and have not yet achieved PhD candidacy; students who have not completed all required PhD course work are not allowed to register for this course. May be repeated once.
BIOE 8986. Research. 0 Hours.
Offers students an opportunity to conduct full-time research under faculty supervision. May be repeated without limit.

BIOE 9000. PhD Candidacy Achieved. 0 Hours.
Indicates successful completion of program requirements for PhD candidacy.

BIOE 9984. Doctoral Research. 1-8 Hours.
Investigates doctoral research topics under supervision of an individual faculty member. May be repeated up to 15 times for up to 16 total credits.

BIOE 9986. Research. 0 Hours.
Offers students an opportunity to conduct full-time research under faculty supervision. May be repeated without limit.

BIOE 9990. Dissertation. 0 Hours.
Offers theoretical and/or experimental work conducted under the auspices of the department. Must be taken in two consecutive semesters. May be repeated once.

BIOE 9996. Dissertation Continuation. 0 Hours.
Offers continued dissertation work conducted under the supervision of a departmental faculty member. May be repeated without limit.