Courses

BIOE 001 Freshman Seminar 1, Introduction to Bioengineering 1: Philosophy to Practice 1 Credit
Overview of the bioengineering field, the advancements of related topics in sciences, technology, engineering and applications for health care and medicine. Humanity and ethical issues. Pass/Fail.

BIOE 002 Freshman Seminar 2, Introduction to Bioengineering II: Current Topics 1 Credit
Overview of a broad spectrum of current topical areas in biotechnology and bioengineering and their applications in health care and medicine. Pass/Fail.

BIOE 020 Bioengineering Sophomore Research Seminar 1 Credit
Exposure to opportunities for on-campus research in bioengineering. Review of current literature on bioengineering topics through written reports and/or oral presentations. Preparation of written research proposal, including definition of topic, objectives, methodologies, research plans, and expected impact.

BIOE 110 Elements of Bioengineering 4 Credits
An introduction to the fields of biotechnology and biomedical engineering. The areas include biomechanics, biomaterials, bioinstrumentation, medical imaging, rehabilitation engineering, biosensors, biotechnology and tissue engineering.
Prerequisites: (BIOS 041 and BIOS 042)

BIOE 210 Introduction to Engineering Physiology 4 Credits
Mammalian physiology for bioengineering students, with an emphasis on control mechanisms and engineering principles. Basic cell function; biological control systems; muscle; neural; endocrine, circulatory, digestive, respiratory, renal, and reproductive systems; regulation of metabolism and defense mechanisms. Includes laboratory work.
Prerequisites: (BIOS 041 and BIOS 042) and (BIOE 110)

BIOE 225 GMP Good manufacturing practice and regulatory affairs for bioengineers 1 Credit
Review of the principles of the Food and Drug Administration including its history, mission and applied regulations. Understanding of how the FDA works with industry and is integral to the development of new products and technologies. Review and critique of case studies in various parts of the biomedical industry to see how FDA regulations are applied. Validation and analysis of products using failure mode analysis.
Prerequisites: BIOE 110

BIOE 226 Ethics in Bioengineering Practice 1 Credit
Introduction to ethical principles and role of critical thinking in ethical decision-making. Analysis of contemporary issues in bioengineering practice. Topics include biomedical device risk and failure, ethics of clinical trials, animal research, human enhancement, and research conduct.

BIOE 242 Bioengineering Research 1-4 Credits
Research on a topic chosen by students, with a faculty advisor typically from the three bioengineering tracks (biopharmaceutical engineering, bioelectronic/biophotonics or biomechanics and biomaterials). Independent meetings with advising professor will track progress. Includes written reports and/or oral presentations. Consent of instructor required.
Repeat Status: Course may be repeated.

BIOE 247 Biological Fluid Mechanics 4 Credits
Prerequisites: MATH 205

BIOE 257 Biomechanics and Biomaterials 3 Credits
Biomechanical analysis of tissues, microstructure of materials, force and mechanics in rigid and deformable bodies, analysis of biological response and biocompatibility, failure processes of implantable biomaterials/devices, strength of materials, and biomechanics of cells. Biomechanics and biomaterials concepts integrated (1) to examine the theoretical and practical implications of material properties and (2) to examine the biomechanical principles governing system behavior.
Prerequisites: MAT 033 and MECH 003 and MATH 205
Can be taken Concurrently: MATH 205

BIOE 290 Bioengineering Thesis 1-3 Credits
Thesis, guided by a faculty advisor, based on research and/or design projects. Independent meetings with advising professor to track progress. Consent of instructor required.
Prerequisites: BIOE 242 or TE 212

BIOE 307 (CSE 307) 3 Credits
Computational techniques and principles of structural biology used to examine molecular structure, function, and evolution. Topics include: protein structure alignment and prediction; molecular surface analysis; statistical modeling; QSAR; computational drug design; influences on binding specificity; protein-ligand, -protein, and -DNA interactions; molecular simulation, electrostatics. Tutorials on UNIX systems and research software support an interdisciplinary collaborative project in computational structural biology. Credit will not be given for both CSE 307 and CSE 407. Must have junior standing or higher.
Prerequisites: BIOS 120 or CSE 109 or CHM 113 or MATH 231

BIOE 308 (CSE 308) Bioinformatics: Issues and Algorithms 3 Credits
Computational problems and their associated algorithms arising from the creation, analysis, and management of bioinformatics data. Genetic sequence comparison and alignment, physical mapping, genome sequencing and assembly, clustering of DNA microarray results in gene expression studies, computation of genomic rearrangements and evolutionary trees. Credit will not be given for both BIOE 308 (CSE 308) and BIOE 408 (CSE 408). No prior background in biology is assumed.
Prerequisites: CSE 017 or CSE 018
Attribute/Distribution: ND

BIOE 315 (ME 315) Bioengineering Statistics 3 Credits
Advanced methods in probability and statistics applied to bioengineering problems focusing on modeling and data analysis. Topics include the following: types of data, types of distributions, parametric and nonparametric analyses, goodness-of-fit, regression, power analysis, and multivariate analysis, life models, simulation, cluster analysis, and Bayesian statistics. Special emphasis is placed on projects and case studies.
Prerequisites: MATH 231

BIOE 316 (ME 316) Introduction to Force Spectroscopy 3 Credits
Fundamentals of major force spectroscopy methods, including atomic force microscopy, optical tweezers, and magnetic tweezers. Principles of force measurement, force calibration, and signal and noise. Applications to the mechanical properties of biomaterials, such as polymer elasticity, protein folding, nanoindentation, and structural transitions in macromolecules. Closed to students who have taken BIOE 416.
Prerequisites: MECH 003

BIOE 320 (CSE 320) Biomedical Image Computing and Modeling 3 Credits
Biomedical image modalities, image computing techniques, and imaging informatics systems. Understanding, using, and developing algorithms and software to analyze biomedical image data and extract useful quantitative information: Biomedical image modalities and formats; image processing and analysis; geometric and statistical modeling; image informatics systems in biomedicine. Credit will not be given for both BioE 320 and BioE 420.
Prerequisites: (MATH 205 or MATH 043) and CSE 017
Attribute/Distribution: ND
**BIOE 321 Biomolecular & Cellular Mechanics 3 Credits**

Mechanics and physics of the components of the cell, ranging in length scale from fundamental biomolecules to the entire cell. The course covers the mechanics of proteins and other biopolymers in 1D, 2D, and 3D structures, cell membrane structure and dynamics, and the mechanics of the whole cell.

**Prerequisites:** MATH 205 and MATH 231 and PHY 022 and (PHY 013 or PHY 021 or PHY 023)

**Attribute/Distribution:** NS

**BIOE 324 (MAT 324) Introduction to Organic Biomaterials 3 Credits**

Property, characterization, fabrication and modification of organic materials for biomedical and biological applications; host responses to biomaterials on the molecular, cellular and system level; general introduction to biosensors, drug delivery devices and tissue engineering.

**Prerequisites:** BIOE 110

**BIOE 325 (MAT 325) Inorganic Biomaterials 3 Credits**

Fabrication methods for biomedical implants and devices. Selection of metals and ceramics with specific bulk and surface physical as well as chemical properties. The role of materials chemistry and microstructure. Biocompatibility. Case studies (dental and orthopedic implants, stents, nonporous ceramic filters for kidney dialysis).

**Prerequisites:** MAT 033

**BIOE 326 (MAT 326) Biomimetic and Bio-enabled Materials 3 Credits**

The structure, function, properties and use of biopolymers, biocomposites, and biomaterials. Biomimetic materials design, including colloids, interfaces, macromolecules, and applications of such materials. Environmental and ethical considerations, such as degradation products when using biomimetic materials. Closed to students who have taken MAT 426 (BioE 426).

**Prerequisites:** MAT 033 or BIOE 110

**Attribute/Distribution:** ND

**BIOE 331 Integrated Bioelectronics/Biophotonics Laboratory 2 Credits**

Experiments in design and analysis of bioelectronics circuits, micropatterning of biological cells, micromanipulation of biological cells using electric fields, analysis of pacemakers, instrumentation and computer interfaces, ultrasound, optic, laser tweezers and advanced imaging and optical microscopy techniques for biological applications.

**Prerequisites:** (ECE 081 or PHY 190) and (PHY 013 or PHY 021 or PHY 023) and PHY 022 and ECE 121 and ECE 123

**Can be taken Concurrently:** ECE 121, ECE 123

**Attribute/Distribution:** NS

**BIOE 335 BioFluid Mechanics of Physiological Systems 3 Credits**

Application of advanced fluid dynamic principles to physiological systems with emphasis on microfluidic devices such as pulmonary airway/alveoli, small blood vessels and biological cells. Introduction to advanced topics relevant to the human body including: a) oscillatory and transient flows in dynamic systems; b) non-Newtonian flows; c) surface tension driven flows; d) fluid-solid interactions, and e) cellular fluid mechanics.

**Prerequisites:** (MATH 205 and ME 231 and MATH 231)

**BIOE 339 Neuronal Modeling and Computation 3 Credits**

Neuroscience in a computational, mathematical, and engineering framework. Literature surveys and case studies with simulations. Computational aspects of information processing within the nervous system by focusing on single neuron modeling. Single neurons and how their biological properties relate to neuronal coding. Biophysics of single neurons, signal detection and signal reconstruction, information theory, population coding and temporal coding.

**Prerequisites:** ENGR 010 and MATH 205

**BIOE 341 (CHE 341) Biotechnology I 3 Credits**

Applications of material and energy balances; heat, mass, and momentum transfer; enzyme and microbial kinetics; and mathematical modeling to the engineering design and scale-up of bio-reactor systems. Closed to students who have taken CHE 441 (BIOE 341 and BIOE 441).

**Prerequisites:** MATH 205 and CHE 031 and (CHM 031 or CHM 041)

**BIOE 342 (CHE 342) Biotechnology II 3 Credits**

Engineering design and analysis of the unit operations used in the recovery and purification of products manufactured by the biotechnology industries. Requirements for product finishing and waste handling will be addressed. Closed to students who have taken CHE 442 (BIOE 342 and BIOE 442).

**Prerequisites:** MATH 205 and CHE 031 and (CHM 031 or CHM 041)

**BIOE 343 Integrated Biotechnology Laboratory 3 Credits**

Biosafety, sterilization, media formulation, biochemical and enzyme assays, recombinant DNA technique, protein and DNA isolation and purification, for microbial fermentation and animal cell culture. Integration of biotechnology techniques for biopharmaceutical production. Consent of instructor required.

**Prerequisites:** BIOE 110 and (CHE 341 or BIOE 341)

**BIOE 344 (CHE 344) Molecular Bioengineering 3 Credits**

Kinetics in small systems, stochastic simulation of biochemical processes, receptor-mediated adhesion, dynamics of ion-channels, ligand binding, biochemical transport, surface Plasmon resonance, DNA microarray design, and chemical approaches to systems biology. Senior standing in BIOE.

**Prerequisites:** (MATH 205 and MATH 231)

**BIOE 345 (CHE 345) Quantitative Biology 3 Credits**

Basic concepts in molecular and cellular biology as well as biochemistry. Connects these to engineering principles in order to (1) develop a quantitative understanding of biological systems and (2) understand how applications of methods and principles in biology are used in modern engineering. Topics include protein structure and function, enzymology, membrane transport and trafficking, transcription/translation, signal transduction and models for cellular processes. An important part of this course is also taking topics discussed in lecture and translating them into practice.

**Prerequisites:** MATH 205

**BIOE 349 Metabolic Engineering 3 Credits**


**Prerequisites:** MATH 205

**BIOE 350 Special Topics 1-4 Credits**

Special topics of study in bioengineering. Permission of Instructor.

**Repeat Status:** Course may be repeated.

**BIOE 357 Integrated Biostructural Mechanics Laboratory 2 Credits**

Experimental manipulation and analysis of mammalian cells, with a focus on the biomechanical properties of cells, the interface of living and non-living materials, and on bioengineering applications. Experimental techniques include mammalian cell culture, advanced microscopy techniques, preparation of bioactive substrates, microfluidic device fabrication, micropatterning of cells and cell growth in 3D matrices. Consent of instructor required.

**Prerequisites:** BIOE 110

**BIOE 358 Biomechanics 3 Credits**

Applications of mechanics to study behavior of anatomical structures and biological tissues of the musculoskeletal system. Specific topics include structure and function of biological tissues, mechanical properties of biological tissues, and analysis of specific tissues (i.e. bone, muscle, and soft connective tissues).

**Prerequisites:** MECH 003

**Can be taken Concurrently:** MECH 003

**BIOE 359 Biomechanics Laboratory 1 Credit**

Applications of mechanics to study behavior of anatomical structures and biological tissues of the musculoskeletal system. Specific topics include structure and function of biological tissues, mechanical properties of biological tissues, and analysis of specific tissues (i.e. bone, muscle, and soft connective tissues).

**Prerequisites:** MECH 003 and BIOE 358

**Can be taken Concurrently:** MECH 003, BIOE 358
BIOE 363 (CHE 363) Numerical Methods for Scientists and Engineers 3 Credits
Introduction to numerical methods in science and engineering. Expose students to the numerical solution of a variety of commonly encountered problems, enhance their numerical programming skills, and provide a broad base on which to build more specialized knowledge of computational methods. Topics include solution of linear and nonlinear sets of algebraic equations, numerical integrals, and numerical solutions to ordinary differential equations. One project per term, typically a graduate student project. Credit will not be given for both BIOE 339 (CHE 339) and BIOE 439 (CHE 439). Must have graduate standing in Bioengineering or Chemical Engineering.

BIOE 366 (ECE 366) Neural Engineering 3 Credits
Neural system interfaces for scientific and health applications. Basic properties of neurons, signal detection and stimulation, instrumentation and microfabricated electrode arrays. Fundamentals of peripheral and central neural signals and EEG, and applications such as neural prostheses, implants and brain-computer interfaces. Credit will not be given for both BIOE 366 (ECE 366) and ECE 466. Prerequisites: ECE 202 or PHY 212.

BIOE 380 (BIOS 380) Biomolecular & Cellular Biophysics 3-4 Credits
Physical principles of biomolecular and cellular organization. Biomolecular interactions and recognition, molecular motors, physical organization and functioning of cellular membranes, electrical signaling in live cells. Modern techniques in biophysics, molecular spectroscopy, molecular modeling, florescence imaging, electrophysiology, electron microscopy. Prerequisites: (BIOS 115) and (PHY 013 or PHY 021).

BIOE 407 (CSE 407) 3 Credits
Computational techniques and principles of structural biology used to examine molecular structure, function, and evolution. Topics include: protein structure alignment and prediction; molecular surface analysis; statistical modeling; Q SAR computational drug design; influences on binding specificity; protein-ligand, -protein, and -DNA interactions; molecular simulation, electrostatics. This course, a version of 307 for graduate students, requires advanced assignments and a collaborative project. Credit will not be given for both BIOE 307 and 407. Consent of instructor required.

BIOE 408 (CSE 408) Bioinformatics: Issues and Algorithms 3 Credits
Computational problems and their associated algorithms arising from the creation, analysis, and management of bioinformatics data. Genetic sequence comparison and alignment, physical mapping, genome sequencing and assembly, clustering of DNA microarray results in gene expression studies, computation of genomic rearrangements and evolutionary trees. This course, a version of 308 for graduate students, requires advanced assignments. Credit will not be given for both BIOE 308 (CSE 308) and BIOE 408 (CSE 408). No prior background in biology is assumed.

BIOE 416 Introduction to Force Spectroscopy 3 Credits
This course is a graduate version of BIOE 316 (ME 316). While the lecture content will be the same as the 300-level course, students in the 400-level class will be expected to complete more advanced assignments. Closed to students who have taken BIOE 316 (ME 316).

BIOE 420 (CSE 420) Biomedical Image Computing and Modeling 3 Credits
Biomedical image modalities, image computing techniques, and imaging informatics systems. Understanding, using, and developing algorithms and software to analyze biomedical image data and extract useful quantitative information. Biomedical image modalities and formats; image processing and analysis; geometric and statistical modeling; image informatics systems in biomedicine. This course, a graduate version of BIOE 320, requires additional advanced assignments. Credit will not be given for both BioE 320 and BIOE 420. Prerequisites: MATH 205 and CSE 109

BIOE 421 (CHE 421) Biomolecular & Cellular Mechanics 3 Credits
Mechanics and physics of cell components, from fundamental biomolecules to the entire cell. The mechanics of proteins and other biopolymers in 1D, 2D, and 3D structures, cell membrane structure and dynamics, and the mechanics of the whole cell. This course is a graduate version of CHE 321 (Bio/E/Phy 321). The lecture content will be the same as in CHE 321 (Bio/E/Phy 321), but students enrolled in CHE 421 (BioE 421) will have more advanced assignments. Closed to students who have completed CHE 321 (Bio/E/Phy 321). Must have graduate standing.

BIOE 422 (MAT 422) Introduction to Organic Biomaterials 3 Credits
Property, characterization, fabrication, and modification of organic materials for biomedical and biological applications; host responses to biomaterials on the molecular, cellular, and system level; general introduction to biosensors, drug delivery, and tissue engineering. Graduate version of BIOE 324 requiring additional assignments. Credit is not given for both BIOE 324 (MAT 324) and BIOE 424 (MAT 424). Prerequisites: MAT 033.

BIOE 425 (MAT 425) Inorganic Biomaterials 3 Credits
Fabrication methods for biomedical implant and devices. Selection of metals and ceramics with specific bulk and surface physical as well as chemical properties. The role of materials chemistry and microstructure. Biocompatibility. Case studies (dental and orthopedic implants, stents, nonporous ceramic filters for kidney dialysis). Graduate version of MAT 325; credit will not be given for both MAT 325 and MAT 425. Prerequisites: MAT 033.

BIOE 426 (MAT 426) Biomimetic and Bio-enabled Materials 3 Credits
This course is a graduate version of BIOE 326 (MAT 326). While the lecture content will be the same as the 300-level course, students enrolled in BIOE 426 (MAT 426) will have more advanced assignments. Closed to students who have taken BIOE 326 (MAT 326). Must have graduate standing in Bioengineering or Materials Science and Engineering. Attribute/Distribution: ND

BIOE 439 (CHE 439) Neuronal Modeling and Computation 3 Credits
This course is a graduate version of BIOE 339 (CHE 339). While the lecture content will be the same as the 300-level course, students in the 400-level class will be expected to complete an independent term project. Closed to students who have completed BIOE 339 (CHE 339). Must have graduate standing in Bioengineering or Chemical Engineering.

BIOE 441 (CHE 441) Biotechnology I 3 Credits
See the course description listed for BioE 341. In order to receive 400-level credits, the student must do an additional, more advanced term project, as defined by the instructor at the beginning of the course. Close to students who have taken BioE 341 (CHE 341).

BIOE 442 (CHE 442) Biotechnology II 3 Credits
See the course description listed for BIOE 342 (CHE 342). In order to receive 400-level credits, the student must do an additional, more advanced term project, as defined by the instructor at the beginning of the course. Closed to students who have taken BIOE 342 (CHE 342).
BIOE 447 (CHE 447) Molecular Bioengineering 3 Credits
This course is a graduate version of CHE 344 (BioE 344). While the lecture content will be the same as the 300-level course, students enrolled in CHE 447 will have more advanced assignments. Closed to students who have completed BioE 344 (CHE 344).

BIOE 449 (CHE 449) Metabolic Engineering 3 Credits
This course is a graduate version of BIOE 349. While the lecture content will be the same as the 300-level course, students enrolled in BIOE 449 (CHE 449) will have more advanced assignments. Closed to students who have completed BIOE 349. Must have graduate standing in Chemical Engineering or Bioengineering.

BIOE 450 Special Topics 1-3 Credits
Special topics of study in bioengineering. Permission of instructor.

BIOE 463 (CHE 463) Numerical Methods for Scientists and Engineers 3 Credits
See the course description listed for ChE 363 (BIOE 363). This course is graduate version of ChE 363 (BIOE 363). The lecture content will be the same as ChE 363 (BIOE 363), but students enrolled in ChE 463 (BIOE 463) will have more advanced assignments. Closed to students who have taken ChE 363 (BIOE 363). Must have graduate standing or consent of the instructor.

BIOE 466 (ECE 466) Neural Engineering 3 Credits
Neural system interfaces for scientific and health applications. Basic properties of neurons, signal detection and stimulation, instrumentation and microfabricated electrode arrays. Fundamentals of peripheral and central neural signals and EEG, and applications such as neural prostheses, implants and brain-computer interfaces. Closed to students who have taken BIOE 366, ECE 366, or ECE 466. Students enrolled in the course at the 400-level must complete additional advanced assignments, as defined by the course instructor.

BIOE 468 (ECE 468) Introduction to Biophotonics and Optical Biomedical Imaging 3 Credits
Optical principles, techniques, and instruments used in biomedical research and clinical medicine. Fundamental concepts of optical imaging and spectroscopy systems, and details of light-tissue interaction. Commercial devices and instruments, as well as novel optical imaging technologies in development. Closed to students who have taken BIOE 368, ECE 368, or ECE 468. Students enrolled in the course at the 400-level must complete additional advanced assignments, as defined by the course instructor.

BIOE 490 Thesis 1-6 Credits
Repeat Status: Course may be repeated.

BIOE 499 Dissertation 1-12 Credits