**BIOE - BIOENGINEERING**

BIOE Class Schedule ([https://courses.illinois.edu/schedule/DEFAULT/BIOE/](https://courses.illinois.edu/schedule/DEFAULT/BIOE/))

**Courses**

BIOE 100 Bioengineering Freshman Seminar  credit: 1 Hour. ([https://courses.illinois.edu/schedule/terms/BIOE/100/](https://courses.illinois.edu/schedule/terms/BIOE/100/))

Bioengineering Freshman Seminar provides a broad introduction to the field, practice, and curriculum of Bioengineering. The major goals are for students to (1) meet the department faculty, (2) understand the curriculum and the 4-year goals, (3) understand and apply technologies central to the field through individual and group projects, (4) begin independent explorations into technologies in the field, and (5) practice teamwork, technical writing, and presentation. The course is designed for freshman Bioengineering majors. Prerequisite: Bioengineering Freshmen Only.

BIOE 120 Introduction to Bioengineering  credit: 1 Hour. ([https://courses.illinois.edu/schedule/terms/BIOE/120/](https://courses.illinois.edu/schedule/terms/BIOE/120/))

Lectures and discussions of recent trends in bioengineering; topics typically include biological interaction with ultrasound and microwave radiation, modeling, instrumentation, biomaterials, biomechanics, biological heat and mass transfer, and medical imaging techniques.

BIOE 198 Special Topics  credit: 1 to 3 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/198/](https://courses.illinois.edu/schedule/terms/BIOE/198/))

Subject offerings related to Bioengineering intended to augment the Bioengineering curriculum. Offerings will be at the freshman level. See class schedule or course information websites for topics and prerequisites. May be repeated if topics vary. Prerequisite: Majors only.

BIOE 199 Undergraduate Open Seminar  credit: 1 to 5 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/199/](https://courses.illinois.edu/schedule/terms/BIOE/199/))

May be repeated.

BIOE 200 Bioengineering Career Immersion  credit: 1 Hour. ([https://courses.illinois.edu/schedule/terms/BIOE/200/](https://courses.illinois.edu/schedule/terms/BIOE/200/))

This course provides exposure to Bioengineering careers through experiences in medicine, industry, and research. Students will observe professional practices to facilitate problem-based discoveries and technology design. Prerequisite: BIOE 120. Majors only.

BIOE 201 Conservation Principles Bioeng  credit: 3 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/201/](https://courses.illinois.edu/schedule/terms/BIOE/201/))

Material, energy, charge, and momentum balances in biological problems. Steady-state and transient conservation equations for mass, energy, charge, and momentum will be derived and applied to mathematically analyze physiological systems using basic mathematical principles, physical laws, stoichiometry, and thermodynamic properties. Prerequisite: CHEM 104, MCB 150, and PHYS 211.

BIOE 202 Cell & Tissue Engineering Lab  credit: 2 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/202/](https://courses.illinois.edu/schedule/terms/BIOE/202/))

Principles of cell biology inherent in tissue engineering design. Lab experience in safely and skillfully manipulating cells of the four tissue types and performing various quantitative analyses on products produced by cells that have differentiated. Prerequisite: MCB 150, and credit or concurrent enrollment in BIOE 206.

BIOE 205 Signals & Systems in Bioengr  credit: 3 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/205/](https://courses.illinois.edu/schedule/terms/BIOE/205/))

Introduction to signals and linear systems with examples from biology and medicine. Linear systems and mathematical models of systems, including differential equations, convolution, Laplace transforms, Fourier series and transforms, and discrete representations. Class examples and coursework apply general techniques to problems in biological signal analysis, including circuits, enzyme kinematics, and physiological system analysis. Use of Matlab and Simulink software to understand more complex systems. Prerequisite: CS 101, PHYS 212, and credit or concurrent registration in MATH 285.

BIOE 206 Cellular Bioengineering  credit: 3 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/206/](https://courses.illinois.edu/schedule/terms/BIOE/206/))

Molecular and cellular biology focusing on instrumentation and measurement techniques: gene expression, translation, and regulation; cellular energetics and enzyme kinetics; membrane transport and cell signaling; cytoskeleton and the cell cycle; cell biology fundamentals emphasizing modern imaging and measurement systems to quantify cellular function. Credit is not given for both BIOE 206 and MCB 252. Prerequisite: MCB 150.

BIOE 210 Linear Algebra for Biomedical Data Science  credit: 3 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/210/](https://courses.illinois.edu/schedule/terms/BIOE/210/))

Using analytical and computational tools from linear algebra, students will Solve large systems of linear equations, systems of linear ODEs, and linear PDEs; Analyze large, multivariable datasets to quantify relationships between variables; Decompose complex datasets into simpler representations; Introduce and solve common problems in classification, image processing, and machine learning; Develop a geometric understanding of high-dimensional spaces. Prerequisite: CS 101 and MATH 231. For Bioengineering majors only.

BIOE 297 Individual Study  credit: 1 to 4 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/297/](https://courses.illinois.edu/schedule/terms/BIOE/297/))

Special project or reading activity. May be repeated in the same or separate terms to a maximum of 12 hours. Prerequisite: Approved written application to department as specified by department or instructor.

BIOE 298 Special Topics  credit: 0 to 4 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/298/](https://courses.illinois.edu/schedule/terms/BIOE/298/))

Subject offerings of new and developing areas of knowledge in bioengineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary to a maximum of 8 hours.

BIOE 302 Modeling Human Physiology  credit: 3 Hours. ([https://courses.illinois.edu/schedule/terms/BIOE/302/](https://courses.illinois.edu/schedule/terms/BIOE/302/))

Description, quantification, and modeling of human physiological systems, based on systems fundamentals. Components, relationships, and homeostatic controls of neural, musculoskeletal, respiratory, cardiovascular, endocrine, digestion, and renal-filtration systems. Application of mathematical modeling and MATLAB simulation to further understanding of the systems and relate physiological consequences to changes in environment or component function. Prerequisite: BIOE 205 and one of MCB 252 or BIOE 206.

Information listed in this catalog is current as of 12/2021
BIOE 303  Quantitative Physiology Lab  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/303/)
Experiments involving the modeling and measurement of animal and human physiology systems. Use of computer simulations to provide mathematical descriptions of physiology behavior. Calibration and validation of models through hands-on experiments. Focus on quantitative measurement of neural, cardiovascular, respiratory, muscular, and endocrine system functions. Prerequisite: Concurrent enrollment in BIOE 302 is allowed.

BIOE 306  Biofabrication Lab  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/306/)
Experiments involving design of bioreactors and microfluidic systems, advanced cell culture, and quantitative analysis techniques such as polmerase chain reaction and atomic force microscopy. Laboratory techniques relating to current literature and state of the art in the field of bioengineering. Prerequisite: BIOE 202. Departmental approval required for non-majors.

BIOE 310  Comp Tools Bio Data  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/310/)
Fundamental and applied statistics, including probability distributions, parameter estimation, descriptive statistics, hypothesis testing, and linear regression. Statistical methods in genomics including sequence analysis, gene expression data analysis, human genomic variation, regulatory genomics, and cancer genomics. Credit is not given for both BIOE 310 and IE 300. Prerequisites: BIOE 205 and BIOE 206.

BIOE 360  Transport & Flow in Bioengrg  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/360/)
Fundamentals of fluid dynamics and mass transport applied to analysis of biological systems. Quantitative understanding of microscopic to macroscopic phenomena in biological systems related to their sensing by imaging techniques. Molecular phenomena in both healthy tissue and disease using examples from cardiovascular problems and cancer using ultrasound, optical and MRI techniques. Credit is not given for both BIOE 360 and any of CHBE 421, CHBE 451, or TAM 335. Prerequisite: BIOE 201 and MATH 285.

BIOE 380  Biomedical Imaging  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/380/)
Same as ECE 380. See ECE 380.

BIOE 397  Individual Study  credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/397/)
Special project or reading activity. May be repeated up to 8 hours in a term to a maximum of 12 total hours. Prerequisite: Approved written application to department as specified by department or instructor.

BIOE 398  Special Topics  credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/398/)
Subject offerings of new and developing areas of knowledge in bioengineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary to a maximum of 8 hours.

BIOE 414  Biomedical Instrumentation  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/414/)
Engineering aspects of the detection, acquisition, processing, and display of signals from living systems; biomedical sensors for measurements of biopotentials, ions and gases in aqueous solution, force, displacement, blood pressure, blood flow, heart sounds, respiration, and temperature; therapeutic and prosthetic devices; medical imaging instrumentation. Same as ECE 414. 3 undergraduate hours. 3 graduate hours. Prerequisite: BIOE 205, ECE 205 or ECE 210.

BIOE 415  Biomedical Instrumentation Lab  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/415/)
Laboratory to accompany BIOE 414. Use of sensors and medical instrumentation for static and dynamic biological inputs. Measurement of biomedical signals. Same as ECE 415. 2 undergraduate hours. 2 graduate hours. Prerequisite: Credit or concurrent registration in BIOE 414.

BIOE 416  Biosensors  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/416/)
Same as ECE 416. See ECE 416.

BIOE 420  Intro Bio Control Systems  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/420/)
Systems engineering approach to modeling physiological systems to examine natural biological control systems, homeostasis, and control through external medical devices. Introduces open loop and closed loop feedback control; Laplace and Fourier analysis of system behavior; impulse and steady state responses; physiological modeling and system identification; and stability. Includes biological systems for endocrine function, muscle position, neuronal circuits, and cardiovascular function. Mathematical modeling, Matlab and Simulink simulation, and physiological measurements to relate control systems to maintenance of internal environment. 3 undergraduate hours. No graduate credit. Credit is not given for BIOE 420 if credit for AE 353, ECE 486, SE 320, or ME 340 has been earned. Prerequisite: BIOE 302, BIOE 303, BIOE 414, BIOE 415.

BIOE 430  Intro Synthetic Biology  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/430/)
Introduction to the field of synthetic biology. Engineering applications of biomolecular systems and cellular capabilities for a variety of application biological background of gene regulation, experimental methods for circuit engineering, and mathematical basis for circuit modeling. Examples in biofuels, biomedicine, and other areas will be discussed. 3 undergraduate hours. 4 graduate hours. Prerequisite: BIOE 206 or MCB 252, and MATH 285.

BIOE 435  Senior Design I  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/435/)
Capstone bioengineering design activity to develop solutions to projects provided by academia, industry, or clinical settings, utilizing principles of design, engineering analysis, and functional operation of engineering systems. Concept-design, safety, human-factors, quality, and Six-Sigma considerations. Initial solution proposals meeting professional technical-writing and communication standards. Concluded in BIOE 436. 2 undergraduate hours. No graduate credit. Prerequisite: BIOE 414, BIOE 415, BIOE 302, and BIOE 303.

BIOE 436  Senior Design II  credit: 2 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/436/)
Continuation of BIOE 435. Design teams finalize concepts, evaluate alternatives, model and analyze solutions, build and test a final product, and present the results professionally to project sponsors. 2 undergraduate hours. No graduate credit. Prerequisite: BIOE 435.
BIOE 460  Gene Editing Lab  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/460/)
The objective of this course is to provide the knowledge and hands-on experience required for both designing and building tools that are necessary to engineer biological systems at the molecular and cellular levels. This particular course will highlight diverse examples of applications in synthetic biology. It will deal with such topics as gene editing, epigenome engineering, regulation of gene expression and synthetic life. Projects will be assigned for small teams. Students will submit a report after completion of each project. Students will have the opportunity to independently design and execute a genetic engineering project and present their project to the class. 3 undergraduate hours. No graduate credit. Prerequisite: BIOE 202 and BIOE 206. For bioengineering undergraduate majors only.

BIOE 461  Cellular Biomechanics  credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/461/)
Same as TAM 461. See TAM 461.

BIOE 467  Biophotonics  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/467/)
Same as ECE 467. See ECE 467.

BIOE 479  Cancer Nanotechnology  credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/479/)
An elective course for undergraduate students who are interested in learning nanotechnology and its applications in biology and medicine. Key topics include: (1) cancer biology and clinical oncology, (2) fundamentals of nanoscience, (3) principles of nanoscale engineering, (4) major classes of nanoparticles and nanostructures, and (5) nanomedicine technologies and applications. 3 undergraduate hours. 3 graduate hours. Prerequisite: MCB 150 and BIOE 206.

BIOE 481  Whole-Body Musculoskel Biomech  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/481/)
Same as ME 481. See ME 481.

BIOE 482  Musculoskel Tissue Mechanics  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/482/)
Same as ME 482. See ME 482.

BIOE 483  Biomedical Computed Imaging Systems  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/483/)
The frontier of biomedical imaging is computed imaging where multi-dimensional images must be reconstructed from measured data that is otherwise not meaningful to human observers. In this course, computational image reconstruction techniques will be developed and employed across a broad range of radiographic, magnetic resonance, and nuclear imaging modalities. General imaging and detection principles common to all computational modalities will be covered in context of specific biomedical imaging scenarios. X-ray computed tomography will be covered in depth and in the context of the imaging science principles presented the co-requisites; this also includes practical concerns about computing resources and modern GPU-based computing. The physics of magnetic resonance imaging will be presented and related to specific mathematical issues of image reconstruction and under-sampled measurement space. Positron emission tomography (PET) will be covered and specific clinical issues discussed in terms of reconstruction algorithm and parameter choices. 3 undergraduate hours. 4 graduate hours. Prerequisite: BIOE 205, BIOE 210, ECE 380/BIOE 380. Concurrent enrollment in BIOE 485 and BIOE 580 is required.

BIOE 484  Statistical Analysis of Biomedical Images  credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/484/)
Biomedical image data often come in extreme numbers: there is either so many of them that humans can’t analyze them in reasonable time (e.g., three-dimensional light sheet microscopy data) or they are few, highly varied and of limited spatial and intensity resolutions (e.g., positron emission tomography scans). Furthermore, the extraction of image features and the characterization of modality-dependent background noise can be particularly challenging in typical biomedical scenarios. In this course, several applications of statistical learning to biomedical image data will be covered in depth from first principles. Analyses will be done in Python using the Scikit-learn package and all homework assignments comprise statistical analyses of biomedical image data in real decision scenarios. Histogram transforms and the fundamental properties of image texture will be introduced and revisited throughout the course. The extraction of both low- and high-order spatial features at multiple scales will be demonstrated and employed throughout the course. Support vector machines will be introduced and applied to image classification and interpretation tasks. The random forest algorithm will be introduced and used on a number of large- and small-data tasks. Multiple linear regression will be applied to neuroimaging data and some common methods of assessing model robustness shown. Cross-validation of image-derived decisions and some common methods of assessing model robustness will be shown. Feature selection and dimensionality will be discussed in terms of diagnostic task performance. The effects of inter-feature correlation upon prediction confidence will be discussed. Principal component analysis will be described and applied to various image processing tasks. Unsupervised clustering and cluster analysis of extracted image features will be introduced. Stochastic object models will be introduced and applied in various validation tasks. 3 undergraduate hours. 4 graduate hours. Prerequisite: BIOE 485 or permission of the instructor. Students are expected to be familiar with calculus, basic probability & sampling, vector spaces, matrix algebra and constrained optimization. Several NumPy objects and manipulations will be reviewed, and all necessary Sci-kit functions introduced; however, students are expected to have substantial experience with Python programming as the basics of such will not be covered.

Information listed in this catalog is current as of 12/2021
BIOE 485  Computational Mathematics for Machine Learning and Imaging credit: 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/485/)
Covers fundamental mathematical and computational methods needed to implement computational imaging and machine learning solutions. First, relevant aspects of probability theory, matrix decompositions, and vector calculus will be introduced. Subsequently, methods that underlie approximate inference, such as stochastic sampling methods, are introduced. Finally, numerical optimization methods that represent core components of computed imaging and machine learning will be introduced. This will include numerical optimization-based formulations of inverse problems. An emphasis will be placed on first order deterministic and stochastic gradient-based methods. Second order optimization techniques including quasi-Newton and Hessian free methods will also be surveyed. The application of these methods to computed imaging and machine learning problems will be addressed in detail. 4 undergraduate hours. 4 graduate hours. Prerequisite: Restricted to senior undergraduate or graduate standing in an engineering degree program or consent of instructor.

BIOE 486  Applied Deep Learning for Biomedical Imaging credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/486/)
Covers basic concepts, methodology and algorithms in deep learning and their applications to solve various biomedical imaging problems. Introduction to neural networks and their application to supervised and unsupervised learning problems formulated for biomedical imaging will be provided. Connections between general learning methodologies and specific challenges in the field of biomedical imaging, and design, implementation and evaluation of deep neural network-based solutions to imaging problems will be emphasized. Problems covered will include imaging system design and optimization, image recovery and reconstruction (built on the imaging physics and system course – BIOE 483), image processing (e.g., denoising, super-resolution and enhancement) and image analysis (e.g., same-contrast, multi-contrast and multimodal image registration, segmentation, classification and quality assessment). Biomedical application specific problems and solutions will be covered via hands-on problems and team-based projects. 3 undergraduate hours. 4 graduate hours. Prerequisite: MATH 241 or equivalent; BIOE 210, MATH 415 or equivalent; BIOE 310, ECE 310, STAT 410 or equivalent; BIOE 198, CS 101 or equivalent; BIOE 483; BIOE 485; consent of the instructor.

BIOE 487  Stem Cell Bioengineering credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/487/)
Stem Cell Bioengineering will provide a foundation in the application of engineering approaches for the quantitative analysis of stem cell biology and the translation of stem cells into therapies. There will be 4 main sections of the course; (i) Stem Cell Basics, (ii) Stem Cell Genetics, (iii) Stem Cell Microenvironments, and (iv) Stem Cell Applications. The course will be targeted for first year graduate students and senior-level undergraduate students. The course will use a lecture and discussion format to effectively present relevant information. 3 undergraduate hours. 4 graduate hours. Prerequisite: BIOE 476.

BIOE 488  Applied High-Performance Computing for Imaging Science credit: 3 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/488/)
Will introduce students to basic principles and practical applications of scientific computing as they relate to problems in machine learning and computed imaging. In this self-contained course, students will be introduced to a variety of important topics that underlie real-world machine learning and biomedical image computing tasks that are not typically comprised in a single course. The material will be presented in a practical way that will be accessible to engineering students who have a moderate level of experience in scientific computing but lack specific training in computer science. The emphasis will be on immediate applicability of scientific computing techniques as opposed to theoretical knowledge. The course will begin with an overview of good scientific coding practices in Python and introductions to canonical computing architectures. Subsequently, parallel computing concepts will be surveyed that address multi-core CPU and GPU-enabled systems. Distributed GPU computing on a cluster will also be covered. The salient aspects of TensorFlow and/or other relevant machine learning programming environments will be introduced and utilized in applications of machine learning. 3 undergraduate hours. 3 graduate hours. Prerequisite: Familiarity with the Python programming language. Restricted to students with senior undergraduate or graduate standing in an engineering major.

BIOE 489  Regulations, Ethics and Logistics in Biomedical Applications of Machine Learning credit: 3 or 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/489/)
The application of machine learning (ML) to medical image data is an area of intense, well-funded research. Due to practical logistics, however, the ideas expounded in published research articles do not necessarily translate perfectly into clinical implementation. The purposeful design and assessment of machine learning experiments will be introduced and revisited throughout the course. The financial cost of training, data acquisition and expert labelling will be considered in the context of product delivery. Some relevant university, corporate and governmental regulatory policies will be presented by expert guest lecturers. Specific issues of clinical implementation and adoption of new technology will be covered. The ethics of using images influenced or analyzed by ML in patient care and/or medical research will be explored in depth. Topics include: diagnosis accuracy, mandated system upgrades, informed consent, patient privacy, researcher/vendor liability and the role and reliability of federal regulations in ethical application of ML to biomedical data. The policies and procedures of NIH study sections and internal review boards will be highlighted and some key issues related to intellectual property will be surveyed. 3 undergraduate hours. 4 graduate hours. Prerequisite: Restricted to students with senior undergraduate or graduate standing and familiarity with machine learning principles.

BIOE 497  Individual Study credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/497/)
Special project or reading activity. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated up to 8 hours in a term to a maximum of 12 total hours. Prerequisite: Approved written application to department as specified by department or instructor.

BIOE 498  Special Topics credit: 1 to 4 Hours. (https://courses.illinois.edu/schedule/terms/BIOE/498/)
Subject offerings of new and developing areas of knowledge in bioengineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary to a maximum of 12 hours, but no more than 8 in any one term.

Information listed in this catalog is current as of 12/2021
BIGE 499 Senior Thesis credit: 1 to 5 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/499/]
Limited in general to seniors in the curriculum in bioengineering. Any others must have the consent of the department chief advisor. Each student taking the course must register in a minimum of 5 hours either in one term or divided over two terms. 1 to 5 graduate hours. No graduate credit. May be repeated to a maximum of 10 hours between two semesters. Prerequisite: Senior Standing.

BIGE 500 Graduate Seminar credit: 0 or 1 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/500/]
Lecture surveying a broad range of Bioengineering topics. 0 or 1 graduate hours. No professional credit. Approved for S/U grading only. May be repeated to a maximum of 2 hours.

BIGE 501 Seminar Discussion credit: 1 Hour. [https://courses.illinois.edu/schedule/terms/BIOE/501/]
Familiarization with reading and discussing academic journals in Bioengineering. Approved for S/U grading only.

BIGE 502 Bioengineering Professionalism credit: 2 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/502/]
Ethical questions and conduct, procedures, and professional standards in the practice of bioengineering. Authorship and mentoring, use of animal and human subjects, conflict of interest, ethical behavior in scientific research, intellectual property, and approval processes for drugs and biomedical devices. 2 graduate hours. No professional credit.

BIGE 504 Analytical Methods in Bioeng credit: 4 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/504/]
Mathematical concept relating to modeling of physiological and biomolecular processes and the instrumentation used to measure those processes. Review of matrix methods, probability, linear systems, and integral transforms. Singular value decomposition, Bayesian decision making, and linear system solutions to ordinary differential equations. Application of concepts to biosensor design and evaluation, tracer kinetic modeling, and filtering and curve-fitting approaches to forward modeling problems. Prerequisite: MATH 285.

BIGE 505 Computational Bioengineering credit: 4 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/505/]
Mathematical and statistical models plus accompanying computational techniques central to many aspects of systems biology and bioengineering research. Theory of supervised and unsupervised learning; linear models; dimension reduction; Monte Carlo computation; analysis of gene expression data and genome sequence data; modeling of gene transcription network signaling pathways. Same as CSE 505. 4 graduate hours. No professional credit. Prerequisite: STAT 400.

BIGE 506 Molecular Biotechniques credit: 4 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/506/]
Introduction to modern biotechnologies for studies on the Central Dogma of Biology (DNA, RNA, and Protein) as well as cellular organelles and cell imaging. In-depth review of traditional established methods and emerging ones, emphasizing high precision, high spatial/temporal resolution, high-throughput, molecular accuracy, sensitivity and real-time imaging. Techniques include single molecule sequencing, super resolution cell imaging, and gene therapeutic methods. Example applications of technology are included through relevant journal articles. 4 graduate hours. No professional credit. Prerequisite: MCB 250.

BIGE 507 Advanced Bioinstrumentation credit: 4 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/507/]
Instrumentation and underlying theory employed in bioengineering. Concepts in the design and operation of sensors, fundamentals of optics, basic control theory and systems, digital components, and fundamental principles of medical imaging techniques. Specific knowledge of one biomedical instrument or system will be emphasized including detailed mathematical analysis. Prerequisite: BIGE 504.

BIGE 510 Computational Cancer Biology credit: 4 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/510/]
Mathematical modeling of the process of carcinogenesis as somatic cell evolution. Focus on current research topics in cancer biology using data from next-generation sequencing technologies. Overview of database resources and algorithmic and modeling methods related to biological problems. 4 graduate hours. No professional credit. Prerequisite: BIOE 206, CS 101, MATH 285.

BIGE 531 Principles of Pharmaceutical Technology credit: 4 Hours. [https://courses.illinois.edu/schedule/terms/BIOE/531/]
This is a core course for the pharmaceutical engineering concentration. Drug manufacturing often relies on principles of chemistry, pharmaceutics, and technology. This course will discuss in-depth understanding of compounds and materials to help designers predict and measure compound properties to define and characterize their constitutive behaviors. This course will provide students with an understanding of the principles, strategies, and materials used in the processes of controlled drug delivery systems. Gaining knowledge in ingredient interaction (thermodynamics vs. kinetics) and how the delivery requirements determine the ingredients and the corresponding processing is critical for the success of a pharmaceutical development. This course will first discuss the synthetic approaches to new drug discovery and repurposing followed by introducing the technology methodologies involved in translating a drug compound produced in the lab to an industrial process. It will also focus on topics at the interface between engineering and chemistry and biology covering fundamentals of drug delivery, including physiology pharmakokinetics/ pharmacodynamics, drug diffusion and permeation, and biomaterials used in drug delivery. Controlled release strategies for various administration routes will also discussed. 4 graduate hours. No professional credit. Prerequisite: Student should have completed courses in advanced math, including linear algebra and differential equations, as well as courses in chemistry and biological sciences. Open to all M.Eng. in Bioengineering students.
BIOE 532  Advanced Pharmaceutical Technology  credit: 4 Hours.  
(https://courses.illinois.edu/schedule/terms/BIOE/532/)
This is a core course for the pharmaceutical engineering concentration. 
This course will follow a combination of modular lecture and laboratory-based teaching (lab modules will require students to participate 
in conducting wet lab experiments followed by calculations). Drug 
manufacturing often relies on principles of chemistry, pharmaceutics, 
and technology. Most of the classical pharmaceutical engineering 
degree programs either do not extensively address newly defined design-based 
approaches or require long years of work experience to acquire 
integrated knowledge on pharm-science, relevant regulations and 
process technology. This knowledge gap on the interface of pharmacy 
and process technology has been identified independently by WHO 
and AAPS survey (Lawrence 2017; O’Connor 2016). The goal of this 
course is to help develop the desired skill sets covering the concepts 
to adapt technology principles to pharmaceutical and life sciences with 
topics ranging from process technology in the drug discovery, high 
throughput characterization and optimization of new chemical entities, 
solid-state engineering, and intelligent pharmaceutical manufacturing 
systems. The basic features of common unit operations used in the 
pharmaceutical industry will be reviewed, including batch reaction, solid-liquid 
separation, crystallization, drying, mixing, batch distillation and 
other separation systems. 4 graduate hours. No professional credit. 
Prerequisite: BIOE 531. Open to all M.Eng. in Bioengineering students.

BIOE 570  Seminar Series  credit: 1 Hour.  (https://courses.illinois.edu/ 
schedule/terms/BIOE/570/)
Guest topics will vary, but will typically cover topics of current interest 
relevant to the bioengineering field. Lecture and discussion on topics 
relevant to the development, regulatory approval, marketing, and 
application of systems used in the fields of biomedical imaging, life 
science research, and pharmaceutical discovery. Emphasis upon case 
studies on topics that will include regulatory approval, intellectual 
property, strategy, and technology innovation. 1 graduate hour. No 
professional credit. Approved for S/U grading only. May be repeated up 
to 2 hours in separate terms. Prerequisite: For students enrolled in the 
M.Eng. in Bioengineering degree program.

BIOE 571  Biological Measurement I  credit: 4 Hours.  (https:// 
courses.illinois.edu/schedule/terms/BIOE/571/)
With special focus on medical imaging, this course will introduce 
fundamental concepts related to the detection and analysis of biological 
analytes, biomedical images, and physiological parameters. Topics 
include signal-to-noise analysis, noise characterization, data aliasing, 
analog-to-digital conversion, common strategies for noise reduction, 
exogenous contrast agents and fundamentals of molecular imaging. 
The fundamental phenomena behind biological measurements such as 
DNA sequencing, fluorescence microscopy. MRI imaging, OCT imaging, 
and ultrasound imaging will be discussed along with the factors that 
influence noise and contrast from the standpoint of fundamental 
physics, instrumentation/hardware, and post-measurement data/signal 
processing. 4 graduate hours. No professional credit. Prerequisite: For 
students enrolled in the M.Eng in Bioengineering degree program.

BIOE 572  Biological Measurement II  credit: 4 Hours.  (https:// 
courses.illinois.edu/schedule/terms/BIOE/572/)
With special focus on medical imaging, learn about advanced techniques 
related to state-of-the-art bioinstrumentation technologies. Topics 
will broadly include fluorescence, genomic and proteomic diagnostics, 
biosensors, ultrasound imaging, microscopy and their uses relevant to 
physiological changes related to major human diseases. 4 graduate 
hours. No professional credit. Prerequisite: BIOE 571. For students 
enrolled in the M.Eng in Bioengineering degree program.

BIOE 573  Managing Business Operations  credit: 4 Hours.  (https:// 
courses.illinois.edu/schedule/terms/BIOE/573/)
Introduction to fundamental principles of design, management, and 
 improvement of business operations and product innovations. Strategies 
and techniques for managing processes, projects, process improvement 
and new product development. 4 graduate hours. No professional credit. 
Prerequisite: For students enrolled in the M.Eng in Bioengineering degree program.

BIOE 574  Innovation and Introduction to Financial Decision Making  
credit: 4 Hours.  (https://courses.illinois.edu/schedule/terms/BIOE/574/)
Tools, concepts, and analytical frameworks that enhance the ability to 
define and analyze strategic problems stemming from innovation and 
technological change, and to identify sources of competitive advantage 
from both an industry and firm-level perspective. Introduction to financial 
decision making, including topics in valuation, project analysis and 
risk-return relationships. 4 graduate hours. No professional credit. 
Prerequisite: For students enrolled in the M.Eng. in Bioengineering degree program.

BIOE 575  Capstone Project  credit: 3 Hours.  (https:// 
courses.illinois.edu/schedule/terms/BIOE/575/)
Students in the Master of Engineering (M.Eng.) in Bioengineering 
program will demonstrate their proficiency through a capstone project, 
where students will work on a translational project to develop solutions 
for real world problems utilizing principles of design, engineering analysis, 
and functional operation of engineering systems. Depending on the 
student’s flexibility and availability, capstone projects may include 
collaboration with other online M.Eng. students on a team-based project, 
analysis of case studies, or even a self-directed project that directly 
relates to a specific area of interest or on behalf of their employer. Project 
presentations and demonstrations may be required at the end of the 
program. 3 graduate hours. No professional credit. May be repeated for 
6 hours in separate semesters. Students in the Master of Engineering 
program will be required to sign up for BIOE 575 in both the Fall and 
Spring semesters. Prerequisite: Proficiency in MATLAB and completion 
of or concurrent enrollment in core classes required for the Master of 
Engineering (M.Eng.) in Bioengineering program. Class only available to 
students in the M.Eng. in Bioengineering degree program.

BIOE 580  Foundations of Imaging Science  credit: 4 Hours.  (https:// 
courses.illinois.edu/schedule/terms/BIOE/580/)
Exposes students to a broad treatment of the mathematical and 
statistical principles of biomedical imaging. In addition to providing a 
foundation for understanding general principles of image formation 
and objective image quality assessment that are widely applicable, this 
material will be essential for the principled and successful application 
of artificial intelligence methods in biomedical imaging. This course will 
cover the mathematical concepts needed for the deterministic analysis 
of imaging systems. Linear operator theory will be employed to describe 
continuous-to-continuous, continuous-to-discrete, and discrete-to-
discrete mappings from objects to images. In addition, imaging systems 
will be analyzed in a statistical framework where stochastic models 
for objects and images will be introduced. Methodologies for objective 
assessment of image quality (OAIQ) will be introduced, which will address 
classification tasks, receiver operator characteristic (ROC) analysis, 
and salient aspects estimation theory. An introduction to numerical 
observer for quantification of OAIQ will be provided. 4 graduate hours. 
No professional credit. Prerequisite: Concurrent enrollment in BIOE 485 
and BIOE 483 is required. Restricted to graduate standing or consent of 
instructor.
Modular approach to pulse sequence programming in magnetic resonance imaging; descriptions of current pulse sequences; RF pulse design; data sampling considerations; k-space acquisition trajectories. Pulse sequence development simulator usage to program, simulate, and reconstruct images from student-designed acquisitions. Prerequisite: ECE 480.

This course will provide students with the practical knowledge of statistical analysis and computational modeling techniques relevant for applications in genomics and systems biology. The focus will be on the fundamental concepts and algorithms for gene finding, genome annotation, sequence alignment, phylogenetic reconstruction, gene expression and network analysis, Genome-Wide Association Studies (GWAS), etc. 4 graduate hours. No professional credit. Prerequisite: STAT 100, MCB 250, MATH 220, CS 101, or equivalent. Restricted to MEng Students only.

The course will provide students with important practical skills for handling genomic big data and analyzing the results of various types of high-throughput sequencing experiments. The focus will be on achieving proficiency in data management and processing based on popular file formats in genomic biology. 4 graduate hours. No professional credit. Prerequisite: STAT 100, MCB 250, CS 101, or equivalent. For students enrolled in the M.Eng in Bioengineering program or with consent of the M.Eng. program.

A generative model is a powerful way of learning any kind of data distribution using unsupervised learning and they have achieved tremendous success in recent years. In the context of biomedical imaging, generative models are being actively explored for many important and diverse applications that include image and video synthesis, representation learning and semi-supervised learning, domain adaptation, text to image synthesis, image compression, super-resolution, inpainting, saliency prediction, image enhancement, style transfer and texture synthesis, and image-to-image translation. Generative models also hold great potential for regularizing inverse problems that arise in biomedical image formation. This course will provide an introduction to the use of deep neural networks for generative modeling in the context of biomedical image science. An emphasis will be placed on variational autoencoders (VAEs) and generative adversarial networks (GANs), as these are currently two of the most commonly employed and efficient approaches. The use of generative models for exploring data-acquisition designs optimizing the performance of imaging systems will also be introduced. Practical details regarding the successful training and evaluation of deep generative models using biomedical image data will be introduced throughout the course. This will be reinforced via homework assignments and a final project that require hands-on training of networks facilitated by allocations of GPU time. 4 graduate hours. No professional credit. Prerequisite: BIOE 486, BIOE 485, BIOE 483, BIOE 580 or consent of instructor.

This journal-club style course will expose students to the modern literature on biomedical imaging and machine learning. Students will be exposed to cutting edge topics in the rapidly evolving field of biomedical image computing. Additionally, the course will prepare students for the capstone project in the Biomedical Image Computing MS degree program that will take place in the third semester of the program. During this course, students will interact with potential project mentors and engage in detailed literature reviews related to potential projects. 1 graduate hour. No professional credit. Approved for S/U grading only. Prerequisite: Graduate student standing. Concurrent enrollment in BIOE 484 and BIOE 486 is required. Restricted to students in the Biomedical Image Computing M.S. degree program only.

In this course students will complete a project that utilizes machine learning methods and advanced computational tools to solve a problem related to bioimaging. The projects will utilize experimental bioimage data that is contributed by a project sponsor and/or available via open source databases. While these projects need not be publishable or perfectly novel, they will involve the systematic application and evaluation of machine learning and image computing methods. It is expected that, by solving actual problems posed by industry or clinical partners, students will gain marketable experience but, ideally, also will make inroads with their future employers. 4 graduate hours. No professional credit. Prerequisite: BIOE 588, BIOE 484, BIOE 486, BIOE 580. Concurrent enrollment in BIOE 489 is required. Restricted to students enrolled in the Biomedical Image Computing MS degree program only.

Special project or reading activity. May be repeated. Prerequisite: Approved written application to department as specified by department or instructor.

Subject offerings of new and developing areas of knowledge in bioengineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 graduate hours. No professional credit. May be repeated in the same or separate terms if topics vary.

Bioengineering graduate thesis research. Approved for S/U grading only. May be repeated.