Bioengineering

The Department of Bioengineering offers a Master of Engineering (MEng) in Bioengineering. The PhD in Bioengineering is granted jointly by UCSF and UC Berkeley.

Master of Engineering (MEng)

The Master of Engineering is a one-year master's degree with a strong emphasis on engineering and entrepreneurship designed for students planning to move directly into industry after completing the program.

Doctor of Philosophy (PhD)

The PhD in Bioengineering is granted jointly by Berkeley and UCSF, two of the top public universities in the world in health sciences and engineering. Our interdisciplinary program combines the outstanding resources in biomedical and clinical sciences at UCSF with the excellence in engineering, physical, and life sciences at Berkeley.

All students in the program are simultaneously enrolled in the graduate divisions of both the San Francisco and Berkeley campuses and are free to take advantage of courses and research opportunities on both campuses. The program awards the PhD in Bioengineering degree from both campuses.

Admission to the University

Uniform minimum requirements for admission

The following minimum requirements apply to all programs and will be verified by the Graduate Division:

1. A bachelor's degree or recognized equivalent from an accredited institution;
2. A minimum grade-point average of B or better (3.0);
3. If the applicant comes from a country or political entity (e.g. Quebec) where English is not the official language, adequate proficiency in English to do graduate work, as evidenced by a TOEFL score of at least 570 on the paper-and-pencil test, 230 on the computer-based test, 90 on the iBT test, or an IELTS Band score of at least 7 (note that individual programs may set higher levels for any of these); and
4. Enough undergraduate training to do graduate work in the given field.

Applicants who already hold a graduate degree

The Graduate Council views academic degrees as evidence of broad research training, not as vocational training certificates; therefore, applicants who already have academic graduate degrees should be able to take up new subject matter on a serious level without undertaking a graduate program, unless the fields are completely dissimilar.

Programs may consider students for an additional academic master's or professional master's degree if the additional degree is in a distinctly different field.

Applicants admitted to a doctoral program that requires a master's degree to be earned at Berkeley as a prerequisite (even though the applicant already has a master's degree from another institution in the same or a closely allied field of study) will be permitted to undertake the second master's degree, despite the overlap in field.

The Graduate Division will admit students for a second doctoral degree only if they meet the following guidelines:

1. Applicants with doctoral degrees may be admitted for an additional doctoral degree only if that degree program is in a general area of knowledge distinctly different from the field in which they earned their original degree. For example, a physics PhD could be admitted to a doctoral degree program in music or history; however, a student with a doctoral degree in mathematics would not be permitted to add a PhD in statistics.
2. Applicants who hold the PhD degree may be admitted to a professional doctorate or professional master's degree program if there is no duplication of training involved.

Applicants may only apply to one single degree program or one concurrent degree program per admission cycle.

Any applicant who was previously registered at Berkeley as a graduate student, no matter how briefly, must apply for readmission, not admission, even if the new application is to a different program.

Required documents for admissions applications

1. **Transcripts:** Upload unofficial transcripts with the application for the departmental initial review. Official transcripts of all college-level work will be required **if admitted**. Official transcripts must be in sealed envelopes as issued by the school(s) you have attended. Request a current transcript from every post-secondary school that you have attended, including community colleges, summer sessions, and extension programs.
   If you have attended Berkeley, upload unofficial transcript with the application for the departmental initial review. Official transcript with evidence of degree conferral ***will not*** be required if admitted.
2. **Letters of recommendation:** Applicants can request online letters of recommendation through the online application system. Hard copies of recommendation letters must be sent directly to the program, not the Graduate Division.
3. **Evidence of English language proficiency:** All applicants from countries in which the official language is not English are required to submit official evidence of English language proficiency. This requirement applies to applicants from Bangladesh, Burma, Nepal, India, Pakistan, Latin America, the Middle East, the People's Republic of China, Taiwan, Japan, Korea, Southeast Asia, and most European countries. However, applicants who, at the time of application, have already completed at least one year of full-time academic course work with grades of B or better at a U.S. university may submit an official transcript from the U.S. university to fulfill this requirement. The following courses will not fulfill this requirement: 1) courses in English as a Second Language, 2) courses conducted in a language other than English, 3) courses that will be completed after the application is submitted, and 4) courses of a non-academic nature. If applicants have previously been denied admission to Berkeley on the basis of their English language proficiency, they must submit new test scores that meet the current minimum from one of the standardized tests.

Curriculum

BIO ENG 100	Ethics in Science and Engineering	3
BIO ENG 200	The Graduate Group Introductory Seminar	1
BIO ENG C280	Introduction to Nano-Science and Engineering	3
or BIO ENG C281	The Berkeley Lectures on Energy: Energy from Biomass	
BIO ENG 301	Teaching Techniques for Bioengineering	1
Area Requirements		
Anatomy, Physiology, Biology		9
Biochemistry, Chemistry		3
Engineering (traditional discipline) & Computer Science		7
Mathematics (beyond basics) & Statistics		2

Curriculum

ENGIN 271	Engineering Leadership I	3
ENGIN 271	Engineering Leadership I	3
ENGIN 296	Course Not Available	3
Graduate BIO ENG electives, per approved study, list according to student interest		

Bioengineering

BIO ENG 200 The Graduate Group Introductory Seminar 1 Unit
An introduction to research in bioengineering including specific case studies and organization of this rapidly expanding and diverse field.
Rules & Requirements

Prerequisites: Enrollment in PhD Program in Bioengineering or consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of seminar per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

BIO ENG C208 Biological Performance of Materials 4 Units
This course is intended to give students the opportunity to expand their knowledge of topics related to biomedical materials selection and design. Structure-property relationships of biomedical materials and their interaction with biological systems will be addressed. Applications of the concepts developed include blood-materials compatibility, biomimetic materials, hard and soft tissue-materials interactions, drug delivery, tissue engineering, and biotechnology.
Objectives & Outcomes

Course Objectives: The course is separated into four parts spanning the principles of synthetic materials and surfaces, principles of biological materials, biological performance of materials and devices, and state-of-the-art materials design. Students are required to attend class and master the material therein. In addition, readings from the clinical, life and materials science literature are assigned. Students are encouraged to seek out additional reference material to complement the readings assigned. A mid-term examination is given on basic principles (parts 1 and 2 of the outline). A comprehensive final examination is given as well. The purpose of this course is to introduce students to problems associated with the selection and function of biomaterials. Through class lectures and readings in both the physical and life science literature, students will gain broad knowledge of the criteria used to select biomaterials, especially in devices where the material-tissue or material-solution interface dominates performance. Materials used in devices for medicine, dentistry, tissue engineering, drug delivery, and the biotechnology industry will be addressed.

This course also has a significant design component (~35%). Students will form small teams (five or less) and undertake a semester-long design project related to the subject matter of the course. The project includes the preparation of a paper and a 20 minute oral presentation critically analyzing a current material-tissue or material-solution problem. Students will be expected to design improvements to materials and devices to overcome the problems identified in class with existing materials.

Student Learning Outcomes: Work independently and function on a team, and develop solid communication skills (oral, graphic & written) through the class design project.
• Develop an understanding of the social, safety and medical consequences of biomaterial use and regulatory issues associated with the selection of biomaterials in the context of the silicone breast implant controversy and subsequent biomaterials crisis.
• Design experiments and analyze data from the literature in the context of the class design project.

• Understanding of the origin of surface forces and interfacial free energy, and how they contribute to the development of the biomaterial interface and ultimately biomaterial performance.
• Apply math, science & engineering principles to the understanding of soft materials, surface chemistry, DLVO theory, protein adsorption kinetics, viscoelasticity, mass diffusion, and molecular (i.e., drug) delivery kinetics.
• Apply core concepts in materials science to solve engineering problems related to the selection biomaterials, especially in devices where the material-tissue or material-solution interface dominates performance.

Rules & Requirements

Prerequisites: Engineering 45; Chemistry C130/Molecular and Cell Biology C100A or Engineering 115 or equivalent; Bioengineering 102 and 104 recommended

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

BIO ENG C209 Advanced Orthopedic Biomechanics 4 Units
Students will learn the application of engineering concepts including statics, dynamics, optimization theory, composite beam theory, beam-on-elastic foundation theory, Hertz contact theory, and materials behavior. Topics will include forces and moments acting on human joints; composition and mechanical behavior of orthopedic biomaterials; design/analysis of artificial joint, spine, and fracture fixation prostheses; musculoskeletal tissues including bone, cartilage, tendon, ligament, and muscle; osteoporosis and fracture-risk predication of bones; and bone adaptation. Students will be challenged in a MATLAB-based project to integrate the course material in an attempt to gain insight into contemporary design/analysis/problems.
Objectives & Outcomes

Course Objectives: The purpose of this course is twofold:
• to learn the fundamental concepts of orthopaedic biomechanics;
• to enhance skills in mechanical engineering and bioengineering by analyzing the mechanical behavior of various complex biomedical problems.

Student Learning Outcomes: Working knowledge of various engineering concepts such as composite beam theory, beam-on-elastic-foundation theory, Hertz contact theory and MATLAB-based optimization design analysis. Understanding of basic concepts in orthopaedic biomechanics and the ability to apply the appropriate engineering concepts to solve realistic biomechanical problems, knowing clearly the assumptions involved.

Rules & Requirements

Prerequisites: ME C85/CE C30 or Bio Eng 102; concurrent enrollment OK. Proficiency in MatLab or equivalent. Prior knowledge of biology or anatomy is not assumed

Credit Restrictions: Students will not receive credit for this course if they have taken ME C176/Bio E C119.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 1 hour of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: O'Connell, Keaveny

Also listed as: MEC ENG C210

BIO ENG 211 Cell and Tissue Mechanotransduction 3 Units
This course will focus on biophysical and bioengineering aspects of mechanotransduction, the process through which living cells sense and respond to their mechanical environment. Students will learn how mechanical inputs to cells influence both subcellular biochemistry and whole-cell behavior. They will also study newly-engineered technologies for force manipulation and measurement in living cells, and synthetic strategies to control the mechanics and chemistry of the extracellular matrix. Finally, students will learn about the role of mechanotransduction in selected human organ systems and how these mechanisms may go awry in the setting of the disease. Instruction will feature lectures, discussions, analysis of relevant research papers, assembly of a literature review and a research proposal, and an oral presentation.
Rules & Requirements

Prerequisites: Undergraduate cell biology or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Kumar

BIO ENG C212 Heat and Mass Transport in Biomedical Engineering 3 Units
Fundamental processes of heat and mass transport in biological systems; organic molecules, cells, biological organs, whole animals. Derivation of mathematical models and discussion of experimental procedures. Applications to biomedical engineering.
Rules & Requirements

Prerequisites: 106 and 109 (106 and 109 may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Formerly known as: Mechanical Engineering 212

Also listed as: MEC ENG C212

BIO ENG C213 Fluid Mechanics of Biological Systems 3 Units
Fluid mechanical aspects of various physiological systems, the circulatory, respiratory, and renal systems. Motion in large and small blood vessels. Pulsatile and peristaltic flows. Other biofluidmechanical flows: the ear, eye, etc. Instrumentation for fluid measurements in biological systems and for medical diagnosis and applications. Artificial devices for replacement of organs and/or functions, e.g. blood oxygenators, kidney dialysis machines, artificial hearts/circulatory assist devices.

Rules & Requirements

Prerequisites: 106 or equivalent; 265A or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Berger, Liepmann

Also listed as: MEC ENG C213

BIO ENG C214 Advanced Tissue Mechanics 3 Units
The goal of this course is to provide a foundation for characterizing and understanding the mechanical behavior of load-bearing tissues. A variety of mechanics topics will be introduced, including anisotropic elasticity and failure, cellular solid theory, biphasic theory, and quasi-linear viscoelasticity (QLV) theory. Building from this theoretical basis, we will explore the constitutive behavior of a wide variety of biological tissues. After taking this course, students should have sufficient background to independently study the mechanical behavior of most biological tissues. Formal discussion section will include a seminar series with external speakers.

Rules & Requirements

Prerequisites: 102A, 176, 185; graduate standing or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Also listed as: MEC ENG C214

BIO ENG C215 Molecular Biomechanics and Mechanobiology of the Cell 4 Units
This course develops and applies scaling laws and the methods of continuum and statistical mechanics to understand micro- and nano-scale mechanobiological phenomena involved in the living cell with particular attention the nucleus and the cytoskelton as well as the interactions of the cell with the extracellular matrix and how these interactions may cause changes in cell architecture and biology, consequently leading to functional adaptation or pathological conditions.

Objectives & Outcomes

Course Objectives: This course, which is open to graduate students in diverse disciplines ranging from engineering to biology to chemistry and physics, is aimed at exposing students to subcellular biomechanical phenomena spanning scales from molecules to the whole cell.

Student Learning Outcomes: The students will develop tools and skills to (1) understand and analyze subcelluar biomechanics and transport phenomena, and (2) ultimately apply these skills to novel biological and biomedical applications.

Rules & Requirements

Prerequisites: MATH 54; PHYSICS 7A; BioE 102 or ME C85 or instructor’s consent

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Mofrad

Also listed as: MEC ENG C216

BIO ENG C216 Macromolecular Science in Biotechnology and Medicine 4 Units
Overview of the problems associated with the selection and function of polymers used in biotechnology and medicine. Principles of polymer science, polymer synthesis, and structure-property-performance relationships of polymers. Particular emphasis is placed on the performance of polymers in biological environments. Interactions between macromolecular and biological systems for therapy and diagnosis. Specific applications will include drug delivery, gene therapy, tissue engineering, and surface engineering.
Rules & Requirements

Prerequisites: Bioengineering 115 or equivalent; open to seniors with consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Healy

Also listed as: MAT SCI C216

BIO ENG C217 Biomimetic Engineering -- Engineering from Biology 3 Units
Study of nature's solutions to specific problems with the aim of determining appropriate engineering analogs. Morphology, scaling, and design in organisms applied to engineering structures. Mechanical principles in nature and their application to engineering devices. Mechanical behavior of biological materials as governed by underlying microstructure, with the potential for synthesis into engineered materials. Trade-offs between redundancy and efficiency. Students will work in teams on projects where they will take examples of designs, concepts, and models from biology and determine their potential in specific engineering applications.
Rules & Requirements

Prerequisites: Graduate standing in engineering or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Dharan

Also listed as: INTEGBI C217/MEC ENG C217

BIO ENG C218 Stem Cells and Directed Organogenesis 3 Units
This course will provide an overview of basic and applied embryonic stem cell (ESC) biology. Topics will include early embryonic development, ESC laboratory methods, biomaterials for directed differentiation and other stem cell manipulations, and clinical uses of stem cells.
Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Conboy

Also listed as: MCELLBI C237

BIO ENG C219 Protein Engineering 3 Units
An in-depth study of the current methods used to design and engineer proteins. Emphasis on how strategies can be applied in the laboratory. Relevant case studies presented to illustrate method variations and applications. Intended for graduate students.
Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Tullman-Ercek

Also listed as: CHM ENG C270

BIO ENG 220L Cells and Biomaterials Laboratory 4 Units
The objective of this course is to teach graduate students the essential laboratory techniques in the design and characterization and analysis of cells and biomaterials. The course will cover basics on synthetic biomaterials and native matrix, cellular responses to biomaterials, three-dimensional culture, and tissue engineering. The course includes a lecture and a laboratory section each week. There will be a midterm exam, final exam, and a tissue engineering group project.
Rules & Requirements

Prerequisites: Cell and tissue engineering; upper division cell biology course or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture and 6 hours of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Li

BIO ENG 221 Advanced BioMEMS and Bionanotechnology 4 Units
Biophysical and chemical principles of biomedical devices, bionanotechnology, bionanophotonics, and biomedical microelectromechanical systems (BioMEMS). Topics include basics of nano-& microfabrication, soft-lithography, DNA arrays, protein arrays, electrokinetics, electrochemical transducers, microfluidic devices, biosensor, point of care diagnostics, lab-on-a-chip, drug delivery microsystems, clinical lab-on-a-chip, advanced biomolecular probes, biomolecular spectroscopy, and etc.

Rules & Requirements

Prerequisites: Chemistry 3A, PHYSICS 7A and 7B, Electrical Engineering 143 or equivalent

Repeat rules: Students will receive no credit for 221 after taking 121. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Summer:
6 weeks - 7.5 hours of lecture per week
8 weeks - 5.5 hours of lecture per week
10 weeks - 4.5 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: L. Lee

BIO ENG 221L BioMEMS and BioNanotechnology Laboratory 4 Units
Students will become familiar with BioMEMS and Lab-on-a-Chip research. Students will design and fabricate their own novel micro- or nano-scale device to address a specific problem in biotechnology using the latest micro- and nano-technological tools and fabrication techniques. This will involve an intensive primary literature review, experimental design, and quantitative data analysis. Results will be presented during class presentations and at a final poster symposium.

Rules & Requirements

Prerequisites: 102 or 104; 22/22L or Molecular and Cell Biology C100A/ Chemistry C130 or equivalent

Hours & Format

Fall and/or spring: 15 weeks - 6 hours of laboratory and 2 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Dueck, L. Lee

BIO ENG C222 Advanced Structural Aspects of Biomaterials 4 Units
This course covers the structure and mechanical functions of load bearing tissues and their replacements. Biocompatibility of biomaterials and host response to structural implants are examined. Quantitative treatment of biomechanical issues and constitutive relationships of materials are covered in order to design implants for structural function. Material selection for load bearing applications including reconstructive surgery, orthopedics, dentistry, and cardiology are addressed.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 2 hours of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Also listed as: MEC ENG C215

BIO ENG C223 Polymer Engineering 3 Units
A survey of the structure and mechanical properties of advanced engineering polymers. Topics include rubber elasticity, viscoelasticity, mechanical properties, yielding, deformation, and fracture mechanisms of various classes of polymers. The course will discuss degradation schemes of polymers and long-term performance issues. The class will include polymer applications in bioengineering and medicine.

Rules & Requirements

Prerequisites: Civil Engineering 130, Engineering 45

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Also listed as: MEC ENG C223

BIO ENG 224 Basic Principles of Drug Delivery 3 Units
This course focuses on providing students with the foundations needed to understand contemporary literature in drug delivery. Concepts in organic chemistry, biochemistry, and physical chemistry needed to understand current problems in drug delivery are emphasized.
Objectives & Outcomes

Course Objectives: The goal of this course is to give students the ability to understand problems in drug delivery. Emphasis is placed on the design and synthesis of new molecules for drug delivery.

Student Learning Outcomes: At the completion of this course students should be able to design new molecules to solve drug delivery problems.

Rules & Requirements

Prerequisites: CHEM 3A and MCB C100A/CHEM C130

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Murthy

BIO ENG 231 Introduction to Computational Molecular and Cellular Biology 4 Units
Topics include computational approaches and techniques to gene structure and genome annotation, sequence alignment using dynamic programming, protein domain analysis, RNA folding and structure prediction, RNA sequence design for synthetic biology, genetic and biochemical pathways and networks, UNIX and scripting languages, basic probability and information theory. Various "case studies" in these areas are reviewed and web-based computational biology tools will be used by students and programming projects will be given.
Rules & Requirements

Credit Restrictions: Students will receive no credit for 231 after taking 131.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Holmes

BIO ENG 232 Genetic Devices 4 Units
This graduate-level course is a comprehensive survey of genetic devices. These DNA-based constructs are comprised of multiple "parts" that together encode a higher-level biological behavior and perform useful human-defined functions. Such constructs are the engineering target for most projects in synthetic biology. Included within this class of constructs are genetic circuits, sensors, biosynthetic pathways, and microbiological functions.
Rules & Requirements

Prerequisites: Engineering 7 or Computer Science 61A, Mathematics 54, Chemistry 3A, and Chemistry C130/Molecular and Cell Biology C100A

Credit Restrictions: Students will receive no credit for 232 after taking 132.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Anderson

BIO ENG 235 Frontiers in Microbial Systems Biology 4 Units
This course is aimed at graduate and advanced undergraduate students from the (bio) engineering and chemo-physical sciences interested in a research-oriented introduction to current topics in systems biology. Focusing mainly on two well studied microbiological model systems--the chemotaxis network and Lambda bacteriophage infection--the class systematically introduces key concepts and techniques for biological network deduction, modelling, analysis, evolution and synthetic network design. Students analyze the impact of approaches from the quantitative sciences--such as deterministic modelling, stochastic processes, statistics, non-linear dynamics, control theory, information theory, graph theory, etc.--on understanding biological processes, including (stochastic) gene regulation, signalling, network evolution, and synthetic network design. The course aims identify unsolved problems and discusses possible novel approaches while encouraging students to develop ideas to explore new directions in their own research.
Rules & Requirements

Prerequisites: Designed for graduates with background in differential equations and probability. Course work in molecular cell biology or biochemistry helpful

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Arkin, Bischofs-Pfeifer, Wolf

BIO ENG 241 Probabilistic Modeling in Computational Biology 4 Units
This course reviews the statistical and algorithmic foundations of bioinformatics viewed through the lens of paleogenetics, the science of "Jurassic Park", i.e., the reconstruction of ancient genes and genomes by reverse Bayesian inference under various stochastic models of molecular evolution. Such methods, first proposed in the 1960s by Linus Pauling (and others), are now in reach of practical experimentation due to the falling cost of DNA synthesis technology. Applications of these methods are granting insight into the origin of life and of the human species, and may be powerful tools of synthetic biology. Lectures will review the theoretical content; homework and laboratory exercises will involve writing and applying programs for computational reconstruction of ancient protein and DNA sequences and other measurably evolving entities, both biological (e.g., gene families) and otherwise (e.g., natural language).
Rules & Requirements

Prerequisites: Mathematics 53 and 54 or equivalent; Molecular and Cell Biology C100A/C102 or equivalent; programming class or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 3 hours of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Holmes

BIO ENG 243 Computational Methods in Biology 4 Units
An introduction to biophysical simulation methods and algorithms, including molecular dynamics, Monte Carlo, mathematical optimization, and "non-algorithmic" computation such as neural networks. Various case studies in applying these areas in the areas of protein folding, protein structure prediction, drug docking, and enzymatics will be covered. Core Specialization: Core B (Informatics and Genomics); Core D (Computational Biology); Bioengineering Content: Biological.
Rules & Requirements

Prerequisites: Mathematics 53 and 54; programming experience preferred but not required

Credit Restrictions: Students will receive no credit for 243 after taking 143.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 2 hours of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Head-Gordon

BIO ENG C244 Introduction to Protein Informatics 4 Units
This course will introduce students to the fundamentals of molecular biology, and to the bioinformatics tools and databases used for the prediction of protein function and structure. It is designed to impart both a theoretical understanding of popular computational methods, as well as some experience with protein sequence analysis methods applied to real data. This class includes no programming, and no programming background required.
Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Sjolander

Also listed as: PLANTBI C244

BIO ENG C244L Protein Informatics Laboratory 3 Units
This course is intended to introduce students to a variety of bioinformatics techniques that are used to predict protein function and structure. It is designed to be taken concurrently with C244 (which provides the theoretical foundations for the methods used in the laboratory class), although students can petition to take this laboratory course separately. No programming is performed in this class, and no prior programming experience is required.
Rules & Requirements

Prerequisites: Bioengineering C244/Plant and Microbial Biology C244

Hours & Format

Fall and/or spring: 15 weeks - 9 hours of laboratory and 1 hour of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Sjolander

Also listed as: PLANTBI C244L

BIO ENG 247 Principles of Synthetic Biology 4 Units
The field of synthetic biology is quickly emerging as potentially one of the most important and profound ways by which we can understand and manipulate our physical world for desired purposes. In this course, the field and its natural scientific and engineering basis are introduced. Relevant topics in cellular and molecular biology and biophysics, dynamical and engineering systems, and design and operation of natural and synthetic circuits are covered in a concise manner that then allows the student to begin to design new biology-based systems.
Rules & Requirements

Prerequisites: MATH 53 and 54; Molecular and Cell Biology C100A/ Chemistry C130; or consent of instructor

Credit Restrictions: Students will receive no credit for 247 after taking 147.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Arkin

BIO ENG 248 Bioenergy and Sustainable Chemical Synthesis: Metabolic Engineering and Synthetic Biology Approaches 3 Units
This course will cover metabolic engineering and the various synthetic biology approaches for optimizing pathway performance. Use of metabolic engineering to produce biofuels and general "green technology" will be emphasized since these aims are currently pushing these fields. The course is meant to be a practical guide for metabolic engineering and the related advances in synthetic biology as well the related industrial research and opportunities.
Rules & Requirements

Prerequisites: Chemistry 3A and Molecular and Cell Biology C100A/ Chemistry C130A or equivalent

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Dueber

BIO ENG C250 Nanomaterials in Medicine 3 Units
The course is designed for graduate students interested in the emerging field of nanomedicine. The course will involve lectures, literature reviews and proposal writing. Students will be required to formulate a nanomedicine research project and write an NIH-style proposal during the course. The culmination of this project will involve a mock review panel in which students will serve as peer reviewers to read and evaluate the proposals.
Objectives & Outcomes

Course Objectives: To review the current literature regarding the use of nanomaterials in medical applications; (2) To describe approaches to nanomaterial synthesis and surface modification; (3) To understand the interaction of nanomaterials with proteins, cells and biological systems; (4) To familiarize students with proposal writing and scientific peer review.

Student Learning Outcomes: Students should be able to (1) identify the important properties of metal, polymer and ceramic nanomaterials used in healthcare; (2) understand the role of size, shape and surface chemistry of nanomaterials in influencing biological fate and performance; (3) understand common methods employed for surface modification of nanomaterials; (4) comprehend the range of cell-nanomaterial interactions and methods for assaying these interactions; (5) read and critically review the scientific literature relating to nanomedicine; (6) formulate and design an experimental nanomedicine research project; (7) understand the principles of the peer review system.

Rules & Requirements

Prerequisites: Graduate Standing

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Messersmith

Also listed as: MAT SCI C250

BIO ENG 251 Micro/Nanofluidics for Bioengineering and Lab-On-A-Chip 4 Units
Introduction and in-depth treatment of theory relevant to fluid flow in microfluidic and nanofluidic systems supplemented by critical assessment of recent applications drawn from the literature. Topics include low Reynolds Number flow, mass transport including diffusion phenomena, and emphasis on electrokinetic systems and bioanalytical applications of said phenomena.

Rules & Requirements

Prerequisites: Chemistry 3B, PHYSICS 7B, Bioengineering 102, or Mechanical Engineering 106 or consent of instructor

Credit Restrictions: Students will receive no credit for 251 after taking 151.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Herr

BIO ENG C261 Medical Imaging Signals and Systems 4 Units
Biomedical imaging is a clinically important application of engineering, applied mathematics, physics, and medicine. In this course, we apply linear systems theory and basic physics to analyze X-ray imaging, computerized tomography, nuclear medicine, and MRI. We cover the basic physics and instrumentation that characterizes medical image as an ideal perfect-resolution image blurred by an impulse response. This material could prepare the student for a career in designing new medical imaging systems that reliably detect small tumors or infarcts.

Objectives & Outcomes

Course Objectives: • understand how 2D impulse response or 2D spatial frequency transfer function (or Modulation Transfer Function) allow one to quantify the spatial resolution of an imaging system.
• understand 2D sampling requirements to avoid aliasing
• understand 2D filtered backprojection reconstruction from projections based on the projection-slice theorem of Fourier Transforms
• understand the concept of image reconstruction as solving a mathematical inverse problem.
• understand the limitations of poorly conditioned inverse problems and noise amplification
• understand how diffraction can limit resolution---but not for the imaging systems in this class
• understand the hardware components of an X-ray imaging scanner
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• understand the physics and hardware limits to spatial resolution of an X-ray imaging system
• understand tradeoffs between depth, contrast, and dose for X-ray sources
• understand resolution limits for CT scanners
• understand how to reconstruct a 2D CT image from projection data using the filtered backprojection algorithm
• understand the hardware and physics of Nuclear Medicine scanners
• understand how PET and SPECT images are created using filtered backprojection
• understand resolution limits of nuclear medicine scanners
• understand MRI hardware components, resolution limits and image reconstruction via a 2D FFT
• understand how to construct a medical imaging scanner that will achieve a desired spatial resolution specification.

Student Learning Outcomes: • students will be tested for their understanding of the key concepts above
• undergraduate students will apply to graduate programs and be admitted
• students will apply this knowledge to their research at Berkeley, UCSF, the national labs or elsewhere
• students will be hired by companies that create, sell, operate or consult in biomedical imaging

Rules & Requirements

Prerequisites: El Eng 20N and Engineering 7 or equivalent. Knowledge of Matlab or linear algebra assumed

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Conolly

Also listed as: EL ENG C261

BIO ENG 263 Principles of Molecular and Cellular Biophotonics 4 Units
Topics in the emerging field of biophotonics with an emphasis on fluorescence spectroscopy, biosensors, and devices for optical imaging and detection of biomolecules. The course will cover the photophysics and photochemistry of organic molecules, the design and characterization of biosensors, and their applications within diverse environments, ranging from the detection of single molecules in vitro and in cells to studies of detection, diagnosis, and monitoring of specific health conditions and disease.

Rules & Requirements

Prerequisites: 102 or consent of instructor, and Chemistry 3A and PHYSICS 7B

Credit Restrictions: Students will receive no credit for 263 after taking 163.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Marriott

BIO ENG 263L Molecular and Cellular Biophotonics Laboratory 4 Units
This course provides undergraduate and graduate bioengineering students with an opportunity to acquire essential experimental skills in fluorescence spectroscopy and the design, evaluation, and optimization of optical biosensors for quantitative measurements of proteins and their targets. Groups of students will be responsible for the research, design, and development of a biosensor or diagnostic device for the detection, diagnosis, and monitoring of a specific biomarker(s).

Rules & Requirements

Prerequisites: 263; experience in a research lab and consent of instructor

Credit Restrictions: Students will receive no credit for 263L after taking 163L.

Hours & Format

Fall and/or spring: 15 weeks - 6 hours of laboratory and 2 hours of discussion per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructor: Marriott

BIO ENG C265 Principles of Magnetic Resonance Imaging 4 Units
Fundamentals of MRI including signal-to-noise ratio, resolution, and contrast as dictated by physics, pulse sequences, and instrumentation. Image reconstruction via 2D FFT methods. Fast imaging reconstruction via convolution-back projection and gridding methods and FFTs. Hardware for modern MRI scanners including main field, gradient fields, RF coils, and shim supplies. Software for MRI including imaging methods such as 2D FT, RARE, SSFP, spiral and echo planar imaging methods.

Objectives & Outcomes

Course Objectives: Graduate level understanding of physics, hardware, and systems engineering description of image formation, and image reconstruction in MRI. Experience in Imaging with different MR Imaging systems. This course should enable students to begin graduate level research at Berkeley (Neuroscience labs, EECS and Bioengineering), LBNL or at UCSF (Radiology and Bioengineering) at an advanced level and make research-level contribution

Rules & Requirements

Prerequisites: Either Electrical Engineering 120 or Bioengineering C165/Electrical Engineering C145B or consent of instructor

Credit Restrictions: Students will receive no credit for Bioengineering C265/El Engineering C225E after taking El Engineering 265.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Lustig, Conolly

Also listed as: EL ENG C225E

BIO ENG 280 Ethical and Social Issues in Translational Medicine 1 Unit
This class is designed to introduce MTM students to their professional responsibilities
as engineers and translational scientists. By the end of it, students will have
experience communicating their ideas appropriately and effectively to their peers,
their superiors, and those whom they manage or mentor. We will also discuss
methods for having a successful graduate school experience - choosing and working
on a project and preparing to meet post-graduate goals. Finally, some of the ethical
challenges likely to be met by a working bioengineer will be explored.
While this syllabus is meant to be an accurate description of the course and its content,
it may be modified at the instructor's discretion.

Objectives & Outcomes

Course Objectives: Objectives
Communications skills and best practices
Research ethics in translational medicine
Professional development for MTM graduate students

Student Learning Outcomes: MTM students will become aware of ethical issues commonly confronted in
translational medicine and learn how to evaluate and act accordingly. They will also
leave capable of independently considering new ethical issues that arise during their
careers.

Rules & Requirements

Prerequisites: Open only to students in the Masters of Translational Medicine Graduate program

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Johnson, Terry

BIO ENG C280 Introduction to Nano-Science and Engineering 3 Units
A three-module introduction to the fundamental topics of Nano-Science and Engineering (NSE) theory and research within chemistry, physics, biology, and engineering. This course includes quantum and solid-state physics; chemical synthesis, growth fabrication, and characterization techniques; structures and properties of semiconductors, polymer, and biomedical materials on nanoscales; and devices based on nanostructures. Students must take this course to satisfy the NSE Designated Emphasis core requirement.

Rules & Requirements

Prerequisites: Major in physical science such as chemistry, physics, etc., or engineering; consent of advisor or instructor

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Gronsky, S.W. Lee, Wu

Also listed as: MAT SCI C261/NSE C201/PHYSICS C201

BIO ENG C281 The Berkeley Lectures on Energy: Energy from Biomass 3 Units
After an introduction to the different aspects of our global energy consumption, the course will focus on the role of biomass. The course will illustrate how the global scale of energy guides the biomass research. Emphasis will be places on the integration of the biological aspects (crop selection, harvesting, storage, and distribution, and chemical composition of biomass) with the chemical aspects to convert biomass to energy. The course aims to engage students in state-of-art research.

Rules & Requirements

Prerequisites: BIOLOGY 1A; Chemistry 1B or 4B, Mathematics 1B

Repeat rules: Repeatable when topic changes with consent of instructor.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Bell, Blanch, Clark, Smit, C. Somerville

Also listed as: CHEM C238/CHM ENG C295A/PLANTBI C224

BIO ENG 290 Advanced Topics in Bioengineering 1 - 4 Units
This course covers current topics of research interest in bioengineering. The course content may vary from semester to semester.
Rules & Requirements

Prerequisites: Consent of instructor

Credit Restrictions: One hour of lecture per week per unit.

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

BIO ENG C290D Advanced Technical Communication: Proposals, Patents, and Presentations 3 Units
This course will help the advanced Ph.D. student further develop critically important technical communication traits via a series of lectures, interactive workshops, and student projects that will address the structure and creation of effective research papers, technical reports, patents, proposals, business plans, and oral presentations. One key concept will be the emphasis on focus and clarity--achieved through critical thinking regarding objectives and context. Examples will be drawn primarily from health care and bioengineering multidisciplinary applications.
Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

Instructors: Keaveny, Pruitt

Also listed as: MEC ENG C290X

BIO ENG 296 MTM Capstone Project 3 Units
Members of the MTM Program Committee will help design several capstone projects in collaboration with clinical, academic, and/or industry partners, aiming to incorporate emerging technologies, industry requirements, and the potential for significant economic or social impact with regard to medicine and health care. All projects will be designed and vetted by the MTM Program Committee and in consultation with the MTM Advisory Board. For each selected project, an Academic Senate member from the Department of Bioengineering or BTS will serve as research adviser.
Objectives & Outcomes

Course Objectives: The objective of the one year professional MTM program is to develop engineering leaders who can synthesize the technical, environmental, economic, and social issues involved in the design and operation of complex engineering devices, systems, and organizations. Students will develop and demonstrate this skill at synthesis through the capstone project.

Student Learning Outcomes: Projects will provide practical instruction and experience in solving real problems in translational medicine, and it is anticipated that some will lead to innovations with commercial potential. This experience, undertaken by each student as a member of a team and marked by extensive interaction with faculty, peers, and industry partners, enables the student to integrate the leadership and technical dimensions of the professional MTM curriculum.

Rules & Requirements

Prerequisites: Graduate status in the MTM program

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 9-9 hours of independent study per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Letter grade.

Instructors: Li, Song

BIO ENG 298 Group Studies, Seminars, or Group Research 1 - 8 Units
Advanced studies in various subjects through special seminars on topics to be selected each year. Informal group studies of special problems, group participation in comprehensive design problems, or group research on complete problems for analysis and experimentation.
Rules & Requirements

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1-8 hours of directed group study per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

BIO ENG 299 Individual Study or Research 1 - 12 Units
Investigations of advanced problems in bioengineering.
Rules & Requirements

Prerequisites: Graduate standing

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

BIO ENG N299 Individual Study or Research 1 - 6 Units
Investigations of advanced problems in bioengineering.
Rules & Requirements

Prerequisites: Graduate standing

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Summer:
6 weeks - 2.5-15 hours of independent study per week
8 weeks - 2-11.5 hours of independent study per week

Additional Details

Subject/Course Level: Bioengineering/Graduate

Grading: Offered for satisfactory/unsatisfactory grade only.

BIO ENG 301 Teaching Techniques for Bioengineering 1 Unit
Weekly seminars and discussions of effective teaching techniques. Use of educational objectives, alternative forms of instruction, and special techniques for teaching key concepts and techniques in bioengineering. Course is intended to orient new graduate student instructors to teaching in the Bioengineering department at Berkeley.
Rules & Requirements

Prerequisites: Graduate standing

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of seminar per week

Additional Details

Subject/Course Level: Bioengineering/Professional course for teachers or prospective teachers

Grading: Offered for satisfactory/unsatisfactory grade only.

Instructor: Johnson