

Bioengineering

Bachelor of Science (BS)

Rated one of the top 10 Bioengineering undergraduate programs in the country, Bioengineering at Berkeley is a multidisciplinary major intended for academically strong students who excel in the physical sciences, mathematics, and biology. Coursework provides a strong foundation in engineering and the biological sciences, with the freedom to explore a variety of topics and specialize in advanced areas of research. All students benefit from intensive group design work, either through a senior capstone project (<http://bioeng.berkeley.edu/undergrad/capstone>) or through independent research in faculty laboratories. The major features small, specialized upper division courses, and direct interaction with faculty.

The stimulating environment of Berkeley offers a wealth of opportunity for learning, research, service, and community involvement, and provides dedicated students the knowledge and skills to become the next leaders in bioengineering.

Course of Study Overview

The department offers one Bioengineering major, with several concentrations. For detailed descriptions of these concentrations, please see the department's website (<http://bioeng.berkeley.edu/undergrad/program/concentrations>).

- Biomedical Devices
- Biomedical Imaging
- Cell & Tissue Engineering
- Computational Bioengineering
- Synthetic Biology

Admission to the Major

Prospective undergraduates of the College of Engineering will apply for admission to a specific program in the college. For further information, please see the College of Engineering's website (<http://coe.berkeley.edu/students/prospective-students/admissions.html>).

Admission to engineering via a Change of College application for current UC Berkeley students is not guaranteed. For further information regarding a Change of College to Engineering, please see the college's website (<http://coe.berkeley.edu/students/current-undergraduates/change-of-college>).

Minor Program

The department offers a minor in Bioengineering that is open to all students who are not majoring in bioengineering and who have completed the necessary prerequisites for the minor. For further information regarding the prerequisites, please see the Minor Requirements tab on this page.

Joint Major

The Department of Bioengineering also offers a joint major with the Department of Materials Science and Engineering, for students who have an interest in the field of biomaterials. For further information regarding this program, please see the Bioengineering/Materials Science and Engineering joint major (<http://guide.berkeley.edu/archive/2017-18/>

[undergraduate/degree-programs/bioengineering-materials-science-engineering-joint-major](#)) page in this Guide.

In addition to the University, campus, and college requirements, students must fulfill the below requirements specific to their major program.

General Guidelines

1. All technical courses taken in satisfaction of major requirements must be taken for a letter grade.
2. No more than one upper division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
3. A minimum overall grade point average (GPA) of 2.0 is required for all work undertaken at UC Berkeley.
4. A minimum GPA of 2.0 is required for all technical courses taken in satisfaction of major requirements.

For information regarding residence requirements and unit requirements, please see the College Requirements tab.

For a detailed plan of study by year and semester, please see the Plan of Study tab.

Students are advised to consult the approved concentrations (<http://bioeng.berkeley.edu/undergrad/program/concentrations>) to identify an appropriate course sequence for bioengineering specialty areas and may also design their own program that meets with the below requirements with permission from their faculty adviser. Regular consultation with an adviser is strongly encouraged. Recommended courses for each concentration can be found on the department's website (<http://bioeng.berkeley.edu/undergrad/program/concentrations>).

Summary of Major Requirements

The requirements for the Bioengineering Bachelor's Degree is a minimum of 120 semester units and must include the following:

1. A minimum of 24 total (<http://bioeng.berkeley.edu/undergrad/program/#one>)¹ (<http://bioeng.berkeley.edu/undergrad/program/#one>) upper-division Bioengineering course units (including at least two bioengineering fundamentals (<http://bioeng.berkeley.edu/undergrad/program/biofundamentals>) courses, a bioengineering design (<http://bioeng.berkeley.edu/undergrad/program/design>) course, and a bioengineering laboratory (<http://bioeng.berkeley.edu/undergrad/program/bioelabs>) course)
2. A minimum of 36 total (<http://bioeng.berkeley.edu/undergrad/program/#two>)² upper-division units in technical topics (<http://bioeng.berkeley.edu/undergrad/program/techelect>) courses
3. A minimum of 48 total units in engineering courses³
4. Six courses (of at least 3 units each) selected to meet the college's current humanities and social sciences requirements (<http://engineering.berkeley.edu/student-services/degree-requirements/humanities-and-social-sciences>)
5. One course with a substantial ethics component (<http://bioeng.berkeley.edu/undergrad/program/ethics>)
6. BioE 10⁴, 11, 25, and 26
7. Math 1A, 1B, 53, and 54
8. Physics 7A and 7B
9. Chem 1A & 1AL (or 4A), and 3A & 3AL (or 12A)

10. E7 or CS 61A

Lower Division Requirements

BIO ENG 10	Introduction to Biomedicine for Engineers (Junior transfers exempt from requirement) ⁴	4
BIO ENG 11	Engineering Molecules 1	3
BIO ENG 25	Careers in Biotechnology	1
BIO ENG 26	Introduction to Bioengineering	1
MATH 1A	Calculus	4
MATH 1B	Calculus	4
MATH 53	Multivariable Calculus	4
MATH 54	Linear Algebra and Differential Equations	4
PHYSICS 7A	Physics for Scientists and Engineers	4
PHYSICS 7B	Physics for Scientists and Engineers	4
CHEM 1A & 1AL	General Chemistry and General Chemistry Laboratory	4
or CHEM 4A	General Chemistry and Quantitative Analysis	
CHEM 3A & 3AL	Chemical Structure and Reactivity and Organic Chemistry Laboratory	5
or CHEM 12A	Organic Chemistry	
ENGIN 7	Introduction to Computer Programming for Scientists and Engineers	4
or COMPSCI 61A	The Structure and Interpretation of Computer Programs	

¹ Not including BioE 100, 198, 199, any other seminar-style courses or group meetings, or any course taken on a P/NP basis. Up to 4 research units (e.g., BioE 196) can be included in this total.

² Not including BioE 100, 198, 199, any other seminar-style courses or group meetings, or any course taken on a P/NP basis. Up to 8 research units can be included in this total.

³ Not including: any course taken on a P/NP basis; courses numbered 24, 39, 84; BioE 100; ChemE 185; CS 70, C79, 195, H195; Des Inv courses (except Des Inv 15, 22, 90E, 190E); Engin 125, 157AC, 180; IEOR 95, 172, 185, 186, 190 series, 191, 192, 195; ME 191AC, 190K, 191K. There is no limit to the number of letter-graded research units that can be applied to the 48 engineering units.

⁴ Juniors transfers are exempted from taking BioE 10.

Upper Division Requirements

A total of 24 upper division Bioengineering units, including the following: ¹ 24

Bioengineering Fundamentals: Choose two courses from list below.

Bioengineering Lab Course: Choose one course from list below.

Bioengineering Design Project or Research: Choose one course from list below.

Technical Topics: a minimum of 36 total upper-division units from list below (includes 24 units of upper division Bioengineering courses). ¹ 36

Ethics Requirement: Choose one course from list below. 3-4

Bioengineering Fundamentals

Choose two courses from the following:

BIO ENG 101	Instrumentation in Biology and Medicine	4
BIO ENG 102	Biomechanics: Analysis and Design	4

BIO ENG 103	Engineering Molecules 2 (Students will receive no credit for Bioengineering 103 after completing Chemistry 120B, Molecular Cell Biology C100A/ Chemistry C130, or Physics 137)	4
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BIO ENG 104	Biological Transport Phenomena	4
BIO ENG 110	Biomedical Physiology for Engineers	4
BIO ENG 131	Introduction to Computational Molecular and Cell Biology	4
BIO ENG 144L	Protein Informatics Laboratory	3

Bioengineering Lab

Choose one course from the following:

BIO ENG 101	Instrumentation in Biology and Medicine	4
BIO ENG 115	Cell Biology for Engineers	4
BIO ENG 121L	BioMems and BioNanotechnology Laboratory	4
BIO ENG 131	Introduction to Computational Molecular and Cell Biology	4
BIO ENG C136L	Laboratory in the Mechanics of Organisms	3
BIO ENG 140L	Synthetic Biology Laboratory	4
BIO ENG 144L	Protein Informatics Laboratory	3
BIO ENG 163L	Molecular and Cellular Biophotonics Laboratory	4
BIO ENG 168L	Practical Light Microscopy	3

Technical Topics

Choose 36 upper division units from the following:

Any Bioengineering 100-level or 200-level class ¹ 3-4

CHEM 12B	Organic Chemistry	5
CHEM 120A	Physical Chemistry	3
CHEM 120B	Physical Chemistry	3
CHEM 135	Chemical Biology	3
CHM ENG 140	Introduction to Chemical Process Analysis	4
CHM ENG 141	Chemical Engineering Thermodynamics	4
CHM ENG 150A	Transport Processes	4
CHM ENG 150B	Transport and Separation Processes	4
CHM ENG 170A	Biochemical Engineering	3
CHM ENG 170B	Biochemical Engineering	3
CHM ENG C170L	Biochemical Engineering Laboratory	3
CHM ENG 171	Transport Phenomena	3
CHM ENG C178	Polymer Science and Technology	3
COMPSCI 160	User Interface Design and Development	4
COMPSCI 161	Computer Security	4
COMPSCI 169	Software Engineering	4
COMPSCI 170	Efficient Algorithms and Intractable Problems	4
COMPSCI 176	Algorithms for Computational Biology	4
COMPSCI 186	Introduction to Database Systems	4
COMPSCI 188	Introduction to Artificial Intelligence	4
COMPSCI 189	Introduction to Machine Learning	4
COMPSCI C191	Quantum Information Science and Technology	3
or PHYSICS C191	Quantum Information Science and Technology	
ENGIN 40	Engineering Thermodynamics	4
EL ENG 105	Microelectronic Devices and Circuits	4
EL ENG 117	Electromagnetic Fields and Waves	4

EL ENG 118	Introduction to Optical Engineering	3	MCELLBI 166	Biophysical Neurobiology	3
EL ENG 120	Signals and Systems	4	MEC ENG 102B	Mechatronics Design	4
EL ENG 123	Digital Signal Processing	4	MEC ENG 104	Engineering Mechanics II	3
EL ENG 126	Probability and Random Processes	4	MEC ENG 106	Fluid Mechanics	3
EECS 127	Optimization Models in Engineering	4	MEC ENG 109	Heat Transfer	3
EL ENG C128	Feedback Control Systems	4	MEC ENG 118	Introduction to Nanotechnology and Nanoscience	3
EL ENG 142	Integrated Circuits for Communications	4	MEC ENG 119	Introduction to MEMS (Microelectromechanical Systems)	3
EL ENG 143	Microfabrication Technology	4	MEC ENG 132	Dynamic Systems and Feedback	3
EL ENG 147	Introduction to Microelectromechanical Systems (MEMS)	3	MEC ENG 133	Mechanical Vibrations	3
EL ENG C149	Course Not Available	4	MEC ENG 167	Microscale Fluid Mechanics	3
EL ENG 192	Mechatronic Design Laboratory	4	MEC ENG 185	Introduction to Continuum Mechanics	3
MATH 110	Linear Algebra	4	MAT SCI 102	Bonding, Crystallography, and Crystal Defects	3
INTEGBI 115	Introduction to Systems in Biology and Medicine	4	MAT SCI 103	Phase Transformations and Kinetics	3
INTEGBI 127L	Motor Control with Laboratory	3	MAT SCI 104	Materials Characterization	4
INTEGBI 131	General Human Anatomy	3	MAT SCI 111	Properties of Electronic Materials	4
INTEGBI 132	Survey of Human Physiology	4	MAT SCI 112	Corrosion (Chemical Properties)	3
INTEGBI 135	The Mechanics of Organisms	4	MAT SCI 113	Mechanical Behavior of Engineering Materials	3
INTEGBI 148	Comparative Animal Physiology	3	MAT SCI 130	Experimental Materials Science and Design	3
INTEGBI 161	Population and Evolutionary Genetics	4	MAT SCI 151	Polymeric Materials	3
INTEGBI 163	Molecular and Genomic Evolution	3	NUC ENG 101	Nuclear Reactions and Radiation	4
IND ENG 160	Nonlinear and Discrete Optimization	3	NUC ENG 107	Introduction to Imaging	3
IND ENG 162	Linear Programming and Network Flows	3	NUC ENG 162	Radiation Biophysics and Dosimetry	3
IND ENG 172	Probability and Risk Analysis for Engineers	3	PHYSICS 110A	Electromagnetism and Optics	4
MATH 110	Linear Algebra	4	PHYSICS 112	Introduction to Statistical and Thermal Physics	4
MATH 118	Fourier Analysis, Wavelets, and Signal Processing	4	PHYSICS 137A	Quantum Mechanics	4
MATH 127	Mathematical and Computational Methods in Molecular Biology	4	PHYSICS 177	Principles of Molecular Biophysics	3
MATH 128A	Numerical Analysis	4	STAT 133	Concepts in Computing with Data	3
MATH 170	Mathematical Methods for Optimization	4	STAT 134	Concepts of Probability	4
MCELLBI C100A	Biophysical Chemistry: Physical Principles and the Molecules of Life (Students should take BioE 103 instead of MCB C100A, credit applied for those who have already taken C100A before F17) ²	4	STAT 135	Concepts of Statistics	4
MCELLBI 100B	Biochemistry: Pathways, Mechanisms, and Regulation	4	STAT 150	Stochastic Processes	3
MCELLBI 102	Survey of the Principles of Biochemistry and Molecular Biology	4			
MCELLBI 110	Molecular Biology: Macromolecular Synthesis and Cellular Function	4			
MCELLBI C112	General Microbiology	4			
or PLANTBI C112	General Microbiology				
MCELLBI 130	Cell and Systems Biology	4			
MCELLBI 132	Biology of Human Cancer	4			
MCELLBI 133L	Physiology and Cell Biology Laboratory	4			
MCELLBI 136	Physiology	4			
MCELLBI 140	General Genetics	4			
MCELLBI 140L	Genetics Laboratory	4			
MCELLBI C148	Microbial Genomics and Genetics	4			
or PLANTBI C148	Microbial Genomics and Genetics				
MCELLBI 150	Molecular Immunology	4			
MCELLBI 160	Cellular and Molecular Neurobiology	4			
MCELLBI 160L	Neurobiology Laboratory	4			

¹ Not including BioE 100, 198, 199, any other seminar-style courses or group meetings, or any course taken on a P/NP basis. Up to 4 research units (e.g., BioE 196) can be included in this total.

² Students should take BioE 103 instead of MCB C100A. Credit applied for those who have already taken C100A before F17.

Bioengineering Design Project or Research

Choose one course from the following:

BIO ENG 101	Instrumentation in Biology and Medicine	4
BIO ENG 121L	BioMems and BioNanotechnology Laboratory	4
BIO ENG 140L	Synthetic Biology Laboratory	4
BIO ENG 145	Intro to Machine Learning in Computational Biology	4
BIO ENG 168L	Practical Light Microscopy	3
BIO ENG 192	Senior Design Projects	4
BIO ENG H194	Honors Undergraduate Research	3-4
BIO ENG 196	Undergraduate Design Research	4

Ethics

All Ethics courses of 3 units or more fulfill one Humanities/Social Sciences requirement.

Choose one course from the following:

BIO ENG 100	Ethics in Science and Engineering (Recommended.)	3
ENGIN 125	Ethics, Engineering, and Society	3
ENGIN 157AC	Engineering, The Environment, and Society	4
or IAS 157AC	Engineering, The Environment, and Society	
ESPM 161	Environmental Philosophy and Ethics	4
ESPM 162	Health, Medicine, Society and Environment	4
L & S 160B	Effective Personal Ethics for the Twenty-First Century	3
PHILOS 104	Ethical Theories	4
PHILOS 107	Moral Psychology	4

Minor programs are areas of concentration requiring fewer courses than an undergraduate major. These programs are optional, but can provide depth and breadth to a UC Berkeley education. The College of Engineering does not offer additional time to complete a minor, but it is usually possible to finish within the allotted time with careful course planning. Students are encouraged to meet with their ESS adviser to discuss the feasibility of completing a minor program.

All the engineering departments offer minors. Students may also consider pursuing a minor in another school or college.

Applicants can apply after second semester sophomore year and up to first semester senior year. Applicants who have completed all of the courses prior to applying will not be accepted into the minor; **students must apply first.**

General Guidelines

1. All courses taken to fulfill the minor requirements must be taken for graded credit.
2. A minimum technical grade point average of 3.0 (math, science & engineering courses) is required for acceptance into the minor program.
3. A minimum grade point average (GPA) of 2.0 is required for courses used to fulfill the minor requirements.
4. No more than one upper division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
5. Completion of the minor program cannot delay a student's graduation.
6. Please see more details at the department website (<http://bioeng.berkeley.edu/undergrad/bioeminor>).

Procedure

- **Students should apply first, before taking courses.** Applications are available in 306 Stanley Hall or on the department website (<http://bioeng.berkeley.edu/undergrad/bioeminor>). Completed applications should be returned to 306 Stanley Hall. Please include an unofficial copy of your transcript with the application.
- The department will approve or deny the application. If approved, the department will contact the student via email advising of the decision.
- Upon completion of the requirements for the minor, the student should complete the Confirmation of Completion form ([http://](http://bioeng.berkeley.edu/undergrad/bioeminor)

bioeng.berkeley.edu/undergrad/bioeminor). Please submit the form along with an unofficial transcript to 306 Stanley Hall.

- The department will verify the completion of the minor and send the original form to the Office of the Registrar. (Note: for graduating seniors, this must be done no later than two weeks after the end of the term.)
- A notation in the memorandum section of the student's transcript will indicate completion of the minor.

Recommended Preparation

The upper division requirements for the BioE minor require competency in subject matters covered in the following recommended courses.

CHEM 3A	Chemical Structure and Reactivity	3
MATH 53	Multivariable Calculus	4
MATH 54	Linear Algebra and Differential Equations	4
PHYSICS 7A	Physics for Scientists and Engineers ¹	4
PHYSICS 7B	Physics for Scientists and Engineers ¹	4

- ¹ Students who have already taken PHYSICS 8A and PHYSICS 8B may substitute them for these courses.

Upper Division Minor Requirements

- One course from the BioE Fundamentals List (<http://guide.berkeley.edu/archive/2017-18/undergraduate/degree-programs/bioengineering/#majorrequirementstext>)
- Two upper division courses from the Technical Topics List (<http://guide.berkeley.edu/archive/2017-18/undergraduate/degree-programs/bioengineering/#majorrequirementstext>)
- Two upper division bioengineering courses.

Students in the College of Engineering must complete no fewer than 120 semester units with the following provisions:

1. Completion of the requirements of one engineering major program (<http://engineering.berkeley.edu/academics/undergraduate-programs>) study.
2. A minimum overall grade point average of 2.00 (C average) and a minimum 2.00 grade point average in upper division technical coursework required of the major.
3. The final 30 units and two semesters must be completed in residence in the College of Engineering on the Berkeley campus.
4. All technical courses (math, science and engineering), required of the major or not, must be taken on a letter graded basis (unless they are only offered P/NP).
5. Entering freshmen are allowed a maximum of eight semesters to complete their degree requirements. Entering junior transfers are allowed a maximum of four semesters to complete their degree requirements. (Note: junior transfers admitted missing three or more courses from the lower division curriculum are allowed five semesters.) Summer terms are optional and do not count toward the maximum. Students are responsible for planning and satisfactorily completing all graduation requirements within the maximum allowable semesters.
6. Adhere to all college policies and procedures (<http://engineering.berkeley.edu/academics/undergraduate-guide>) as they complete degree requirements.

7. Complete the lower division program before enrolling in upper division engineering courses.

Humanities and Social Science (H/SS) Requirement

To promote a rich and varied educational experience outside of the technical requirements for each major, the College of Engineering has a six-course Humanities and Social Sciences breadth requirement (<http://engineering.berkeley.edu/student-services/degree-requirements/humanities-and-social-sciences>), which must be completed to graduate. This requirement, built into all the engineering programs of study, includes two reading and composition courses (R&C), and four additional courses within which a number of specific conditions must be satisfied. Follow these guidelines to fulfill this requirement:

1. Complete a minimum of six courses from the approved Humanities/Social Sciences (H/SS) lists (<http://coe.berkeley.edu/hssreq>).
2. Courses must be a minimum of 3 semester units (or 4 quarter units).
3. Two of the six courses must fulfill the college's Reading and Composition (R&C) requirement. These courses must be taken for a letter grade (C- or better required) and must be completed by no later than the end of the sophomore year (fourth semester of enrollment). The first half of R&C, the "A" course, must be completed by the end of the freshman year; the second half of R&C, the "B" course, must be completed by no later than the end of the sophomore year. View a detailed list of courses (<http://ls-advise.berkeley.edu/requirement/rccourses.html>) that fulfill Reading and Composition requirements, or use the College of Letters and Sciences search engine (<http://ls-breadth.berkeley.edu>) to view R&C courses offered in a given semester.
4. The four additional courses must be chosen within College of Engineering guidelines from the H/SS lists (see below). These courses may be taken on a Pass/Not Passed basis (P/NP).
5. Two of the six courses must be upper division (courses numbered 100-196).
6. One of the six courses must satisfy the campus American Cultures requirement. For detailed lists of courses that fulfill American Cultures requirements, visit the American Cultures (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/engineering/american-cultures-requirement>) site.
7. A maximum of two exams (Advanced Placement, International Baccalaureate, or A-Level) may be used toward completion of the H/SS requirement. View the list of exams (<http://engineering.berkeley.edu/academics/undergraduate-guide/exams>) that can be applied toward H/SS requirements.
8. Courses may fulfill multiple categories. For example, if you complete CY PLAN 118AC (<http://guide.berkeley.edu/search/?P=CY%20PLAN%20118AC>) that would satisfy the American Cultures requirement and one upper division H/SS requirement.
9. No courses offered by any engineering department other than BIO ENG 100 (<http://guide.berkeley.edu/search/?P=BIO%20ENG%20100>), COMPSCI C79 (<http://guide.berkeley.edu/search/?P=COMPSCI%20C79>), ENGIN 125 (<http://guide.berkeley.edu/search/?P=ENGIN%20125>), ENGIN 157AC (<http://guide.berkeley.edu/search/?P=ENGIN%20157AC>), MEC ENG 191K (<http://guide.berkeley.edu/search/?P=MEC%20ENG%20191K>) and MEC ENG 191AC may be used to complete H/SS requirements.

10. Foreign language courses may be used to complete H/SS requirements. View the list of language options (<http://ls-advise.berkeley.edu/requirement/fl.html>).
11. Courses numbered 97, 98, 99, or above 196 may not be used to complete any H/SS requirement
12. The College of Engineering uses modified versions of five of the College of Letters and Science (L&S) breadth requirements lists to provide options to our students for completing the H/SS requirement. No courses on the L&S Biological Sciences or Physical Sciences breadth lists may be used to complete H/SS requirements. Within the guidelines above, choose courses from any of the lists below.
 - Arts and Literature (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/letters-science/breadth-requirement-arts-literature>)
 - Foreign Language (<http://ls-advise.berkeley.edu/requirement/fl.html>)
 - Historical Studies (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/letters-science/breadth-requirement-historical-studies>)
 - International Studies (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/letters-science/breadth-requirement-international-studies>)
 - Philosophy and Values (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/letters-science/breadth-requirement-philosophy-values>)
 - Social and Behavioral Studies (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/letters-science/breadth-requirement-social-behavioral-sciences>)

Class Schedule Requirements

- Minimum units per semester: 12.0.
- Maximum units per semester: 20.5.
- Minimum technical courses: College of Engineering undergraduates must enroll each semester in no fewer than two technical courses (of a minimum of 3 units each) required of the major program of study in which the student is officially declared. (Note: for most majors, normal progress will require enrolling in 3-4 technical courses each semester).
- All technical courses (math, science, engineering), required of the major or not, must be taken on a letter-graded basis (unless only offered as P/NP).
- A student's proposed schedule must be approved by a faculty adviser (or on approval from the dean or a designated staff adviser) each semester prior to enrolling in courses.

Minimum Academic (Grade) Requirements

- A minimum overall and semester grade point average of 2.00 (C average) is required of engineering undergraduates. A student will be subject to dismissal from the University if during any fall or spring semester their overall UC GPA falls below a 2.00, or their semester GPA is less than 2.00.
- Students must achieve a minimum grade point average of 2.00 (C average) in upper division technical courses required for the major curriculum each semester. A student will be subject to dismissal from the University if their upper division technical grade point average falls below 2.00.

- A minimum overall grade point average of 2.00, and a minimum 2.00 grade point average in upper division technical course work required for the major is needed to earn a Bachelor of Science in Engineering.

Unit Requirements

To earn a Bachelor of Science in Engineering, students must complete at least 120 semester units of courses subject to certain guidelines:

- Completion of the requirements of one engineering major program (<http://engineering.berkeley.edu/academics/undergraduate-programs>) of study.
- A maximum of 16 units of special studies coursework (courses numbered 97, 98, 99, 197, 198, or 199) is allowed towards the 120 units; a maximum of four is allowed in a given semester.
- A maximum of 4 units of physical education from any school attended will count towards the 120 units.
- Students may receive unit credit for courses graded P (including P/ NP units taken through EAP) up to a limit of one-third of the total units taken and passed on the Berkeley campus at the time of graduation.

Normal Progress

Students in the College of Engineering must enroll in a full-time program and make normal progress each semester toward the bachelor's degree. The continued enrollment of students who fail to achieve minimum academic progress shall be subject to the approval of the dean. (Note: students with official accommodations established by the Disabled Students' Program, with health or family issues, or with other reasons deemed appropriate by the dean may petition for an exception to normal progress rules.)

University of California Requirements

Entry Level Writing (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/natural-resources/entry-level-writing-requirement>)

All students who will enter the University of California as freshmen must demonstrate their command of the English language by fulfilling the Entry Level Writing Requirement. Fulfillment of this requirement is also a prerequisite to enrollment in all reading and composition courses at UC Berkeley.

American History and American Institutions (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/natural-resources/american-history-institutions-requirement>)

The American History and Institutions requirements are based on the principle that a U.S. resident graduated from an American university should have an understanding of the history and governmental institutions of the United States.

Campus Requirement

American Cultures (<http://guide.berkeley.edu/archive/2017-18/undergraduate/colleges-schools/natural-resources/american-cultures-requirement>)

American Cultures (AC) is the one requirement that all undergraduate students at UC Berkeley need to take and pass in order to graduate. The requirement offers an exciting intellectual environment centered on the study of race, ethnicity and culture in the United States. AC courses offer students opportunities to be part of research-led, highly accomplished

teaching environments, grappling with the complexity of American Culture.

For more detailed information regarding the courses listed below (e.g., elective information, GPA requirements, etc.), please see the College Requirements and Major Requirements tabs.

Freshman				
	Fall	Units	Spring	Units
MATH 1A		4	MATH 1B	4
BIO ENG 10 ¹		4	PHYSICS 7A (taken Sophomore year in Synthetic Biology concentration)	4
CHEM 1A & 1AL		4	CHEM 3A & 3AL	5
BIO ENG 26		1	BIO ENG 25	1
Reading and Composition		4	Reading and Composition	4
		17		18
Sophomore				
	Fall	Units	Spring	Units
MATH 53		4	BIO ENG 11	3
PHYSICS 7B		4	MATH 54	4
ENGIN 7 or COMPSCI 61A		4	Humanities/ Social Sciences course	3
Humanities/Social Sciences course		3	Additional course per concentration	3
		15		13
Junior				
	Fall	Units	Spring	Units
Varies by concentration. Please see concentration-specific grids at http://bioeng.berkeley.edu/undergrad/program/concentrations		12	Varies by concentration. Please see concentration- specific grids at http://bioeng.berkeley.edu/undergrad/program/concentrations	12
BIO ENG 100 (or Humanities/Social Sciences course with Ethics content)		3	Humanities/ Social Sciences course	3
		15		15
Senior				
	Fall	Units	Spring	Units
Varies by concentration. Please see concentration-specific grids at http://bioeng.berkeley.edu/undergrad/program/concentrations		15	Varies by concentration. Please see concentration- specific grids at http://bioeng.berkeley.edu/undergrad/program/concentrations	12
		15		12
Total Units: 120				120

¹ Junior transfer admits are exempt from completing BIO ENG 10.

Mission

Since our founding in 1998, the BioE faculty have been working to create an integrated, comprehensive program. Much thought has been put into the question, "What does every bioengineer need to know?" The faculty have been engaged in considerable dialogue over the years about what needs to be included, in what order, and how to do so in a reasonable time frame. Balancing depth with breadth has been the key challenge, and we have reached a point where the pieces have come together to form a coherent bioengineering discipline.

Learning Goals for the Major

1. Describe the fundamental principles and methods of engineering.
2. Understand the physical, chemical, and mathematical basis of biology.
3. Appreciate the different scales of biological systems.
4. Apply the physical sciences and mathematics in an engineering approach to biological systems.
5. Effectively communicate scientific and engineering data and ideas, both orally and in writing.
6. Demonstrate the values of cooperation, teamwork, social responsibility, and lifelong learning necessary for success in the field.
7. Design a bioengineering solution to a problem of technical, scientific, or societal importance.
8. Demonstrate advanced knowledge in a specialized field of bioengineering.

Bioengineering provides an array of programmatic and individual advising services. Each student is required to consult with a faculty adviser each semester. Our dedicated Bioengineering undergraduate affairs officer is available through appointments or drop-in times to consult on topics such as course selection, degree requirements, concentration selection, and achieving personal and academic goals. Further advising support is available from staff in the Engineering Student Services Office.

Please see more information on advising on the department website (<http://bioeng.berkeley.edu/undergrad/advising>).

Advising Staff and Hours

Undergraduate Adviser:

Cindy Manly-Fields
Phone: 510-642-5860
cmanly@berkeley.edu
306C Stanley Hall

Appointment times: Monday – Friday, 9am- 11:30am

Afternoon drop-in time: Tuesday-Thursday, 1:15-5pm, Friday 2-4pm

Undergraduate Research

We believe it is essential for undergraduates to experience the hands-on application of skills to prepare them for a career in bioengineering. Every student is required to complete at least one semester of research or design before graduation, although most do more. This can be accomplished through our outstanding senior capstone design course (<http://bioeng.berkeley.edu/undergrad/capstone>), or through other independent study options and research in faculty laboratories. A recent survey shows that 94% of our senior students have undertaken extracurricular research, usually starting in their sophomore year.

For research resources, please visit the department website (<http://bioeng.berkeley.edu/undergrad/undergradresearch>).

Student Organizations

There are several active student organizations related to bioengineering, focusing on academics, research, global healthcare, local outreach, social life, career planning, and other worthy efforts. For further information, please see the Student Life (<http://bioeng.berkeley.edu/resources/student-life>) page on the department website.

Bioengineering

BIO ENG 10 Introduction to Biomedicine for Engineers 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

This course is intended for lower division students interested in acquiring a foundation in biomedicine with topics ranging from evolutionary biology to human physiology. The emphasis is on the integration of engineering applications to biology and health. The goal is for undergraduate engineering students to gain sufficient biology and human physiology fundamentals so that they are better prepared to study specialized topics, e.g., biomechanics, imaging, computational biology, tissue engineering, biomonitoring, drug development, robotics, and other topics covered by upper division and graduate courses in UC Berkeley departments of Molecular and Cell Biology, Integrative Biology, Bioengineering, Electrical Engineering and Computer Science, Mechanical Engineering, and courses in the UC San Francisco Division of Bioengineering. The specific lecture topics and exercises will include the key aspects of genomics and proteomics as well as topics on plant and animal evolution, stem cell biomedicine, and tissue regeneration and replacement. Medical physiology topics include relevant engineering aspects of human brain, heart, musculoskeletal, and other systems.

Introduction to Biomedicine for Engineers: Read More [+]

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructors: Conboy, Kumar

Introduction to Biomedicine for Engineers: Read Less [-]

BIO ENG 11 Engineering Molecules 1 3 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

This course focuses on providing students with a foundation in organic chemistry and biochemistry needed to understand contemporary problems in synthetic biology, biomaterials and computational biology.

Engineering Molecules 1: Read More [+]

Objectives Outcomes

Course Objectives: The goal of this course is to give students the background in organic chemistry and biochemistry needed understand problems in synthetic biology, biomaterials and molecular imaging. Emphasis is on basic mechanisms

Student Learning Outcomes: Students will learn aspects of organic and biochemistry required to begin the rational manipulation and/or design of biological systems and the molecules they are comprised of.

Rules & Requirements

Prerequisites: Chemistry 3A

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Engineering Molecules 1: Read Less [-]

BIO ENG 24 Freshmen Seminar 1 Unit

Terms offered: Spring 2018, Spring 2017, Fall 2016

The Berkeley Seminar Program has been designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small-seminar setting. Berkeley seminars are offered in all campus departments, and topics vary from department to department and semester to semester.

Freshmen Seminar: Read More [+]

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Freshmen Seminar: Read Less [-]

BIO ENG 25 Careers in Biotechnology 1 Unit

Terms offered: Spring 2018, Spring 2017, Spring 2016

This introductory seminar is designed to give freshmen and sophomores an opportunity to explore specialties related to engineering in the pharmaceutical/biotech field. A series of one-hour seminars will be presented by industry professionals, professors, and researchers. Topics may include biotechnology and pharmaceutical manufacturing; process and control engineering; drug inspection process; research and development; compliance and validation; construction process for a GMP facility; project management; and engineered solutions to environmental challenges. This course is of interest to students in all areas of engineering and biology, including industrial engineering and manufacturing, chemical engineering, and bioengineering.

Careers in Biotechnology: Read More [+]

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam required.

Careers in Biotechnology: Read Less [-]

BIO ENG 26 Introduction to Bioengineering 1 Unit

Terms offered: Fall 2018, Fall 2017

This introductory seminar is designed to give freshmen and sophomores a glimpse of a broad selection of bioengineering research that is currently underway at Berkeley and UCSF. Students will become familiar with bioengineering applications in the various concentration areas and see how engineering principles can be applied to biological and medical problems.

Introduction to Bioengineering: Read More [\[+\]](#)

Objectives Outcomes

Course Objectives: This course is designed to expose students to current research and problems in bioengineering. As a freshman/sophomore class, its main purpose is to excite our students about the possibilities of bioengineering and to help them to choose an area of focus.

Student Learning Outcomes: This course demonstrates the rapid pace of new technology and the need for life-long learning (2). In addition, the course, because of its state-of-the-art research content, encourages our students to explore new horizons (3).

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Instructors: T. Johnson, H. Lam

Introduction to Bioengineering: Read Less [\[-\]](#)

BIO ENG 84 Sophomore Seminar 1 or 2 Units

Terms offered: Spring 2018, Spring 2017, Spring 2013

Sophomore seminars are small interactive courses offered by faculty members in departments all across the campus. Sophomore seminars offer opportunity for close, regular intellectual contact between faculty members and students in the crucial second year. The topics vary from department to department and semester to semester. Enrollment limited to 15 sophomores.

Sophomore Seminar: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: At discretion of instructor

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

Hours & Format

Fall and/or spring:

5 weeks - 3-6 hours of seminar per week

10 weeks - 1.5-3 hours of seminar per week

15 weeks - 1-2 hours of seminar per week

Summer:

6 weeks - 2.5-5 hours of seminar per week

8 weeks - 1.5-3.5 hours of seminar and 2-4 hours of seminar per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

Sophomore Seminar: Read Less [\[-\]](#)

BIO ENG 98 Supervised Independent Group Studies 1 - 4 Units

Terms offered: Fall 2018, Spring 2018, Fall 2017

Organized group study on various topics under the sponsorship of a member of the Bioengineering faculty.

Supervised Independent Group Studies: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Consent of instructor

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week

Summer: 8 weeks - 1-4 hours of directed group study per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Supervised Independent Group Studies: Read Less [\[-\]](#)

BIO ENG 99 Supervised Independent Study and Research 1 - 4 Units

Terms offered: Fall 2018, Fall 2017, Spring 2017

Supervised independent study for lower division students.

Supervised Independent Study and Research: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Freshman or sophomore standing and consent of instructor

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

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

Summer:

8 weeks - 1.5-7.5 hours of independent study per week

10 weeks - 1.5-6 hours of independent study per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Supervised Independent Study and Research: Read Less [\[-\]](#)

BIO ENG 100 Ethics in Science and Engineering 3 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

The goal of this semester course is to present the issues of professional conduct in the practice of engineering, research, publication, public and private disclosures, and in managing professional and financial conflicts. The method is through historical didactic presentations, case studies, presentations of methods for problem solving in ethical matters, and classroom debates on contemporary ethical issues. The faculty will be drawn from national experts and faculty from religious studies, journalism, and law from the UC Berkeley campus.

Ethics in Science and Engineering: Read More [\[+\]](#)

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructors: Lam, Hayley

Ethics in Science and Engineering: Read Less [\[-\]](#)

BIO ENG 101 Instrumentation in Biology and Medicine 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

This course teaches the fundamental principles underlying modern sensing and control instrumentation used in biology and medicine.

The course takes an integrative analytic and hands-on approach to measurement theory and practice by presenting and analyzing example instruments currently used for biology and medical research, including EEG, ECG, pulsed oximeters, Complete Blood Count (CBC), etc.

Instrumentation in Biology and Medicine: Read More [\[+\]](#)

Objectives Outcomes

Course Objectives: Students should understand the architecture and design principles of modern biomedical sensor data-acquisition (sensor-DAQ) systems. They should understand how to choose the appropriate biomedical sensor, instrumentation amplifier, number of bits, sampling rate, anti-aliasing filter, and DAQ system. They will learn how to design a low-noise instrumentation amplifier circuit. They should understand the crucial importance of suppressing 60 Hz and other interferences to acquire high quality low-level biomedical signals. They should understand the design principles of building, debugging.

Student Learning Outcomes: Students will achieve knowledge and skills in biomedical signal acquisition. They will be assessed in their success with the Course Objectives through tests, homeworks, and laboratories. In particular, the tests will ensure that the students have absorbed the theoretical concepts. The laboratories will provide assessment of learning practical skills (e.g., building an ECG circuit).

Rules & Requirements

Prerequisites: EI Eng 16A & 16B, Math 53, 54, Physics 7A-7B, 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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Conolly

Instrumentation in Biology and Medicine: Read Less [\[-\]](#)

BIO ENG 102 Biomechanics: Analysis and Design 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

This course introduces, develops and applies the methods of continuum mechanics to biomechanical phenomena abundant in biology and medicine. It is intended for upper level undergraduate students who have been exposed to vectors, differential equations, and undergraduate course(s) in physics and certain aspects of modern biology.

Biomechanics: Analysis and Design: Read More [\[+\]](#)

Objectives Outcomes

Course Objectives: This course introduces, develops and applies scaling laws and the methods of continuum mechanics to biomechanical phenomena related to tissue or organ levels. It is intended for upper level undergraduate students who have been exposed to vectors, differential equations, and undergraduate course(s) in physics and certain aspects of modern biology.

Topics include:

- Biosolid mechanics
- Stress, strain, constitutive equation
- Vector and tensor math
- Equilibrium
- Extension, torsion, bending, buckling
- Material properties of tissues

Student Learning Outcomes: The course will equip the students with a deep understanding of principles of biomechanics. The intuitions gained in this course will help guide the analysis of design of biomedical devices and help the understanding of biological/medical phenomena in health and disease.

The students will develop insight, skills and tools in quantitative analysis of diverse biomechanical systems and topics, spanning various scales from cellular to tissue and organ levels.

Rules & Requirements

Prerequisites: Math 53, 54; Physics 7A

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Mofrad

Biomechanics: Analysis and Design: Read Less [\[-\]](#)

BIO ENG 103 Engineering Molecules 2 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

Thermodynamic and kinetic concepts applied to understanding the chemistry and structure of biomolecules (proteins, membranes, DNA, and RNA) and their thermodynamic and kinetic features in the crowded cellular environment. Topics include entropy, bioenergetics, free energy, chemical potential, reaction kinetics, enzyme kinetics, diffusion and transport, non-equilibrium systems, and their connections to the cellular environment.

Engineering Molecules 2: Read More [\[+\]](#)

Objectives Outcomes

Course Objectives: (1) To introduce the basics of thermodynamics and chemical kinetics for molecular to cellular biological systems; (2) To give students an understanding of biological size and timescales illustrated through computational exercises on model problems in physical biology.

Student Learning Outcomes: students will be able to (1) relate statistical thermodynamics and chemical kinetics to analyze molecular and cellular behavior beyond the ideal gas and Carnot cycle.

Rules & Requirements

Prerequisites: Bio10gy 1A or Bioengineering 11, Physics 7A-7B, Math 1A, 1B, 53, 54

Credit Restrictions: Students will receive no credit for Bioengineering 103 after completing Chemistry 120B, or Molecular Cell Biology C100A/Chemistry C130.

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Head-Gordon

Engineering Molecules 2: Read Less [\[-\]](#)

BIO ENG 104 Biological Transport Phenomena 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

The transport of mass, momentum, and energy are critical to the function of living systems and the design of medical devices. Biological transport phenomena are present at a wide range of length scales: molecular, cellular, organ (whole and by functional unit), and organism. This course develops and applies scaling laws and the methods of continuum mechanics to biological transport phenomena over a range of length and time scales. The course is intended for undergraduate students who have taken a course in differential equations and an introductory course in physics. Students should be familiar with basic biology; an understanding of physiology is useful, but not assumed.

Biological Transport Phenomena: Read More [a]

Rules & Requirements

Prerequisites: Mathematics 53, 54, and Physics 7A

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Johnson

Biological Transport Phenomena: Read Less [-]

BIO ENG 105 Engineering Devices 1 4 Units

Terms offered: Fall 2018

This course provides students with an introduction to medical device design through fundamentals of circuit design/analysis, signal processing, and instrumentation development from concept to market. Important concepts will include impulse responses of systems, op-amps, interference, and noise; the origin of biological signals and recording mechanisms; and design considerations including sensitivity, accuracy, and market potential. This course is designed to be an introduction to these tools and concepts to prepare students to engage deeply and mindfully with device design in their future courses

Engineering Devices 1: Read More [a]

Objectives Outcomes

Course Objectives: # To prepare students to engage in upper division device design work

Establish a foundational understanding of biomedical device electronics, signal acquisition, sampling, and reconstruction

To learn quantitative approaches to analyze biomedical signals

Reinforce mathematical principles including linear algebra, differential equations

Establish proficiency in the use of MATLAB as a tool for analyzing biomedical data

Student Learning Outcomes: to give students the mathematical and physical tools required to engage in device design.

Rules & Requirements

Prerequisites: Math 53 and Physics 7A & 7B 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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Moriel Vandsburger

Engineering Devices 1: Read Less [-]

BIO ENG C106A Introduction to Robotics 4 Units

Terms offered: Fall 2018, Fall 2017

An introduction to the kinematics, dynamics, and control of robot manipulators, robotic vision, and sensing. The course covers forward and inverse kinematics of serial chain manipulators, the manipulator Jacobian, force relations, dynamics, and control. It presents elementary principles on proximity, tactile, and force sensing, vision sensors, camera calibration, stereo construction, and motion detection. The course concludes with current applications of robotics in active perception, medical robotics, and other areas.

Introduction to Robotics: [Read More](#) [+]

Rules & Requirements

Prerequisites: Electrical Engineering 120 or equivalent, consent of instructor

Credit Restrictions: Students will receive no credit for Electrical Engineering and Computer Science C106A/Bioengineering C106A after completing EE C106A/BioE C125, Electrical Engineering 206A, or Electrical Engineering and Computer Science 206A.

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/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructor: Bajcsy

Also listed as: EECS C106A

Introduction to Robotics: [Read Less](#) [-]

BIO ENG C106B Robotic Manipulation and Interaction 4 Units

Terms offered: Spring 2018

This course is a sequel to EECS C106A/Bioengineering C106A, which covers kinematics, dynamics and control of a single robot. This course will cover dynamics and control of groups of robotic manipulators coordinating with each other and interacting with the environment. Concepts will include an introduction to grasping and the constrained manipulation, contacts and force control for interaction with the environment. We will also cover active perception guided manipulation, as well as the manipulation of non-rigid objects. Throughout, we will emphasize design and human-robot interactions, and applications to applications in manufacturing, service robotics, tele-surgery, and locomotion.

Robotic Manipulation and Interaction: [Read More](#) [+]

Rules & Requirements

Prerequisites: Electrical Engineering and Computer Science C106A/Bioengineering C106A or consent of the instructor

Credit Restrictions: Students will receive no credit for Electrical Engineering and Computer Science C106B/Bioengineering C106B after completing Electrical Engineering C106B/Bioengineering C125B, Electrical Engineering 206B, or Electrical Engineering and Computer Science 206B.

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/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructors: Bajcsy, Sastry

Also listed as: EECS C106B

Robotic Manipulation and Interaction: [Read Less](#) [-]

BIO ENG 110 Biomedical Physiology for Engineers 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

This course introduces students to the physiology of human organ systems, with an emphasis on quantitative problem solving, engineering-style modeling, and applications to clinical medicine.

Biomedical Physiology for Engineers: Read More [+]

Objectives Outcomes

Course Objectives: This 15-week course will introduce students to the principles of medical physiology, with a strong emphasis on quantitative problem solving, the physiological basis of human disease, and applications to biomedical devices and prostheses.

Student Learning Outcomes: Students will be exposed to the basic physiological systems which govern the function of each organ system, examples of diseases in which these systems go awry, and medical devices which have been developed to correct the deficits.

Rules & Requirements

Prerequisites: BioE 10, BioE 11 or Biology 1A; Math 54 recommended

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Kumar

Biomedical Physiology for Engineers: Read Less [-]

BIO ENG 111 Functional Biomaterials Development and Characterization 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

This course is intended for upper level engineering undergraduate students interested in the development of novel functional proteins and peptide motifs and characterization of their physical and biological properties using various instrumentation tools in quantitative manners. The emphasis of the class is how to develop novel proteins and peptide motifs, and to characterize their physical and biological functions using various analytical tools in quantitative manners.

Functional Biomaterials Development and Characterization: Read More [+]

Objectives Outcomes

Course Objectives: To provide students with basic and extended concepts for the development of the functional proteins and their characterization for various bioengineering and biomedical purposes.

Student Learning Outcomes: Upon completing the course, the student should be able:

1. To understand the directed evolution processes of functional proteins.
2. To identify the natural protein products from proteomic database.
3. To design various experiments to characterize the new protein products.
4. To develop novel functional proteins and characterize their properties.
5. To understand basic concepts and instrumentation of protein characterization tools.

Rules & Requirements

Prerequisites: Chemistry 1A or 4A, Bio Eng 11 or Biology 1A; Bio Eng 103 or equivalent

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: SW Lee

Functional Biomaterials Development and Characterization: Read Less [-]

BIO ENG C112 Molecular Biomechanics and Mechanobiology of the Cell 4 Units

Terms offered: Spring 2016, Spring 2015, Spring 2014

This course applies methods of statistical continuum mechanics to subcellular biomechanical phenomena ranging from nanoscale (molecular) to microscale (whole cell and cell population) biological processes at the interface of mechanics, biology, and chemistry.

Molecular Biomechanics and Mechanobiology of the Cell: [Read More](#) [+]

Objectives Outcomes

Course Objectives: This course, which is open to senior undergraduate students or 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 subcellular biomechanics and transport phenomena, and (2) ultimately apply these skills to novel biological and biomedical applications

Rules & Requirements

Prerequisites: Math 54; Physics 7A; BioE102 or MEC85 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/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructor: Mofrad

Also listed as: MEC ENG C115

Molecular Biomechanics and Mechanobiology of the Cell: [Read Less](#) [-]

BIO ENG 113 Stem Cells and Technologies 4 Units

Terms offered: Fall 2015, Fall 2014, Fall 2013

This course will teach the main concepts and current views on key attributes of embryonic stem cells (ESC), will introduce theory of their function in embryonic development, methods of ESC derivation, propagation, and characterization, and will discuss currently developing stem cell technologies.

Stem Cells and Technologies: [Read More](#) [+]

Rules & Requirements

Prerequisites: 10 and Biology 1A, 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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Conboy

Stem Cells and Technologies: [Read Less](#) [-]

BIO ENG 114 Cell Engineering 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

This course will teach the main concepts and current views on key attributes of animal cells (somatic, embryonic, pluripotent, germ-line; with the focus on mammalian cells), will introduce theory of the regulation of cell function, methods for deliberate control of cell properties and resulting biomedical technologies. Techniques for primary cell-line derivation, propagation characterization and therapeutic use (transplantation and drug-screening) will be outlined. Current bioengineering strategies will be discussed.

Cell Engineering: Read More [+]

Objectives Outcomes

Course Objectives: The purpose of this course is to introduce the student to problems associated with the molecular regulation of cell properties, proper selection of in vitro and in vivo conditions and experimental techniques best suited for derivation, propagation and characterization of primary cell lines and provide knowledge of the currently developing cell and tissue engineering technologies. The level of course-work presupposes knowledge of fundamentals of cellular and molecular biology and of biomaterials at the freshman/sophomore undergraduate level.

Student Learning Outcomes: Through class lectures and readings in the theory and experimental methods of cell science, material science and bioengineering the student will gain a fundamental understanding of the principles and techniques guiding the current cell and tissue engineering research. In addition, this course will aid the student in cultivating broad knowledge of the stem cell and regenerative medicine field and in learning about the interface with biomedical and translational sciences.

Rules & Requirements

Prerequisites: Bio1A or Bio Eng 11; 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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Conboy

Cell Engineering: Read Less [-]

BIO ENG 115 Cell Biology for Engineers 4 Units

Terms offered: Fall 2018, Spring 2018, Fall 2017

This course aims to provide a practical understanding of the nature of cell and tissue biology research. Students will be introduced to cell biology techniques as applied to cells and tissues including immunofluorescence, image analysis, protein quantification, protein expression, gene expression, and cell culture. The course culminates with a group project which synthesizes literature review, experimental design, implementation, troubleshooting, and analysis of results.

Cell Biology for Engineers: Read More [+]

Objectives Outcomes

Course Objectives:

- To introduce a variety of basic cellular biology laboratory techniques, and develop a conceptual and theoretical understanding of the reliability and limitations of these tools.
- To support students in developing a research question, defining project goals and designing experiments that can be addressed within the constraints of the course.
- To engage students in applying their knowledge and research to others in professional activities such as presentations and papers.

Student Learning Outcomes: Students will gain an understanding of:

- Laboratory safety issues
- Appropriate methods for documenting laboratory procedures
- Phase contrast microscopy
- Fluorescent microscopy
- Image processing
- Cell culture
- Protein quantification, SDS-PAGE, and Western blotting
- Isolation and quantification of mRNA from cells
- RT-PCR
- Data analysis
- Experimental design

Rules & Requirements

Prerequisites: Bioengineering 103 or equivalent, Bioengineering 114 recommended (can be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture and 4 hours of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructors: Lam, Hayley, Irina Conboy

Cell Biology for Engineers: Read Less [-]

BIO ENG 116 Cell and Tissue Engineering 4 Units

Terms offered: Spring 2016, Spring 2015, Spring 2014

The goal of tissue engineering is to fabricate substitutes to restore tissue structure and functions. Understanding cell function in response to environmental cues will help us to establish design criteria and develop engineering tools for tissue fabrication. This course will introduce the basic concepts and approaches in the field, and train students to design and engineer biological substitutes.

Cell and Tissue Engineering: Read More [+]

Objectives Outcomes

Course Objectives: (1) To introduce the basics of tissue engineering, including quantitative cell and tissue characterization, stem cells, cell-matrix interaction, cell migration, bioreactors, mechanical regulation, tissue preservation, and immuno-modulation/isolation; (2) To illustrate the cutting-edge research in tissue engineering; (3) To enhance the skills in analyzing and designing engineered tissue products.

Student Learning Outcomes: Students will be able to (1) use mathematical models to analyze cell functions (e.g., proliferation, apoptosis, migration) and mechanical property of tissues, (2) understand scientific and ethical issues of stem cells, (3) engineer natural matrix, biomaterials and drug delivery, (4) understand mass transport and design appropriate bioreactors, (5) understand clinical issues such as tissue preservation, immune responses, immunomodulation and immunoisolation, (6) apply the knowledge to engineering biological substitutes.

Rules & Requirements

Prerequisites: BioE 103 or equivalent, BioE 104

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Li

Cell and Tissue Engineering: Read Less [-]

BIO ENG C117 Structural Aspects of Biomaterials 4 Units

Terms offered: Spring 2018, Spring 2016, Fall 2013

This course covers the structure and mechanical functions of load bearing tissues and their replacements. Natural and synthetic load-bearing biomaterials for clinical applications are reviewed. Biocompatibility of biomaterials and host response to structural implants are examined. Quantitative treatment of biomechanical issues and constitutive relationships of tissues are covered in order to design biomaterial replacements for structural function. Material selection for load bearing applications including reconstructive surgery, orthopedics, dentistry, and cardiology are addressed. Mechanical design for longevity including topics of fatigue, wear, and fracture are reviewed. Case studies that examine failures of devices are presented.

Structural Aspects of Biomaterials: Read More [+]

Rules & Requirements

Prerequisites: Biology 1A, Engineering 45, Civil and Environmental Engineering 130 or 130N or Bioengineering 102, and Engineering 190

Credit Restrictions: Students will receive no credit for Mechanical Engineering C117 after completing Mechanical Engineering C215/ Bioengineering C222.

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam not required.

Instructor: Pruitt

Also listed as: MEC ENG C117

Structural Aspects of Biomaterials: Read Less [-]

BIO ENG C118 Biological Performance of Materials 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2015

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.

Biological Performance of Materials: [Read More](#) [+]

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: 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.

- Design experiments and analyze data from the literature in the context of the class design project.

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.

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.

Work independently and function on a team, and develop solid communication skills (oral, graphic & written) through 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.

Rules & Requirements

Prerequisites: Engin 45; BioE 103 or equivalent; BioE 102 and BioE 104 recommended

Hours & Format

BIO ENG C119 Orthopedic Biomechanics 4 Units

Terms offered: Fall 2017, Fall 2016, Fall 2015

Statics, dynamics, optimization theory, composite beam theory, beam-on-elastic foundation theory, Hertz contact theory, and materials behavior. 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. MATLAB-based project to integrate the course material.

Orthopedic Biomechanics: [Read More](#) [+]

Rules & Requirements

Prerequisites: Mechanical Engineering C85, Civil Engineering C30, or Bioengineering 102, or equivalent; concurrent enrollment OK. Proficiency in MatLab or equivalent. Prior knowledge of biology or anatomy is not assumed

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Keaveny

Also listed as: MEC ENG C176

Orthopedic Biomechanics: [Read Less](#) [-]

BIO ENG 121 BioMEMS and Medical Devices 4 Units

Terms offered: Fall 2018, Spring 2018, Spring 2017

Biophysical and chemical principles of biomedical devices, bionanotechnology, bionanophotonics, and biomedical microelectromechanical systems (BioMEMS). Topics include basics of nano- and 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, etc. BioMEMS and Medical Devices: Read More [+]

Rules & Requirements

Prerequisites: Chemistry 3A; Physics 7A and 7B

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: L. Lee

BioMEMS and Medical Devices: Read Less [-]

BIO ENG 121L BioMems and BioNanotechnology Laboratory 4 Units

Terms offered: Fall 2018, Fall 2016, Fall 2015

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.

BioMems and BioNanotechnology Laboratory: Read More [+]

Objectives Outcomes

Course Objectives: Students will become familiar with research associated with BioMEMS and Lab-on-a-Chip technologies. Students will gain experience in using creative design to solve a technological problem. Students will learn basic microfabrication techniques. Working in engineering teams, students will learn how to properly characterize a novel device by choosing and collecting informative metrics. Students will design and carry out carefully controlled experiments that will result in the analysis of quantitative data.

Student Learning Outcomes: Students will learn how to critically read BioMEMS and Lab-on-a-Chip primary literature. Students will learn how to use AutoCAD software to design microscale device features. Students will gain hands-on experience in basic photolithography and soft lithography. Students will get experience with a variety of fluid loading interfaces and microscopy techniques. Students will learn how to design properly controlled quantitative experiments. Students will gain experience in presenting data to their peers in the form of powerpoint presentations and also at a poster symposium.

Rules & Requirements

Prerequisites: BioE 103 or equivalent, BioE 104

Credit Restrictions: Students will receive no credit for 121L after taking 221L.

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/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructor: D. Liepmann

BioMems and BioNanotechnology Laboratory: Read Less [-]

BIO ENG 124 Basic Principles of Drug Delivery 3 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

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.

Basic Principles of Drug Delivery: [Read More](#) [+]

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: BioE 11 or Chem 3B; BioE 103, and BioE 104 (or courses equivalent to these)

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Murthy

Basic Principles of Drug Delivery: [Read Less](#) [-]

BIO ENG C125 Introduction to Robotics 4 Units

Terms offered: Fall 2017, Fall 2016, Fall 2015

An introduction to the kinematics, dynamics, and control of robot manipulators, robotic vision, and sensing. The course covers forward and inverse kinematics of serial chain manipulators, the manipulator Jacobian, force relations, dynamics, and control. It presents elementary principles on proximity, tactile, and force sensing, vision sensors, camera calibration, stereo construction, and motion detection. The course concludes with current applications of robotics in active perception, medical robotics, and other areas.

Introduction to Robotics: [Read More](#) [+]

Rules & Requirements

Prerequisites: EE 120 or equivalent, consent of instructor

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Bajcsy

Formerly known as: Electrical Engineering C125/Bioengineering C125

Also listed as: EL ENG C106A

Introduction to Robotics: [Read Less](#) [-]

BIO ENG C125B Robotic Manipulation and Interaction 4 Units

Terms offered: Spring 2017, Spring 2016

This course is a sequel to Electrical Engineering C106A/Bioengineering C125, which covers kinematics, dynamics and control of a single robot. This course will cover dynamics and control of groups of robotic manipulators coordinating with each other and interacting with the environment. Concepts will include an introduction to grasping and the constrained manipulation, contacts and force control for interaction with the environment. We will also cover active perception guided manipulation, as well as the manipulation of non-rigid objects. Throughout, we will emphasize design and human-robot interactions, and applications to applications in manufacturing, service robotics, tele-surgery, and locomotion.

Robotic Manipulation and Interaction: Read More [a+]

Rules & Requirements

Prerequisites: Electrical Engineering C106A/Bioengineering C125 or consent of the instructor

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/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructors: Bajcsy, Sastry

Also listed as: EL ENG C106B

Robotic Manipulation and Interaction: Read Less [-]

BIO ENG 131 Introduction to Computational Molecular and Cell Biology 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

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; web-based computational biology tools will be used by students and programming projects will be given. Computational biology research connections to biotechnology will be explored.

Introduction to Computational Molecular and Cell Biology: Read More [a+]

Objectives Outcomes

Course Objectives: To introduce the biological databases and file formats commonly used in computational biology. (2) To familiarize students with the use of Unix scripting languages in bioinformatics workflows. (3) To introduce common algorithms for sequence alignment, RNA structure prediction, phylogeny and clustering, along with fundamentals of probability, information theory and algorithmic complexity analysis.

Student Learning Outcomes: Students will be able to use knowledge from the lectures and lab sessions to write simple programs to parse bioinformatics file formats and execute basic algorithms, to analyze algorithmic complexity, to navigate and (for simple cases) set up biological databases containing biological data (including sequences, genome annotations and protein structures), and to use basic statistics to interpret results of compbio analyses.

Rules & Requirements

Prerequisites: BioE 11 or Bio 1A (may be taken concurrently), Math 53

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

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1.5 hours of laboratory per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Holmes

Introduction to Computational Molecular and Cell Biology: Read Less [-]

BIO ENG 132 Genetic Devices 4 Units

Terms offered: Spring 2018, Fall 2014, Fall 2013

This senior-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.

Genetic Devices: Read More [+]

Objectives Outcomes

Course Objectives: (1) To introduce the basic biology and engineering principles for constructing genetic devices including biochemical devices, microbiological devices, genetic circuits, eukaryotic devices, and developmental devices, (2) To familiarize students with current literature examples of genetic devices and develop literature searching skills; (3) To develop the students' ability to apply computational tools to the design of genetic devices.

Student Learning Outcomes: Students will be able to (1) use mathematical models to describe the dynamics of genetic devices, (2) comprehend and evaluate publications related to any type of genetic device, (3) perform a thorough literature search, (4) evaluate the technical plausibility of a proposed genetic device, (5) analyze a design challenge and propose a plausible solution to it in the form of a genetic device, and (6) assess any ethical or safety issues associated with a proposed genetic device.

Rules & Requirements

Prerequisites: Computer Science 61A; Math 53 & 54; Chemistry 3A; Chem 3B or BioE 11; BioE 103 or equivalent

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

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Anderson

Genetic Devices: Read Less [-]

BIO ENG 133 Biomolecular Engineering 3 Units

Terms offered: Prior to 2007

This is an introductory course of biomolecular engineering and is required for all CBE graduate students. Undergraduates with knowledge of thermodynamics and transport are also welcome. The topics include structures, functions, and dynamics of biomolecules; molecular tools in biotechnology; metabolic and signaling networks in cellular engineering; and synthetic biology and biomedical engineering applications.

Biomolecular Engineering: Read More [+]

Objectives Outcomes

Course Objectives: Students are expected to become familiar with the terminologies, molecules, and mechanisms, i.e., the language of biomolecular engineering. At end of this course, you are expected to be able to analyze and critique modern literature in related research areas.

Student Learning Outcomes: Students will be able to (1) understand the biochemical basis for protein folding and enzymatic function, (2) mathematically analyze enzyme function, either individually or as part of a metabolic pathway, (3) engineer novel enzymes using rational, computational, and directed evolution based approaches, (4) understand principles of metabolic engineering and synthetic biology, (5) understand the dynamics and mechanisms of cellular signal transduction, and (6) understand principles for engineering cellular signaling and function.

Rules & Requirements

Prerequisites: Bioengineering 104 or Chemical and Biomolecular Engineering 150A-150B or consent of instructor. A course in statistical mechanics and/or thermodynamics is recommended

Credit Restrictions: Students will receive no credit for Bioengineering 133 after completing Chemical Engineering C274, Molecular and Cell Biology C274 or Bioengineering C233.

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Schaffer

Biomolecular Engineering: Read Less [-]

BIO ENG 134 Genetic Design Automation 4 Units

Terms offered: Fall 2018, Fall 2017

Genetic Design Automation is the use of software to design and manage genetics experiments. This course introduces the interface between object-oriented programming and wetlab synthetic biology in a hands-on manner. Through a series of programming assignments, each student will build a computer program that automatically designs experiments starting from a formal specification. They will then independently build a new software module of their own design to augment the basic platform Genetic Design Automation: Read More [+]

Objectives Outcomes

Course Objectives: (1) To develop the skill of translating experimental design into computer code, (2) Develop familiarity with state-of-the-art infrastructure for wetlab automation, (3) Develop proficiency in software development

Student Learning Outcomes: students will be able to (1) Describe molecular biology entities and operations in terms of data structures, (2) Develop moderately-sized computer programs, (3) Write tests and benchmarking suites for biological algorithms (4) Explore different algorithmic approaches to problems and assess their relative merits and efficiencies, (5) Develop proficiency in conceiving and implementing software projects of their own design as they relate to biological problems

Rules & Requirements

Prerequisites: Computer Science 61B; Bioengineering 11; Bioengineering 103 or equivalent

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: J. Christopher Anderson

Genetic Design Automation: Read Less [-]

BIO ENG 135 Frontiers in Microbial Systems Biology 4 Units

Terms offered: Spring 2017, Fall 2009

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 to identify unsolved problems and discusses possible novel approaches while encouraging students to develop ideas to explore new directions in their own research.

Frontiers in Microbial Systems Biology: Read More [+]

Rules & Requirements

Prerequisites: Upper division standing with background in differential equations and probability. Coursework in molecular and cell biology or biochemistry recommended

Credit Restrictions: Students will receive no credit for 135 after taking 235.

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructors: Arkin, Bischofs-Pfeifer, Wolf

Frontiers in Microbial Systems Biology: Read Less [-]

BIO ENG C136L Laboratory in the Mechanics of Organisms 3 Units

Terms offered: Spring 2015, Spring 2014, Spring 2013, Spring 2012

Introduction to laboratory and field study of the biomechanics of animals and plants using fundamental biomechanical techniques and equipment.

Course has a series of rotations involving students in experiments demonstrating how solid and fluid mechanics can be used to discover the way in which diverse organisms move and interact with their physical environment. The laboratories emphasize sampling methodology, experimental design, and statistical interpretation of results. Latter third of course devoted to independent research projects. Written reports and class presentation of project results are required.

Laboratory in the Mechanics of Organisms: [Read More](#) [+]

Rules & Requirements

Prerequisites: Integrative Biology 135 or consent of instructor; for Electrical Engineering and Computer Science students, Electrical Engineering 105, 120 or Computer Science 184

Credit Restrictions: Students will receive no credit for C135L after taking 135L.

Hours & Format

Fall and/or spring: 15 weeks - 6 hours of laboratory, 1 hour of discussion, and 1 hour of fieldwork per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Formerly known as: Integrative Biology 135L

Also listed as: EL ENG C145O/INTEGBI C135L

Laboratory in the Mechanics of Organisms: [Read Less](#) [-]

BIO ENG C137 Designing for the Human Body 3 Units

Terms offered: Fall 2018, Fall 2017

The course provides project-based learning experience in understanding product design, with a focus on the human body as a mechanical machine. Students will learn the design of external devices used to aid or protect the body. Topics will include forces acting on internal materials (e.g., muscles and total replacement devices), forces acting on external materials (e.g., prosthetics and crash pads), design/analysis of devices aimed to improve or fix the human body, muscle adaptation, and soft tissue injury. Weekly laboratory projects will incorporate EMG sensing, force plate analysis, and interpretation of data collection (e.g., MATLAB analysis) to integrate course material to better understand contemporary design/analysis/problems.

Designing for the Human Body: [Read More](#) [+]

Objectives Outcomes

Course Objectives: The purpose of this course is twofold:

- to learn the fundamental concepts of designing devices to interact with the human body;
- to enhance skills in mechanical engineering and bioengineering by analyzing the behavior of various complex biomedical problems;
- To explore the transition of a device or discovery as it goes from “benchtop to bedside”.

Student Learning Outcomes: RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (d) an ability to function on multi-disciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Working knowledge of design considerations for creating a device to protect or aid the human body, force transfer and distribution, data analysis, and FDA approval process for new devices. 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. Critical analysis of current literature and technology.

Rules & Requirements

Prerequisites: Proficiency in MatLab or equivalent. Prior knowledge of biology or anatomy is not assumed. Physics 7A, Math 1A and 1B

Credit Restrictions: There will be no credit given for MEC ENG C178 / BIO ENG C137 after taking MEC ENG 178.

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

BIO ENG 140L Synthetic Biology Laboratory 4 Units

Terms offered: Fall 2015, Spring 2015, Fall 2014

This laboratory course is designed as an introduction to research in synthetic biology, a ground-up approach to genetic engineering with applications in bioenergy, healthcare, materials science, and chemical production. In this course, we will design and execute a real research project. Each student will be responsible for designing and constructing components for the group project and then performing experiments to analyze the system. In addition to laboratory work, we will have lectures on methods and design concepts in synthetic biology including an introduction to Biobricks, gene synthesis, computer modeling, directed evolution, practical molecular biology, and biochemistry.

Synthetic Biology Laboratory: Read More [+]

Rules & Requirements

Prerequisites: Molecular biology, basic chemistry and biochemistry, and differential equations; 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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Anderson

Synthetic Biology Laboratory: Read Less [-]

BIO ENG 143 Computational Methods in Biology 4 Units

Terms offered: Fall 2011, Fall 2010, Fall 2009

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); BioE Content: Biological.

Computational Methods in Biology: Read More [+]

Rules & Requirements

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

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Head-Gordon

Computational Methods in Biology: Read Less [-]

BIO ENG 144 Introduction to Protein Informatics 4 Units

Terms offered: Spring 2017, Fall 2008, Fall 2007

This course will introduce students to the bioinformatics algorithms used by biologists to identify homologs, construct multiple sequence alignments, predict protein structure, estimate phylogenetic trees, identify orthologs, predict protein-protein interaction, and build hidden Markov models. The focus is on the algorithms used, and on the sources of various types of errors in these methods.

Introduction to Protein Informatics: Read More [+]

Objectives Outcomes

Course Objectives: This course is designed to provide a theoretical framework for protein sequence and structure analysis using bioinformatics software tools. Students completing this course will be prepared for subsequent in-depth studies in bioinformatics, for algorithm development, and for the use of bioinformatics methods for biological discovery. It is aimed at two populations: students in the life sciences who need to become expert users of bioinformatics tools, and students in engineering and mathematics/computer science who wish to become the developers of the next generation of bioinformatics methods. As virtually all the problems in this field are very complex, there are many opportunities for research and development of new methods.

Student Learning Outcomes: Students completing this course are likely to find several potential areas of research of interest, which they may want to work on as independent study projects during undergraduate work, or take on as Master's or Ph.D. thesis topics for advanced work.

Rules & Requirements

Prerequisites: Prior coursework in algorithms. No prior coursework in biology is required. This course includes no programming projects and prior experience in programming is not required

Credit Restrictions: BioE 244 or BioE C244L/PMB C244

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Sjolander

Formerly known as: Bioengineering C144/Plant and Microbial Biology C144

Introduction to Protein Informatics: Read Less [-]

BIO ENG 144L Protein Informatics Laboratory 3 Units

Terms offered: Fall 2008

This course is intended to provide hands-on experience with a variety of bioinformatics tools, web servers, and databases that are used to predict protein function and structure. This course will cover numerous bioinformatics tasks including: homolog detection using BLAST and PSI-BLAST, hidden Markov model construction and use, multiple sequence alignment, phylogenetic tree construction, ortholog identification, protein structure prediction, active site prediction, cellular localization, protein-protein interaction and phylogenomic analysis. Some minimal programming/scripting skills (e.g., Perl or Python) are required to complete some of the labs.

Protein Informatics Laboratory: [Read More](#) [+]

Rules & Requirements

Prerequisites: One upper-division course in molecular biology or biochemistry (e.g., MCB C100A/Chem C130 or equivalent). Python programming (e.g., CS 61A) and experience using command-line tools in a Unix environment

Credit Restrictions: Bio Eng 244L or Bio Eng C244L/PMB C244L

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Sjolander

Formerly known as: Bioengineering C144L/Plant and Microbial Biology C144L

Protein Informatics Laboratory: [Read Less](#) [-]

BIO ENG 145 Intro to Machine Learning in Computational Biology 4 Units

Terms offered: Fall 2017

This course will review the fundamentals of Data Science and data mining techniques. We will begin by reviewing Data Science across the disciplines, including guest lectures from data scientists on campus. As the semester progresses, we will focus increasingly on data science techniques in computational biology and bioinformatics, illustrating major methods and issues from these fields. Finally, we will discuss ethical issues related to data from biomedical research and genomics.

Intro to Machine Learning in Computational Biology: [Read More](#) [+]

Objectives Outcomes

Course Objectives: This course aims to equip students with a foundational understanding of machine learning techniques used in genomics and computational biology. Desired Course Outcomes: Students completing this course should have stronger programming skills, the ability to apply simple machine learning techniques to complex biosequence and genomics data, and an understanding of some of the challenges in genomics and bioinformatics.

Student Learning Outcomes: Students completing this course should have stronger programming skills, the ability to apply simple machine learning techniques to complex biosequence and genomics data, and an understanding of some of the challenges in genomics and bioinformatics.

Rules & Requirements

Prerequisites: CS61B, CS70 or Math 55; CS170 or STAT 132 or STAT 133 (may be taken concurrently); BioE 144L (may be taken concurrently)

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: K. Sjolander

Intro to Machine Learning in Computational Biology: [Read Less](#) [-]

BIO ENG C145L Introductory Electronic Transducers Laboratory 3 Units

Terms offered: Fall 2014, Fall 2013, Fall 2012

Laboratory exercises exploring a variety of electronic transducers for measuring physical quantities such as temperature, force, displacement, sound, light, ionic potential; the use of circuits for low-level differential amplification and analog signal processing; and the use of microcomputers for digital sampling and display. Lectures cover principles explored in the laboratory exercises; construction, response and signal to noise of electronic transducers and actuators; and design of circuits for sensing and controlling physical quantities.

Introductory Electronic Transducers Laboratory: Read More [\[+\]](#)

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Derenzo

Also listed as: EL ENG C145L

Introductory Electronic Transducers Laboratory: Read Less [\[-\]](#)

BIO ENG C145M Introductory Microcomputer Interfacing Laboratory 3 Units

Terms offered: Spring 2013, Spring 2012, Spring 2011

Laboratory exercises constructing basic interfacing circuits and writing 20-100 line C programs for data acquisition, storage, analysis, display, and control. Use of the IBM PC with microprogrammable digital counter/timer, parallel I/O port. Circuit components include anti-aliasing filters, the S/H amplifier, A/D and D/A converters. Exercises include effects of aliasing in periodic sampling, fast Fourier transforms of basic waveforms, the use of the Hanning filter for leakage reduction, Fourier analysis of the human voice, digital filters, and control using Fourier deconvolution. Lectures cover principles explored in the lab exercises and design of microcomputer-based systems for data acquisitions, analysis and control. Introductory Microcomputer Interfacing Laboratory: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: EE 16A & 16B

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Derenzo

Also listed as: EL ENG C145M

Introductory Microcomputer Interfacing Laboratory: Read Less [\[-\]](#)

BIO ENG 147 Principles of Synthetic Biology 4 Units

Terms offered: Fall 2018, Fall 2016, Fall 2015

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.

Principles of Synthetic Biology: Read More [\[+\]](#)

Objectives Outcomes

Course Objectives: (1) To introduce the basics of Synthetic Biology, including quantitative cellular network characterization and modeling, (2) to introduce the principles of discovery and genetic factoring of useful cellular activities into reusable functions for design, (3) to inculcate the principles of biomolecular system design and diagnosis of designed systems, and (4) to illustrate cutting-edge applications in Synthetic Biology and to enhance skill in analyzing and designing synthetic biological applications.

Student Learning Outcomes: The goals of this course are to enable students to: (1) design simple cellular circuitry to meet engineering specification using both rational/model-based and library-based approaches, (2) design experiments to characterize and diagnose operation of natural and synthetic biomolecular network functions, and (3) understand scientific, safety and ethical issues of synthetic biology.

Rules & Requirements

Prerequisites: Math 53 and 54; BioE 103 or equivalent or consent of instructor

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

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/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Instructor: Arkin

Principles of Synthetic Biology: Read Less [\[-\]](#)

BIO ENG 148 Bioenergy and Sustainable Chemical Synthesis: Metabolic Engineering and Synthetic Biology Approaches 3 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

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.

Bioenergy and Sustainable Chemical Synthesis: Metabolic Engineering and Synthetic Biology Approaches: [Read More](#) [\[+\]](#)

Objectives Outcomes

Course Objectives: (1) Learn the common engineered metabolic pathways for biofuel biosynthesis
(2) analytical methods
(3) synthetic biology approaches
(4) Industry technologies and opportunities

Student Learning Outcomes: Students will learn (1) the common pathways used for biofuel synthesis and framework for the biosynthesis of specialty chemicals, (2) analytical methods for quantitative measurements of metabolic pathways, (3) synthetic biology approaches for increasing overall pathway performance, and how to (4) utilize available online resources for culling information from large data sources.

Rules & Requirements

Prerequisites: Chem 3A, BioE 103 or equivalent

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Dueber

Bioenergy and Sustainable Chemical Synthesis: Metabolic Engineering and Synthetic Biology Approaches: [Read Less](#) [\[-\]](#)

BIO ENG 150 Introduction of Bionanoscience and Bionanotechnology 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

This course is intended for the bioengineering or engineering undergraduate students interested in acquiring a background in recent development of bio-nanomaterials and bio-nanotechnology. The emphasis of the class is to understand the properties of biological basic building blocks, their assembly principles in nature, and their application to build functional materials and devices.

Introduction of Bionanoscience and Bionanotechnology: [Read More](#) [\[+\]](#)

Objectives Outcomes

Course Objectives: I. Basic building blocks and governing forces: This part is intended to enhance the understanding of the structures and properties of biological basic building blocks and their governing forces to assemble the biological materials. This part covers the chemical structures of amino acids, ribonucleic acids, hydrocarbonates, and lipids, and their physical properties depending on the chemical and physical structures. In addition, governing forces (hydrogen bonding, ionic interaction, van der Waals interaction, hydrophobic interactions, etc) to assemble the basic building blocks to form nanostructures will be covered. Tools and methodologies to analyze the chemical structure of the molecules will be introduced. Quantitative analysis of the properties of biological basic building blocks will also be addressed.
II. Case study of the molecular level structures of biological materials. This part is intended to study the examples of biological molecules to enhance understanding the assembly principle of biological materials, including collagens, keratins, spider webs, silks, bio-adhesives as protein based robust materials, bones, sea shells, diatoms, sponges, and, other biominerals as hierarchical nanostructures, and butterfly wings and insect eyes, other periodic structures for optical applications. Through the case study, we will learn how natural materials are designed to solve the challenging problem to be faced in the natural environments and exploit their design principle to develop novel functional materials and devices.
III. Case study of the artificial nanomaterials and devices inspired by biological nature. This part is intended to enhance understanding the recently developed nanostructures and devices to mimic the natural biological materials and organisms. Hybrid functional nanomaterials and devices, such as biological basic building blocks conjugated with inorganic nanocomponents, such as quantum dots, nanowires, nanotubes will be discussed to fabricate various devices including, bio-sensor, bio-nano electronic materials and devices, bio-computing. Nano medicine and bio imaging will also be covered.
The goal is for the bioengineering students to gain sufficient chemical and physical aspects of biological materials through the case study of spider webs, silks, sea shells, diatoms, bones, and teeth, as well as recently developed self-assembled nanostructures inspired by nature.

Student Learning Outcomes: This course is intended for the undergraduate students interested in acquiring a background of recent development of bio-nanomaterials and bio-nanotechnology focused on the materials point of view. Through this course, students will understand the assembly principle of biological materials and their application in bionanotechnology.

Rules & Requirements

Prerequisites: BioE 11 or Biology 1A, Chem 1A

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/Undergraduate

BIO ENG 151 Micro/Nanofluidics for Bioengineering and Lab-On-A-Chip 4 Units

Terms offered: Spring 2015, Spring 2014, Spring 2013

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.

Micro/Nanofluidics for Bioengineering and Lab-On-A-Chip: Read More [\[+\]](#)

Objectives Outcomes

Course Objectives: We will study mass and momentum transport phenomena of microscale and nanoscale flow devices. Throughout the course, we will place an emphasis on bioanalytical microfluidic system applications where electrophoresis, electroosmosis, molecular diffusion, and/or Brownian motion effects dominate. Successful completion of the course will prepare students to design micro/nanofluidic engineering solutions, as well as critically assess academic and industrial developments in these areas.

The course is an introduction to the physicochemical dynamics associated with fluid flow in nanoscale and microscale devices for graduate students and advance undergraduate students. The course has been created in response to the active field of microfluidics and nanofluidics, as well as the associated interest from industry, government, and academic research groups. The course provides an theoretical treatment of micro/nanofluidic phenomena that complements the well-established laboratory and research content offered in the Department.

Student Learning Outcomes:

1. To introduce students to the governing principles of fluid flow in microfluidic and nanofluidic regimes, with emphasis on phenomena relevant to bioanalytical devices.
2. To provide students with an understanding of scaling laws that define the performance of microfluidic and nanofluidic systems.
3. To provide students with a detailed investigation of applications that do and do not benefit from miniaturization.
4. To give students adequate didactic background for critical assessment of literature reports and conference presentations regarding advances in the topical areas of microfluidics and nanofluidics.

Rules & Requirements

Prerequisites: BioE 11 or Chem 3B, BioE 104 or ME 106 or consent of instructor

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

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Herr

Micro/Nanofluidics for Bioengineering and Lab-On-A-Chip: Read Less [\[-\]](#)

BIO ENG 163 Principles of Molecular and Cellular Biophotonics 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

This course provides undergraduate and graduate bioengineering students with an opportunity to increase their knowledge of topics in the emerging field of biophotonics with an emphasis on fluorescence spectroscopy, biosensors and devices for optical imaging and detection of biomolecules. This course will cover the photophysics and photochemistry of organic molecules, the design and characterization of biosensors and their applications within diverse environments.

Principles of Molecular and Cellular Biophotonics: Read More [\[+\]](#)

Rules & Requirements

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

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam not required.

Instructor: Marriott

Principles of Molecular and Cellular Biophotonics: Read Less [\[-\]](#)

BIO ENG 163L Molecular and Cellular Biophotonics Laboratory 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2015

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).

Molecular and Cellular Biophotonics Laboratory: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Bioengineering 163 and ok to take concurrently

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

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Marriott

Molecular and Cellular Biophotonics Laboratory: Read Less [\[-\]](#)

BIO ENG 164 Optics and Microscopy 4 Units

Terms offered: Fall 2010, Fall 2009, Fall 2008

This course teaches fundamental principles of optics and examines contemporary methods of optical microscopy for cells and molecules. Students will learn how to design simple optical systems, calculate system performance, and apply imaging techniques including transmission, reflection, phase, and fluorescence microscopy to investigate biological samples. The capabilities of optical microscopy will be compared with complementary techniques including electron microscopy, coherence tomography, and atomic force microscopy. Students will also be responsible for researching their final project outside of class and presenting a specific application of modern microscopy to biological research as part of an end-of-semester project.

Optics and Microscopy: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Physics 7A-7B or 8A-8B or equivalent introductory physics course

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Fletcher

Optics and Microscopy: Read Less [\[-\]](#)

BIO ENG C165 Medical Imaging Signals and Systems 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

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.

Medical Imaging Signals and Systems: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Electrical Engineering 16A and 16B

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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Conolly

Also listed as: EL ENG C145B

Medical Imaging Signals and Systems: Read Less [\[-\]](#)

BIO ENG 168L Practical Light Microscopy 3 Units

Terms offered: Fall 2017, Spring 2015, Fall 2013

This laboratory course is designed for students interested in obtaining practical hands-on training in optical imaging and instrumentation. Using a combination of lenses, cameras, and data acquisition equipment, students will construct simple light microscopes that introduce basic concepts and limitations important in biomedical optical imaging. Topics include compound microscopes, Kohler illumination, Rayleigh two-point resolution, image contrast including dark-field and fluorescence microscopy, and specialized techniques such as fluorescence recovery after photobleaching (FRAP). Intended for students in both engineering and the sciences, this course will emphasize applied aspects of optical imaging and provide a base of practical skill and reference material that students can leverage in their own research or in industry.

Practical Light Microscopy: Read More [\[+\]](#)

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructor: Fletcher

Practical Light Microscopy: Read Less [\[-\]](#)

BIO ENG C181 The Berkeley Lectures on Energy: Energy from Biomass 3 Units

Terms offered: Fall 2015, Fall 2014, Fall 2013

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 placed 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-the-art research.

The Berkeley Lectures on Energy: Energy from Biomass: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Chemistry 1B or Chemistry 4B, Mathematics 1B, Biology 1A

Repeat rules: Course may be repeated for credit under special circumstances: Repeatable when topic changes with consent of instructor. 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/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

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

Also listed as: CHEM C138/CHM ENG C195A/PLANTBI C124

The Berkeley Lectures on Energy: Energy from Biomass: Read Less [\[-\]](#)

BIO ENG 190 Special Topics in Bioengineering 1 - 4 Units

Terms offered: Fall 2017, Fall 2016, Spring 2016

This course covers current topics of research interest in bioengineering.

The course content may vary from semester to semester.

Special Topics in Bioengineering: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Special Topics in Bioengineering: Read Less [\[-\]](#)

BIO ENG 192 Senior Design Projects 4 Units

Terms offered: Fall 2018, Fall 2017, Fall 2016

This semester-long course introduces students to bioengineering project-based learning in small teams, with a strong emphasis on need-based solutions for real medical and research problems through prototype solution selection, design, and testing. The course is designed to provide a "capstone" design experience for bioengineering seniors. The course is structured around didactic lectures, and a textbook, from which assigned readings will be drawn, and supplemented by additional handouts, readings, and lecture material. Where appropriate, the syllabus includes guest lectures from clinicians and practicing engineers from academia and industry. The course includes active learning through organized activities, during which teams will participate in exercises meant to reinforce lecture material through direct application to the team design project.

Senior Design Projects: Read More [\[+\]](#)

Rules & Requirements

Prerequisites: Senior standing

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam not required.

Instructor: Herr

Senior Design Projects: Read Less [\[-\]](#)

BIO ENG H194 Honors Undergraduate Research 3 or 4 Units

Terms offered: Spring 2016, Fall 2015, Spring 2015

Supervised research. Students who have completed 3 or more upper division courses may pursue original research under the direction of one of the members of the staff. May be taken a second time for credit only. A final report or presentation is required. A maximum of 4 units of this course may be used to fulfill the research or technical elective requirement or in the Bioengineering program.

Honors Undergraduate Research: Read More [+]

Rules & Requirements

Prerequisites: Upper division technical GPA 3.3 or higher and consent of instructor and adviser

Repeat rules: Course may be repeated for credit up to a total of 8 units. Course may be repeated for a maximum of 8 units.

Hours & Format

Fall and/or spring: 15 weeks - 3-4 hours of independent study per week

Summer:

8 weeks - 1.5-7.5 hours of independent study per week

10 weeks - 1.5-9 hours of independent study per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Final exam not required.

Honors Undergraduate Research: Read Less [-]

BIO ENG 195 Bioengineering Department Seminar 1 Unit

Terms offered: Prior to 2007

This weekly seminar series invites speakers from the bioengineering community, as well as those in related fields, to share their work with our department and other interested parties on the Berkeley campus. The series includes our annual Bioengineering Distinguished Lecture and Rising Star lecture.

Bioengineering Department Seminar: Read More [+]

Objectives Outcomes

Course Objectives: • To introduce students to bioengineering research as it is performed at Berkeley and at other institutions

• To give students opportunities to connect their own work to work in the field overall

• To give students an opportunity to meet with speakers who can inform and contribute to their post-graduation career paths

Student Learning Outcomes: To introduce students to the breadth of bioengineering research, both here at Berkeley and at other institutions, and help them to connect their work here at Berkeley to the field overall.

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Instructor: Faculty

Bioengineering Department Seminar: Read Less [-]

BIO ENG 196 Undergraduate Design Research 4 Units

Terms offered: Fall 2018, Fall 2017, Summer 2016 10 Week Session
Supervised research. This course will satisfy the Senior Bioengineering Design project requirement. Students with junior or senior status may pursue research under the direction of one of the members of the staff. May be taken a second time for credit only. A final report or presentation is required.

Undergraduate Design Research: Read More [a+]

Rules & Requirements

Prerequisites: Junior or senior status, consent of instructor and faculty adviser

Repeat rules: Course may be repeated for credit up to a total of 8 units. Course may be repeated for a maximum of 8 units.

Hours & Format

Fall and/or spring: 15 weeks - 4 hours of independent study per week

Summer: 10 weeks - 6 hours of independent study per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

Undergraduate Design Research: Read Less [-]

BIO ENG 198 Directed Group Study for Advanced Undergraduates 1 - 4 Units

Terms offered: Fall 2018, Spring 2018, Fall 2017
Group study of a selected topic or topics in bioengineering, usually relating to new developments.

Directed Group Study for Advanced Undergraduates: Read More [a+]

Rules & Requirements

Prerequisites: Upper division standing and good academic standing. (2.0 grade point average and above)

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week

Summer:

6 weeks - 2.5-10 hours of directed group study per week

8 weeks - 1.5-7.5 hours of directed group study per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Directed Group Study for Advanced Undergraduates: Read Less [-]

BIO ENG 199 Supervised Independent Study 1 - 4 Units

Terms offered: Fall 2016, Spring 2016, Fall 2015

Supervised independent study.

Supervised Independent Study: Read More [a+]

Rules & Requirements

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

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

Summer:

6 weeks - 2.5-10 hours of independent study per week

8 weeks - 1.5-7.5 hours of independent study per week

10 weeks - 1.5-6 hours of independent study per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

Supervised Independent Study: Read Less [-]