

# 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, 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 (<http://bioeng.berkeley.edu/undergrad/program/devices/>)
- Biomedical Imaging (<http://bioeng.berkeley.edu/undergrad/program/imaging/>)
- Cell & Tissue Engineering (<http://bioeng.berkeley.edu/undergrad/program/celltissue/>)
- Synthetic & Computational Biology (<http://bioeng.berkeley.edu/undergrad/program/syncompbio/>)

## 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/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/>).

## Lower Division Requirements

BIO ENG 10	Introduction to Biomedicine for Engineers <sup>1</sup>	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 <sup>2</sup>	5
	or CHEM 4A General Chemistry and Quantitative Analysis	
CHEM 3A & 3AL	Chemical Structure and Reactivity and Organic Chemistry Laboratory <sup>2</sup>	5
	or CHEM 12A Organic Chemistry	
ENGIN 7	Introduction to Computer Programming for Scientists and Engineers	4
	or COMPSI 61 The Structure and Interpretation of Computer Programs	

<sup>1</sup> Juniors transfers are exempted from taking BIO ENG 10.

<sup>2</sup> CHEM 4A and CHEM 12A are intended for students majoring in chemistry or a closely related field. Note: Prerequisites to CHEM 12A include CHEM 1B or CHEM 4B.

## Upper Division Requirements

A total of 24 upper division Bioengineering units, including the following: 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). 36

A minimum of 48 total units in engineering courses <sup>1</sup> 48

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

Six courses (of at least 3 units each) selected to meet the college's 18-24 current humanities and social studies requirements

<sup>1</sup> Students must complete a minimum of 48 engineering units. See concentrations (<http://bioeng.berkeley.edu/undergrad/program/concentrations/>) for recommendations. The 48 units of engineering courses cannot include: any course taken on a P/NP basis; courses numbered 24, 39, 84; BIOENG 100; CHMENG 185; COMPSCI 70, C79; DESINV courses (except DESINV 15, 22, 23, 90E, 190E); ENGIN 125, 157AC, 180, 183 series, 185, 187, 195 series; INDENG 95, 172, 185, 186, 190 series, 191, 192, 195; MECENG 191AC, 190K, 191K. There is no limit to the number of letter-graded research units that can be applied to the 48 engineering units.

## Bioengineering Fundamentals

Choose two courses from the approved Bioengineering Fundamentals Course list (<https://bioeng.berkeley.edu/undergrad/program/biofundamentals/>).

## Bioengineering Lab

Choose one course from the approved Bioengineering Lab Course list (<https://bioeng.berkeley.edu/undergrad/program/bioelabs/>).

## Technical Topics

- **Students must complete a minimum of 36 units of upper division Technical Topics courses.** Choose courses from the approved Technical Topics list (<http://bioeng.berkeley.edu/undergrad/program/techelect/>). See concentrations (<http://bioeng.berkeley.edu/undergrad/program/concentrations/>) for recommendations. Up to 8 units of research (BIO ENG H194 and/or BIO ENG 196) can be included in this total. The 36 units of upper division Technical Topics cannot include BIO ENG 100, 153, 253, or any other seminar-style courses or group meetings, or any course taken on a P/NP basis.
- **Students must complete a minimum of 24 units of upper division Bioengineering courses,** including at least two Bioengineering Fundamentals courses, one Bioengineering Design Project or Research course, and one Bioengineering Lab course. See concentrations (<http://bioeng.berkeley.edu/undergrad/program/concentrations/>) for recommendations. Up to 4 units of research (BIO ENG H194 and/or BIO ENG 196) can be included in this total. The 24 units of upper division Bioengineering courses cannot include

BIO ENG 100, 153, 253, or any other seminar-style courses or group meetings, or any course taken on a P/NP basis.

- COMPSCI 70 will not count towards the required 48 Engineering units.
- Students should take BIO ENG 103 instead of MCELLBI C100A. Credit applied for those who have already taken MCELLBI C100A before Fall 2017.

## Bioengineering Design Project or Research

Choose one course from the approved Bioengineering Design Project Course list (<https://bioeng.berkeley.edu/undergrad/program/design/>).

## Ethics

Choose one course from the approved Bioengineering Ethics Course list (<https://bioeng.berkeley.edu/undergrad/program/ethics/>). All Ethics courses of 3 units or more fulfill one Humanities/Social Sciences requirement.

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 more than two of the courses prior to applying will not be accepted into the minor; **students must apply first.**

## General Guidelines

1. All minors must be declared no later than one semester before a student's Expected Graduation Term (EGT). If the semester before EGT is fall or spring, the deadline is the last day of RRR week. If the semester before EGT is summer, the deadline is the final Friday of Summer Sessions. To declare a minor, contact the department advisor for information on requirements, and the declaration process.
2. All courses taken to fulfill the minor requirements must be taken for graded credit.
3. A minimum technical grade point average of 3.0 (math, science & engineering courses) is required for acceptance into the minor program.
4. A minimum grade point average (GPA) of 2.0 is required for courses used to fulfill the minor requirements.
5. No more than one upper division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
6. Completion of the minor program cannot delay a student's graduation.
7. 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 review all applications and students will be notified by email of the decision.
- Upon completion of the requirements for the minor, the student should complete the Confirmation of Completion form (<http://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 <sup>1</sup>	4
PHYSICS 7B	Physics for Scientists and Engineers <sup>1</sup>	4

<sup>1</sup> 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 (p. 1).
- Two upper division courses from the Technical Topics List (p. 1).
- Two upper division bioengineering courses. The following courses cannot be used: BIO ENG 100, 198, 199, H194, and 196.

## 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 (<https://engineering.berkeley.edu/students/undergraduate-guide/degree-requirements/major-programs/>) of 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) that can fulfill requirements for the student's major 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 five semesters to complete their degree requirements. 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 (<https://engineering.berkeley.edu/students/undergraduate-guide/policies-procedures/>) as they complete degree requirements.
7. Complete lower division technical courses before enrolling in upper division technical courses.

## Humanities and Social Sciences (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. See the humanities and social sciences (<https://engineering.berkeley.edu/students/undergraduate-guide/degree-requirements/humanities-and-social-sciences/>) section of our website for details.

## Class Schedule Requirements

- Minimum units per semester: 12.0
- Maximum units per semester: 20.5
- Minimum technical courses: College of Engineering undergraduates must include at least two letter graded technical courses (of at least 3 units each) in their semester program. Every semester students are expected to make satisfactory progress in their declared major. Satisfactory progress is determined by the student's Engineering Student Services Advisor. (Note: For most majors, normal progress (<https://engineering.berkeley.edu/academics/undergraduate-guide/policies-procedures/scholarship-progress/#ac12282>) will require enrolling in 3-4 technical courses required of your current major each semester.) Students who are not in compliance with this policy by the end of the fifth week of the semester are subject to a registration block that will delay enrollment for the following semester.
- All technical courses (math, science, engineering) that satisfy requirements for the major must be taken on a letter-graded basis (unless only offered as P/NP).

## Minimum Academic Requirements

- Students must have a minimum overall and semester grade point average of 2.00 (C average). Students 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 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 are required to earn a Bachelor of Science in the College of Engineering.
- Students must make normal degree progress toward the Bachelor of Science degree and their officially declared major.

## 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 (<https://engineering.berkeley.edu/students/undergraduate-guide/degree-requirements/major-programs/>) of study.
- A maximum of 16 units of special studies coursework (courses numbered 97, 98, 99, 197, 198, or 199) is allowed to count towards the B.S. degree, and no more than 4 units in any single term can be counted.
- A maximum of 4 units of physical education from any school attended will count towards the 120 units.
- Passed (P) grades may account for no more than one third of the total units completed at UC Berkeley, Fall Program for Freshmen (FPF), UC Education Abroad Program (UCEAP), or UC Berkeley Washington Program (UCDC) toward the 120 overall minimum unit requirement. Transfer credit is not factored into the limit. This includes transfer units from outside of the UC system, other UC campuses, credit-bearing exams, as well as UC Berkeley Extension XB units.

## Normal Progress

Students in the College of Engineering must enroll in a full-time program and make normal progress (<https://engineering.berkeley.edu/students/undergraduate-guide/policies-procedures/scholarship-progress/#ac12282>) each semester toward their declared major. Students who fail to achieve normal academic progress shall be subject to dismissal. (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/undergraduate/education/#earningyourdegreetext>)

All students who will enter the University of California as freshmen must demonstrate their command of the English language by satisfying the Entry Level Writing Requirement (ELWR). The UC Entry Level Writing Requirement website (<https://admission.universityofcalifornia.edu/elwr/>) provides information on how to satisfy the requirement.

American History and American Institutions (<http://guide.berkeley.edu/undergraduate/education/#earningyourdegreetext>)

The American History and Institutions (AH&I) requirements are based on the principle that a US 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/undergraduate/education/#earningyourdegreetext>)

The American Cultures requirement is a Berkeley campus requirement, one that all undergraduate students at Berkeley need to pass in order to graduate. You satisfy the requirement by passing, with a grade not lower than C- or P, an American Cultures course. You may take an American Cultures course any time during your undergraduate career at Berkeley.

The requirement was instituted in 1991 to introduce students to the diverse cultures of the United States through a comparative framework. Courses are offered in more than fifty departments in many different disciplines at both the lower and upper division level.

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.

For plans of study specific to bioengineering area concentrations, see the department website (<https://bioeng.berkeley.edu/undergrad/program/concentrations/>).

Freshman			
	Fall Units	Spring Units	
MATH 1A		4 MATH 1B	4
BIO ENG 10 <sup>11</sup>		4 PHYSICS 7A (taken Sophomore year in Synthetic Biology concentration)	4
CHEM 1A & 1AL <sup>1</sup>		5 CHEM 3A & 3AL <sup>1</sup>	5
BIO ENG 26 <sup>2</sup>		1 BIO ENG 25 <sup>2</sup>	1
Reading & Composition Part A Course <sup>3</sup>		4 Reading and Composition Part B Course <sup>3</sup>	4
18		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 Engineering Course <sup>4</sup>	3-4
Humanities/Social Sciences Course <sup>2,3</sup>		3-4 Humanities/ Social Sciences Course <sup>2,3</sup>	3-4
15-16		13-15	
Junior			
	Fall Units	Spring Units	
Bioengineering Fundamentals Course <sup>5</sup>		4 Bioengineering Fundamentals Course <sup>5</sup>	3-4
Upper Division Technical Topics Course <sup>6</sup>		3-4 Upper Division Technical Topics (also an Engineering Course) <sup>4,6</sup>	6-8
Engineering Course <sup>4</sup>		3-4 Humanities/ Social Sciences course <sup>2,3</sup>	3
BIO ENG 100 (or Humanities/Social Sciences course with Ethics content) <sup>2,3</sup>		3 Free Elective	3
13-15		15-18	
Senior			
	Fall Units	Spring Units	
Bioengineering Lab course <sup>7</sup>		4 Free Electives <sup>10</sup>	7



Upper Division Technical Topics Course <sup>4,6</sup>	3-4 Bioengineering Upper Division Courses <sup>9</sup>	8
Bioengineering Design Project or Research <sup>8</sup>	3-4	
Free Electives <sup>10</sup>	3-4	
<b>13-16</b>		<b>15</b>

**Total Units: 120-131**

- <sup>1</sup> CHEM 4A and 12A may be substituted for CHEM 1A and 3A. 4A and 12A are intended for students majoring in chemistry or a closely related field. Note: Prerequisites to CHEM 12A include CHEM 1B or CHEM 4B.
- <sup>2</sup> This requirement may be completed at any time in the program.
- <sup>3</sup> The Humanities/Social Sciences (H/SS) requirement includes two approved Reading & Composition (R&C) courses and four additional approved courses, with which a number of specific conditions must be satisfied. R&C courses must be taken for a letter grade (C- or better required). The first half (R&C Part A) must be completed by the end of the freshman year; the second half (R&C Part B) must be completed by no later than the end of the sophomore year. The remaining courses may be taken at any time during the program. See [engineering.berkeley.edu/hss](http://engineering.berkeley.edu/hss) (<https://engineering.berkeley.edu/students/undergraduate-guide/degree-requirements/humanities-and-social-sciences/>) for complete details and a list of approved courses. Consult the Ethics Content List (<http://bioeng.berkeley.edu/undergrad-program/ethics/>) for a list of approved courses with ethics content.
- <sup>4</sup> Students must complete a minimum of 48 engineering units. See concentrations (<http://bioeng.berkeley.edu/undergrad-program/concentrations/>) for recommendations. The 48 units of engineering courses cannot include: any course taken on a P/NP basis; courses numbered 24, 39, 84; BIO ENG 100; CHM ENG 185; COMPSI 70, C79; DES INV courses (except DES INV 15, 22, 23, 90E, 190E); ENGIN 125, 157AC, 180, 183 series, 185, 187, 195 series; IND ENG 95, 172, 185, 186, 190 series, 191, 192, 195; MEC ENG 191AC, 190K, 191K. There is no limit to the number of letter-graded research units that can be applied to the 48 engineering units.
- <sup>5</sup> Choose courses from the approved Bioengineering Fundamentals list (<http://bioeng.berkeley.edu/undergrad-program/biofundamentals/>). See concentrations (<http://bioeng.berkeley.edu/undergrad-program/concentrations/>) for recommendations.
- <sup>6</sup> Students must complete a minimum of 36 units of upper division Technical Topics courses. Choose courses from the approved Technical Topics list (<http://bioeng.berkeley.edu/undergrad-program/techelect/>). See concentrations (<http://bioeng.berkeley.edu/undergrad-program/concentrations/>) for recommendations. Up to 8 units of research (BIO ENG H194 and/or BIO ENG 196) can be included in this total. The 36 units of upper division Technical Topics courses cannot include BIO ENG 100, 153, 253, any other seminar-style courses or group meetings, or any course taken on a P/NP basis.
- <sup>7</sup> Choose course from the approved Bioengineering Lab list (<http://bioeng.berkeley.edu/undergrad-program/bioelabs/>). See concentrations (<http://bioeng.berkeley.edu/undergrad-program/concentrations/>) for recommendations.
- <sup>8</sup> Choose course from the approved Bioengineering Design Project or Research list (<http://bioeng.berkeley.edu/undergrad-program/design/>). See concentrations (<http://bioeng.berkeley.edu/undergrad-program/concentrations/>) for recommendations.
- <sup>9</sup> Students must complete a minimum of 24 units of upper division Bioengineering courses, including at least two Bioengineering Fundamentals courses, one Bioengineering Design Project or Research course, and one Bioengineering Lab course.

See concentrations (<http://bioeng.berkeley.edu/undergrad-program/concentrations/>) for recommendations. Up to 4 units of research (BIOENG H194 and/or BIOENG 196) can be included in this total. The 24 units of upper division Bioengineering courses cannot include BIOENG 100, 153, 253 any other seminar-style courses or group meetings, or any courses taken on a P/NP basis.

- <sup>10</sup> Free electives can be any technical or non-technical course, any course of your interest offered by any department; there are no restrictions. Free electives may be necessary in order to obtain the minimum 120 units for graduation.
- <sup>11</sup> 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.

Major Maps help undergraduate students discover academic, co-curricular, and discovery opportunities at UC Berkeley based on intended major or field of interest. Developed by the Division of Undergraduate Education in collaboration with academic departments, these experience maps will help you:

- **Explore** your major and gain a better understanding of your field of study
- **Connect** with people and programs that inspire and sustain your creativity, drive, curiosity and success
- **Discover** opportunities for independent inquiry, enterprise, and creative expression
- **Engage** locally and globally to broaden your perspectives and change the world
- **Reflect** on your academic career and prepare for life after Berkeley

Use the major map below as a guide to planning your undergraduate journey and designing your own unique Berkeley experience.

View the Bioengineering Major Map PDF. (<https://ue.berkeley.edu/sites/default/files/bioengineering.pdf>)

Bioengineering provides an array of programmatic and individual advising services. Each student is strongly encouraged to consult with a faculty advisor 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

### Undergraduate Advisor:

Marisela Loza

Phone: 510-642-5860

[mariselal@berkeley.edu](mailto:mariselal@berkeley.edu)

306C Stanley Hall

## 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 67% 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

Expand all course descriptions [+]Collapse all course descriptions [-]

## BIO ENG 10 Introduction to Biomedicine for Engineers 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022

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 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 [+]

### Objectives & Outcomes

**Student Learning Outcomes:** 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.

### Rules & Requirements

**Prerequisites:** MATH 1A or MATH 16A or another introductory calculus course (can be taken concurrently)

### 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, Johnson

Introduction to Biomedicine for Engineers: Read Less [-]

## BIO ENG 11 Engineering Molecules 1 3 Units

Terms offered: Spring 2024, Spring 2023, Spring 2022

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:** CHEM 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 2022, Spring 2021, Fall 2020

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 To be decided by the instructor when the class is offered.

Freshmen Seminar: [Read Less](#) [-]

## BIO ENG 25 Careers in Biotechnology 1 Unit

Terms offered: Spring 2024, Spring 2023, Spring 2022

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 not required.

Careers in Biotechnology: [Read Less](#) [-]

## BIO ENG 26 Introduction to Bioengineering 1 Unit

Terms offered: Fall 2024, Fall 2023, Fall 2022

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 98 Supervised Independent Group Studies 1 - 4 Units

Terms offered: Fall 2023, Fall 2022, Fall 2021

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: Spring 2020, Fall 2019, Spring 2019

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 2024, Spring 2024, Fall 2023

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 2024, Spring 2023, Spring 2022

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:** EECS 16A, EECS 16B, MATH 53, MATH 54, PHYSICS 7A, and PHYSICS 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 2024, Fall 2023, Fall 2022

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, MATH 54, and PHYSICS 7A

**Credit Restrictions:** Students will receive no credit for BIO ENG 102 after completing MEC ENG C85.

### 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 2023, Fall 2022, Fall 2021

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:** PHYSICS 7A, PHYSICS 7B, MATH 1A, MATH 1B, MATH 53, and MATH 54; and BIOLOGY 1A or BIO ENG 11

**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 2024, Spring 2023, Spring 2022

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:** MATH 53, MATH 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 2024, Fall 2022, Fall 2021

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, PHYSICS 7A, 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 required.

**Instructor:** Moriel Vandsburger

Engineering Devices 1: Read Less [-]

## BIO ENG C106A Introduction to Robotics 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021, Fall 2020, Fall 2019

This course is an introduction to the field of robotics. It covers the fundamentals of kinematics, dynamics, control of robot manipulators, robotic vision, sensing, forward & inverse kinematics of serial chain manipulators, the manipulator Jacobian, force relations, dynamics, & control. We will present techniques for geometric motion planning & obstacle avoidance. Open problems in trajectory generation with dynamic constraints will also be discussed. The course also presents the use of the same analytical techniques as manipulation for the analysis of images & computer vision. Low level vision, structure from motion, & an introduction to vision & learning will be covered. The course concludes with current applications of robotics.

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

### Rules & Requirements

**Prerequisites:** Familiarity with linear algebra at the level of EECS 16A/EECS 16B or Math 54. Experience coding in python at the level of COMPSI 61A. Preferred: experience developing software at the level of COMPSI 61B and experience using Linux

**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

**Summer:** 8 weeks - 6 hours of lecture, 2 hours of discussion, and 6 hours of laboratory per week

### Additional Details

**Subject/Course Level:** Bioengineering/Undergraduate

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

**Instructor:** Sastry

**Also listed as:** EECS C106A/MEC ENG C106A

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

## BIO ENG C106B Robotic Manipulation and Interaction 4 Units

Terms offered: Spring 2024, Spring 2023, Spring 2022, Spring 2021, Spring 2020, Spring 2019

The course is a sequel to EECS/BIOE/MEC106A/EECS206A, which covers the mathematical fundamentals of robotics including kinematics, dynamics and control as well as an introduction to path planning, obstacle avoidance, and computer vision. This course will present several areas of robotics and active vision, at a deeper level and informed by current research. Concepts will include the review at an advanced level of robot control, the kinematics, dynamics and control of multi-fingered hands, grasping and manipulation of objects, mobile robots: including non-holonomic motion planning and control, path planning, Simultaneous Localization And Mapping (SLAM), and active vision. Additional research topics covered at the instructor's discretion.

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

### Rules & Requirements

**Prerequisites:** EECS C106A / BIO ENG C106A / MEC ENG C106A / EECS C206A or an equivalent course. A strong programming background, knowledge of Python and Matlab, and some coursework in feedback controls (such as EL ENG C128 / MEC ENG C134) are also useful. Students who have not taken the prerequisite course should have a strong programming background, knowledge of Python and Matlab, and exposure to linear algebra, Lagrangian dynamics, and feedback controls at the intermediate level. EECS C106A

**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.

**Instructor:** Sastry

**Also listed as:** EECS C106B/MEC ENG C106B

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

## BIO ENG 110 Biomedical Physiology for Engineers 4 Units

Terms offered: Fall 2024, Spring 2024, Spring 2023

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:** BIO ENG 10; and BIO ENG 11 or BIOLOGY 1A; and 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 2024, Spring 2023, Spring 2022

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:** CHEM 1A or CHEM 4A; BIO ENG 11 or BIOLOGY 1A; and BIO ENG 103

### 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 2023, Spring 2022, Spring 2021, Spring 2020

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:** BIO ENG 102; or MEC ENG C85 / CIV ENG C30; 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. Alternative to final exam.

**Instructor:** Mofrad

**Also listed as:** MEC ENG C115

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

## BIO ENG 114 Cell Engineering 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022

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 and bioengineering technologies.

Cell Engineering: Read More [+]

### Objectives & Outcomes

**Course Objectives:** The goal of this course to establish fundamental understanding of cell engineering technologies and of the key biological paradigms, upon which cell engineering is based, with the focus on biomedical applications of cell engineering.

**Student Learning Outcomes:** At the completion of this course students will understand how bioengineering technologies address the deliberate control of cell properties (and how this advances biomedicine); and students will learn the main concepts and current views on key attributes of animal cells (somatic, embryonic, pluripotent, germ-line; with the focus on mammalian cells).

### Rules & Requirements

**Prerequisites:** BIOLOGY 1A or BIO ENG 11; or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 3 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 required.

**Instructor:** Conboy

Cell Engineering: Read Less [-]

## BIO ENG 115 Tissue Engineering Lab 4 Units

Terms offered: Fall 2023, Spring 2023, Fall 2022

This class provides a conceptual and practical understanding of cell and tissue bioengineering that is vital for careers in medicine, biotechnology, and bioengineering. Students are introduced to cell biology laboratory techniques, including immunofluorescence, quantitative image analysis, protein quantification, protein expression, gene expression, and cell culture.

Tissue Engineering Lab: Read More [ + ]

### Objectives & Outcomes

**Course Objectives:** The goal of this course to provide students with conceptual and practical understanding of cell and tissue bioengineering.

**Student Learning Outcomes:** At the completion of this course, students will learn key cellular bioengineering laboratory techniques, will develop a conceptual and theoretical understanding of the reliability and limitations of these techniques and will enhance their skills in quantitative data analysis, interpretation and integration.

### Rules & Requirements

**Prerequisites:** BIO ENG 11, BIO ENG 114 or BIO ENG 202, or consent of instructor

### Hours & Format

**Fall and/or spring:** 15 weeks - 4 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:** Conboy

Tissue Engineering Lab: Read Less [ - ]

## BIO ENG C117 Structural Aspects of Biomaterials 4 Units

Terms offered: Fall 2024, Spring 2023, Fall 2020

This course covers the basic design, materials selection, stress analysis and clinical case studies for load-bearing medical devices. Implant applications include orthopedics, dentistry and cardiology reconstructive surgery. FDA regulatory requirements and intellectual property issues are discussed. Case studies of medical devices elucidating the trade-offs in structural function and clinical performance are presented. Ongoing challenges with personalized implantable devices are addressed. This is a project-based course.

Structural Aspects of Biomaterials: Read More [ + ]

### Rules & Requirements

**Prerequisites:** MEC ENG 108, BIO ENG 102, MAT SCI 113 or equivalent

**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. Alternative to final exam.

**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 2024, Fall 2023, Fall 2022

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:** MAT SCI 45 and BIO ENG 103 are required. BIO ENG 102 and BIO ENG 104 are strongly recommended

## BIO ENG C119 Orthopedic Biomechanics 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022

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:** MEC ENG C85 / CIV ENG C30 or BIO ENG 102 (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 2024, Fall 2023, Fall 2022

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:** CHEM 3A; PHYSICS 7A and PHYSICS 7B; and BIO ENG 104 or equivalent transport 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. Alternative to final exam.

**Instructors:** Lee, Streets

BioMEMS and Medical Devices: [Read Less](#) [-]

## BIO ENG 121L BioMems and BioNanotechnology Laboratory 4 Units

Terms offered: Spring 2024, Spring 2023, Fall 2022

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:** BIO ENG 104; and BIO ENG 121 (can be taken concurrently)

**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:** Liepmann

BioMems and BioNanotechnology Laboratory: Read Less [-]

## BIO ENG 124 Basic Principles of Drug Delivery 3 Units

Terms offered: Fall 2024, Fall 2023, Fall 2021

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:** BIO ENG 11 or CHEM 3B; BIO ENG 103 and BIO ENG 104

### 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:** EL ENG 120 or 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](#) [+]

### Rules & Requirements

**Prerequisites:** EECS C106A / BIO ENG 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 [+]

### 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:** BIO ENG 11 or BIOLOGY 1A (may be taken concurrently); plus a programming course (ENGIN 7 or COMPSCI 61A)

**Credit Restrictions:** Students will receive no credit for BIO ENG 131 after completing BIO ENG 231. A deficient grade in BIO ENG 131 may be removed by taking BIO ENG C131.

### 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 C131 Introduction to Computational Molecular and Cell Biology 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022, Fall 2021

This class teaches basic bioinformatics and computational biology, with an emphasis on alignment, phylogeny, and ontologies. Supporting foundational topics are also reviewed with an emphasis on bioinformatics topics, including basic molecular biology, probability theory, and information theory.

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

### Rules & Requirements

**Prerequisites:** BioE 11 or Bio 1A (may be taken concurrently), plus a programming course (ENGIN 7 or CS 61A)

**Credit Restrictions:** Students will receive no credit for BIO ENG C131 after completing BIO ENG 131, BIO ENG C131, or BIO ENG C131. A deficient grade in BIO ENG C131 may be removed by taking BIO ENG C131, or BIO ENG C131.

### 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:** Holmes

**Also listed as:** CMPBIO C131

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

## BIO ENG 134 Genetic Design Automation 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022

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:** COMPSCI 61B, BIO ENG 11 and BIO ENG 103

### 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 2024, Spring 2022, Spring 2021

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:** INTEGBI 135 or consent of instructor. For Electrical Engineering and Computer Sciences students: EL ENG 105, EL ENG 120 or COMPSCI 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 4 Units

Terms offered: Fall 2024, Fall 2019, 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:** PHYSICS 7A, MATH 1A, and MATH 1B. Proficiency in MatLab or equivalent. Prior knowledge of biology or anatomy is not assumed

**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

## BIO ENG 140L Synthetic Biology Laboratory 4 Units

Terms offered: Spring 2024, Spring 2023, Spring 2022

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 [\[+\]](#)

### Objectives & Outcomes

**Course Objectives:** Designing and interpreting biological experiments  
Learning how to plan, coordinate, and implement a genetic engineering project in a group format  
To master the wetlab techniques of synthetic biology

**Student Learning Outcomes:** Students will be able to examine analytical data, interpret controls, and make decisions about next steps. Students will be able to perform synthetic biology experiments including reagent preparation, DNA manipulation, analytical methods, and microbiological techniques.

Students will be able to understand responsible conduct expectations for wetlab experimentalists.

Students will be able to understand the techniques and protocols used in synthetic biology.

Students will be able to work within a team and develop communication skills.

### Rules & Requirements

**Prerequisites:** BIO ENG 11 or BIOLOGY 1A

### 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 C142 Machine Learning, Statistical Models, and Optimization for Molecular Problems 4 Units

Terms offered: Spring 2024, Spring 2023

An introduction to mathematical optimization, statistical models, and advances in machine learning for the physical sciences. Machine learning prerequisites are introduced including local and global optimization, various statistical and clustering models, and early meta-heuristic methods such as genetic algorithms and artificial neural networks. Building on this foundation, current machine learning techniques are covered including deep learning artificial neural networks, Convolutional neural networks, Recurrent and long short term memory (LSTM) networks, graph neural networks, decision trees.

Machine Learning, Statistical Models, and Optimization for Molecular Problems: Read More [\[+\]](#)

### Objectives & Outcomes

**Course Objectives:** To build on optimization and statistical modeling to the field of machine learning techniques

To introduce the basics of optimization and statistical modeling techniques relevant to chemistry students

To utilize these concepts on problems relevant to the chemical sciences.

**Student Learning Outcomes:** Students will be able to understand the landscape and connections between numerical optimization, stand-alone statistical models, and machine learning techniques, and its relevance for chemical problems

### Rules & Requirements

**Prerequisites:** MATH 53 and MATH 54; CHEM 120A or CHEM 120B or BIO ENG 103

**Credit Restrictions:** Students will receive no credit for BIO ENG C142 after completing BIO ENG 142. A deficient grade in BIO ENG C142 may be removed by taking BIO ENG 142.

### 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. Alternate method of final assessment during regularly scheduled final exam group (e.g., presentation, final project, etc.).

**Instructor:** Teresa Head-Gordon

**Formerly known as:** Bioengineering C142/Chemistry C142

**Also listed as:** CHEM C142

Machine Learning, Statistical Models, and Optimization for Molecular Problems: 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., MCELLBI C100A / CHEM C130 or equivalent); and Python programming (e.g. COMPSCI 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 Introduction to Machine Learning for Computational Biology 4 Units

Terms offered: Spring 2024, Spring 2023, Spring 2022

Genome-scale experimental data and modern machine learning methods have transformed our understanding of biology. This course investigates classical approaches and recent machine learning advances in genomics including:

- 1)Computational models for genome analysis
- 2)Applications of machine learning to high throughput biological data
- 3)Machine learning for genomic data in health

This course builds on existing skills to introduce methodologies for probabilistic modeling, statistical learning, and dimensionality reduction, while grounding these methods in understanding genomic information. Introduction to Machine Learning for Computational Biology: [Read More](#) [+]

### Objectives & Outcomes

**Course Objectives:** This course aims to equip students with a foundational understanding of computational and machine learning techniques used in genomics and computational biology.

**Student Learning Outcomes:** Students completing this course should have a better understanding of some of the challenges in machine learning as applied to biology  
Students completing this course should have stronger programming skills.

Students completing this course should have the ability to apply simple statistical and machine learning techniques to complex genomics data

### Rules & Requirements

**Prerequisites:** Bio 1A or BioE 11, Math 54, CS61B; CS70 or Math 55 recommended

**Credit Restrictions:** Students will receive no credit for BIO ENG 145 after completing BIO ENG 245. A deficient grade in BIO ENG 145 may be removed by taking BIO ENG 245.

### 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. Alternative to final exam.

**Instructor:** Lareau

Introduction to Machine Learning for 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 C146 Data Science for Biology 3 Units

Terms offered: Spring 2024, Fall 2022, Spring 2007, Spring 2005

Biology has become a data science! This lab course aims for student curiosity to drive hands-on case studies and coding projects about biological applications of data science. The course design supports students' development of fundamental and transferable computational and statistical skills for critically thinking about and using data in biology. Ethical considerations are interwoven throughout. This course offers projects with multiple levels of sophistication and complexity, enabling participation for students with varying levels of experience.

Data Science for Biology: Read More [+]

### Objectives & Outcomes

**Course Objectives:** Students will become empowered to use basic coding approaches to access, work with, and analyze biological data. Students will learn how to appropriately apply statistical tests to biological data. Students will learn how to select and evaluate methods and tools for data analysis. Students will understand how to grapple with the ethical considerations of biological data.

### Rules & Requirements

**Prerequisites:** Biology 1A; Biology 1B (can be taken concurrently); Data C8 or equivalent statistics and programming experience

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Bioengineering/Undergraduate

**Grading/Final exam status:** Letter grade. Alternate method of final assessment during regularly scheduled final exam group (e.g., presentation, final project, etc.).

**Instructors:** Brenner, Eisen

**Also listed as:** MCELLBI C146/PLANTBI C146

Data Science for Biology: Read Less [-]

## BIO ENG 147 Principles of Synthetic Biology 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2021

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 MATH 54; and BIO ENG 103 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 2024, Fall 2023, Fall 2022

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 and BIO ENG 103

### 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 C149 Computational Functional Genomics 4 Units

Terms offered: Fall 2024, Fall 2023

This course provides a survey of the computational analysis of genomic data, introducing the material through lectures on biological concepts and computational methods, presentations of primary literature, and practical bioinformatics exercises. The emphasis is on measuring the output of the genome and its regulation. Topics include modern computational and statistical methods for analyzing data from genomics experiments: high-throughput RNA sequencing data, single-cell data, and other genome-scale measurements of biological processes. Students will perform original analyses with Python and command-line tools.

Computational Functional Genomics: [Read More](#) [+]

### Objectives & Outcomes

**Course Objectives:** This course aims to equip students with practical proficiency in bioinformatics analysis of genomic data, as well as understanding of the biological, statistical, and computational underpinnings of this field.

**Student Learning Outcomes:** Students completing this course should have stronger programming skills, practical proficiency with essential bioinformatics methods that are applicable to genomics research, understanding of the statistics underlying these methods, and awareness of key aspects of genome function and challenges in the field of genomics.

### Rules & Requirements

**Prerequisites:** MATH 54 or EECS 16A/B; COMPSI 61A or equivalent Python course; BIOENG 11 or BIOLOGY 1A; and BIOENG 131. Introductory statistics or data science is 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. Alternative to final exam.

**Instructor:** Lareau

**Also listed as:** CMPBIO C149

Computational Functional Genomics: [Read Less](#) [-]

## BIO ENG 150 Introduction of Bionanoscience and Bionanotechnology 4 Units

Terms offered: Fall 2024, Fall 2023, Fall 2021

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 basis 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:** BIO ENG 11 or BIOLOGY 1A; and CHEM 1A

### Hours & Format

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

## 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:** BIO ENG 11 or CHEM 3B; BIO ENG 104, MEC ENG 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 153 Biotechnology Entrepreneurship: Impact, History, Therapeutics R&D, Entrepreneurship & Careers 2 Units

Terms offered: Spring 2024, Spring 2023, Spring 2021

This course is designed for students interested in an introduction to the biotechnology entrepreneurship, biotherapeutics R and D, and careers in the industry. Students should be interested in the impact of biotechnology on medicine and society, the history of the field (including individual scientists, entrepreneurs and companies), key methodologies, therapeutic product classes, entrepreneurship and innovation within the life sciences. Students will learn principles of drug and biologics discovery, development and commercialization, and will be exposed to the range of careers in the biopharmaceutical industry. Students should be considering careers in the biopharmaceutical and life sciences fields. Biotechnology Entrepreneurship: Impact, History, Therapeutics R&D, Entrepreneurship & Careers: Read More [+] **Objectives & Outcomes**

**Course Objectives:** To educate students on biopharmaceutical company entrepreneurship and innovation through team-based hands on virtual company creation

To educate students on careers in the biopharmaceutical industry

To educate students on the history of the field and industry, including key methodologies, technologies, scientists, entrepreneurs, and companies

To foster understanding and appreciation for the medical and societal impact of the biopharmaceutical field and industry

To introduce the key steps in the process of discovery, development and commercialization of novel therapeutics

**Student Learning Outcomes:** Entrepreneurship principles, including those defined by the Lean Launchpad approach (including the Business Model Canvas, the Minimum Viable Product and Customer Discovery).

The history of the biotech industry

The impact of the biopharmaceutical industry on medicine and society

The methods, product technologies and development methodologies that have driven the evolution of the field

The nature of the ecosystem and specific careers in the biopharmaceutical industry

The product design and development process (with a focus on biotherapeutics), including opportunities and challenges

### Rules & Requirements

**Prerequisites:** Consent of instructor

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Bioengineering/Undergraduate

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

**Instructor:** Kirn

Biotechnology Entrepreneurship: Impact, History, Therapeutics R&D, Entrepreneurship & Careers: Read Less [-]



## BIO ENG C157 Nanomaterials in Medicine 3 Units

Terms offered: Fall 2022, Fall 2021, Fall 2020

Nanomedicine is an emerging field involving the use of nanoscale materials for therapeutic and diagnostic purposes. Nanomedicine is a highly interdisciplinary field involving chemistry, materials science, biology and medicine, and has the potential to make major impacts on healthcare in the future. This upper division course is designed for students interested in learning about current developments and future trends in nanomedicine. The overall objective of the course is to introduce major aspects of nanomedicine including the selection, design and testing of suitable nanomaterials, and key determinants of therapeutic and diagnostic efficacy. Organic, inorganic and hybrid nanomaterials will be discussed in this course.

Nanomaterials in Medicine: Read More [\[+\]](#)

### Objectives & Outcomes

**Course Objectives:** To identify an existing or unmet clinical need and identify a nanomedicine that can provide a solution  
To learn about chemical approaches used in nanomaterial synthesis and surface modification.  
To learn how to read and critique the academic literature.  
To understand the interaction of nanomaterials with proteins, cells, and biological systems.

### Rules & Requirements

**Prerequisites:** MAT SCI 45 or 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.

**Instructor:** Messersmith

**Also listed as:** MAT SCI C157

Nanomaterials in Medicine: Read Less [\[-\]](#)

## BIO ENG 163 Principles of Molecular and Cellular Biophotonics 4 Units

Terms offered: Fall 2024, Fall 2022, Fall 2018

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:** CHEM 3A and PHYSICS 7B; and BIO ENG 102 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. Alternative to final exam.

**Instructor:** Marriott

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

## BIO ENG 163L Molecular and Cellular Biophotonics Laboratory 4 Units

Terms offered: Spring 2024, Spring 2023, Spring 2022

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:** BIO ENG 163 (may be taken 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 and PHYSICS 7B; or PHYSICS 8A and PHYSICS 8B

### 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 2024, Fall 2023, Fall 2022

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:** Prerequisites are introductory level skills in Python/Matlab; and either EECS 16A, EECS 16B, and EL ENG 120; or MATH 54, BIO ENG 105, and BIO ENG 101

### 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 166 Biomedical Imaging Systems II: Targeted Molecular Imaging in Disease 4 Units

Terms offered: Spring 2024, Spring 2023, Spring 2022

This course is designed as an introduction to the growing world of molecular imaging in medicine and research. The course is divided into five modules based on common imaging modalities (optical imaging, ultrasound methods, radiography, nuclear imaging, and magnetic resonance approaches). Within each module the fundamental physics and engineering behind each modality, corresponding methods for targeted molecular imaging including contrast mechanisms and probe design, and signal and image processing algorithms are covered. Homework assignments will utilize imaging data from either clinical or research studies in order to provide training in MATLAB based image analysis techniques.

Biomedical Imaging Systems II: Targeted Molecular Imaging in Disease: [Read More](#) [+]

### Objectives & Outcomes

**Course Objectives:** Discuss limitations to each targeted approach including non-specific binding, unbound probe clearance, signal decay, etc.

Discuss the design of targeted molecular contrast agents for each modality across myriad biological applications

Establish a foundational understanding of MRI (multi-spectral), PET/ SPECT, Ultrasound (including photo-acoustic imaging), and emerging methods including MPI

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

Reinforce mathematical principles relevant to image analysis including linear algebra, convolution and differential equations

To discuss imaging ethics in the context of data interpretation

To expose students interested in biomedical research or clinical practice to fundamentals of modern imaging methods and interpretation

To learn quantitative approaches to analyze biomedical images (includes pharmacokinetic models, attenuation correction, cross modality registration, etc.)

**Student Learning Outcomes:** Analyze imaging data derived from imaging studies using commonly utilized image processing techniques  
Critically evaluate scientific publications in the molecular imaging space.

Understand the devices, techniques and protocols used for in vivo imaging in research and clinical settings

### Rules & Requirements

**Prerequisites:** BIO ENG C165 or BIO ENG 163; and BIO ENG 101 plus BIO ENG 105 or EECS 16A plus EECS 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:** Vandsburger

Biomedical Imaging Systems II: Targeted Molecular Imaging in Disease: [Read Less](#) [-]

## BIO ENG 168L Practical Light Microscopy 3 Units

Terms offered: Fall 2024, Fall 2023, Fall 2022

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 171 Interface Between Neuroethology & Neural Engineering 3 Units

Terms offered: Spring 2023, Spring 2021

The course will provide students with an overview of the tight interface between neural engineering and neuroethological approaches in the field of neuroscience. This course will also discuss the concepts of causal manipulations, such as the control of brain circuits using optics and genetic engineering. Lastly, students will also inquire and discuss what discoveries have yet to be made and how neuroethological approaches can inform neural engineering designs that will revolutionize the future of neural medicine.

Interface Between Neuroethology & Neural Engineering: Read More [\[+\]](#)

### Objectives & Outcomes

**Course Objectives:** Understand the close interface between studies of the nervous system and technology

**Student Learning Outcomes:** The course will review the utilization, development and implementation of a wide diversity of neural engineering technologies to the study of the brain. Students will discuss the bidirectional road between the two approaches.

The overreaching goal of this course is to expose student interested in neural engineering to the remarkable history of neuroethological approaches that have been a foundation of discoveries in the field.

### Rules & Requirements

**Prerequisites:** BIO ENG 105; and BIO ENG 101 or EECS 16A and EECS 16B; or 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.

**Instructor:** Yartsev

Interface Between Neuroethology & Neural Engineering: 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.

### 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: Spring 2024, Fall 2023, Spring 2023

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 5 Units

Terms offered: Spring 2024, Fall 2021, Fall 2020

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.

Senior Design Projects: Read More [a+]

### 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: Fall 2019, Fall 2018, Spring 2016

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 [a+]

### 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.

### 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 [a+]

### 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 2 - 4 Units

Terms offered: Fall 2019, Fall 2018, Fall 2017

Supervised research. This course will satisfy the Bioengineering Design project/research requirement. Students with junior or senior status may pursue research under the direction of one of the members of the staff. A final report or presentation is required. For Bioengineering majors, the following policies apply: A maximum of 8 units of graded research units (BIO ENG H194 and/or BIO ENG 196) can be counted towards the Upper Division Technical Topics unit requirement. A maximum of 4 graded research units can be used towards the Upper Division Bioengineering Unit requirement. There is no limit to the number of letter-graded research units that can be applied to the 48 Engineering Unit requirement.

Undergraduate Design Research: Read More [+]

### 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.

### Hours & Format

**Fall and/or spring:** 15 weeks - 2-4 hours of independent study per week

**Summer:** 10 weeks - 3-9 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 2022, Fall 2021, Spring 2021

Group study of a selected topic or topics in bioengineering, usually relating to new developments.

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

### 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 2021, Spring 2021, Fall 2020

Supervised independent study.

Supervised Independent Study: Read More [+]

### 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 [-]