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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO ENG 10</td>
<td>Introduction to Biomedicine for Engineers ¹</td>
<td>4</td>
</tr>
<tr>
<td>BIO ENG 11</td>
<td>Engineering Molecules 1</td>
<td>3</td>
</tr>
<tr>
<td>BIO ENG 25</td>
<td>Careers in Biotechnology</td>
<td>1</td>
</tr>
<tr>
<td>BIO ENG 26</td>
<td>Introduction to Bioengineering</td>
<td>1</td>
</tr>
<tr>
<td>MATH 1A</td>
<td>Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1B</td>
<td>Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 53</td>
<td>Multivariable Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 54</td>
<td>Linear Algebra and Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 7A</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 7B</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 1A &amp; 1AL</td>
<td>General Chemistry and General Chemistry Laboratory ²</td>
<td>5</td>
</tr>
<tr>
<td>or CHEM 4A</td>
<td>General Chemistry and Quantitative Analysis</td>
<td></td>
</tr>
<tr>
<td>CHEM 3A &amp; 3AL</td>
<td>Chemical Structure and Reactivity and Organic Chemistry Laboratory ²</td>
<td>5</td>
</tr>
<tr>
<td>or CHEM 12A</td>
<td>Organic Chemistry</td>
<td></td>
</tr>
<tr>
<td>ENGIN 7</td>
<td>Introduction to Computer Programming for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>or COMPSCI 61A</td>
<td>The Structure and Interpretation of Computer Programs</td>
<td></td>
</tr>
</tbody>
</table>

¹ Juniors transfers are exempted from taking BIO ENG 10.
Upper Division Requirements

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

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).
A minimum of 48 total units in engineering courses
Ethics Requirement: Choose one course from list below.
Six courses (of at least 3 units each) selected to meet the college’s 18-24 current humanities and social studies requirements

1 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/bioefundamentals/).

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.
- Students should take BIO ENG 103 instead of MCELLBI C100A. Credit applied for those who have already taken MCELLBI C100A before Fall 2017.

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.

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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 3A</td>
<td>Chemical Structure and Reactivity</td>
<td>3</td>
</tr>
<tr>
<td>MATH 53</td>
<td>Multivariable Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 54</td>
<td>Linear Algebra and Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 7A</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 7B</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
</tbody>
</table>

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

**Upper Division Minor Requirements**

• One course from the BioE Fundamentals List (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 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/).

<table>
<thead>
<tr>
<th>Bioengineering Foundation Course²</th>
<th>Fall Units</th>
<th>Spring Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 53</td>
<td>4</td>
<td>BIO ENG 11</td>
</tr>
<tr>
<td>PHYSICS 7B</td>
<td>4</td>
<td>MATH 54</td>
</tr>
<tr>
<td>ENGIN 7 or COMPSCI 61A</td>
<td>4</td>
<td>Engineering Course⁴</td>
</tr>
<tr>
<td>Humanities/Social Sciences Course²³</td>
<td>3-4</td>
<td>3-4</td>
</tr>
<tr>
<td>BIO ENG 100 (or Humanities/Social Sciences course with Ethics content)²³</td>
<td>3</td>
<td>Free Elective</td>
</tr>
</tbody>
</table>

| Upper Division Technical Topics Course⁵ | 3-4 |
| Engineering Course⁶ | 3-4 |
| BIO ENG 100 (or Humanities/Social Sciences course with Ethics content)²³ | 3 | Free Elective |

<table>
<thead>
<tr>
<th>Bioengineering Lab course⁷</th>
<th>Fall Units</th>
<th>Spring Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Free Electives¹⁰</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>
Upper Division Technical Topics Course\(^6\) 3-4  Bioengineering\(^7\) 8  
<table>
<thead>
<tr>
<th>Upper Division Courses(^9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioengineering Design Project or Research(^8) 3-4</td>
</tr>
<tr>
<td>Free Electives(^10) 3-4</td>
</tr>
<tr>
<td><strong>Total Units:</strong> 120-131</td>
</tr>
</tbody>
</table>

1. 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.
2. This requirement may be completed at any time in the program.
3. 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 (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.
4. 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; COMPSCI 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.
5. 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.
6. 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, any other seminar-style courses or group meetings, or any course taken on a P/NP basis.
7. 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.
8. 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.
9. 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.

10. 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.

11. 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
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 2023, Fall 2022, Fall 2021
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

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 not required.

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 2023, Fall 2022, Fall 2021 
This introductory seminar is designed to give freshmen and sophomores a glimpse of a broad selection of bioengineering research that is currently underway at Berkeley and UCSF. Students will become familiar with bioengineering applications in the various concentration areas and see how engineering principles can be applied to biological and medical problems. 
Introduction to Bioengineering: Read More [+]

Objectives & Outcomes

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

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

Hours & Format

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

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

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

Instructors: T. Johnson, H. Lam

Introduction to Bioengineering: Read Less [-]

BIO ENG 84 Sophomore Seminar 1 or 2 Units  
Terms offered: Spring 2018, Spring 2017, Spring 2013 
Sophomore seminars are small interactive courses offered by faculty members in departments all across the campus. Sophomore seminars offer opportunity for close, regular intellectual contact between faculty members and students in the crucial second year. The topics vary from department to department and semester to semester. Enrollment limited to 15 sophomores.

Sophomore Seminar: Read More [+]

Rules & Requirements

Prerequisites: At discretion of instructor

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

Hours & Format

Fall and/or spring: 
5 weeks - 3-6 hours of seminar per week
10 weeks - 1.5-3 hours of seminar per week
15 weeks - 1-2 hours of seminar per week

Summer: 
6 weeks - 2.5-5 hours of seminar per week
8 weeks - 1.5-3.5 hours of seminar and 2-4 hours of seminar per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate

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

Sophomore Seminar: Read Less [-]

BIO ENG 98 Supervised Independent Group Studies 1 - 4 Units  
Terms offered: Fall 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 Curriculum 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.

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.

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.

BIO ENG 100 Ethics in Science and Engineering 3 Units
Terms offered: Spring 2024, Fall 2023, Spring 2022
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.

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

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

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.

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

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 2023, Fall 2022, Spring 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 [+]

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 2022, Fall 2021, Fall 2020
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 [+]

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 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 COMPSCI 61A. Preferred: experience developing software at the level of COMPSCI 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: Spring 2024, Spring 2023, Spring 2022
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.

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.

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.  
**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

**BIO ENG 113 Stem Cells and Technologies 4 Units**
Terms offered: Fall 2015, Fall 2014, Fall 2013
This course will teach the main concepts and current views on key attributes of embryonic stem cells (ESC), will introduce theory of their function in embryonic development, methods of ESC derivation, propagation, and characterization, and will discuss currently developing stem cell technologies.  
**Rules & Requirements**  
**Prerequisites:** BIO ENG 10 and BIOLOGY 1A; or consent of instructor  
**Hours & Format**  
Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week  
**Additional Details**  
**Subject/Course Level:** Bioengineering/Undergraduate  
**Grading/Final exam status:** Letter grade. Final exam required.  
**Instructor:** Conboy

Also listed as: MEC ENG C115
BIO ENG 114 Cell Engineering 4 Units
Terms offered: Fall 2023, Fall 2022, Fall 2021
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 116 Cell and Tissue Engineering 4 Units
Terms offered: Spring 2016, Spring 2015, Spring 2014
The goal of tissue engineering is to fabricate substitutes to restore tissue structure and functions. Understanding cell function in response to environmental cues will help us to establish design criteria and develop engineering tools for tissue fabrication. This course will introduce the basic concepts and approaches in the field, and train students to design and engineer biological substitutes.

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

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

Rules & Requirements
Prerequisites: BIO ENG 103 and BIO ENG 104

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

Additional Details
Subject/Course Level: Bioengineering/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Li

Cell and Tissue Engineering: Read Less [-]

BIO ENG C117 Structural Aspects of Biomaterials 4 Units
Terms offered: Spring 2023, Fall 2020, Spring 2019
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.

Objectives & Outcomes
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 2023, Fall 2022, Fall 2021
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 [+]

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 2023, Fall 2022, Fall 2020
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 [+]

Course Objectives:
1. Apply biophysical and chemical principles of orthopedic devices, microsystems, clinical lab-on-a-chip, advanced biomolecular probes, etc.
2. Analyze forces and moments acting on human joints in orthopedic devices.
3. Design and analyze orthopedic devices using optimization theory.

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.

Orthopedic Biomechanics: Read Less [-]

BIO ENG 121 BioMEMS and Medical Devices 4 Units
Terms offered: Fall 2023, Fall 2022, Fall 2021
Biophysical and chemical principles of biomedical devices, biomanufacturing, biophotonics, and biomedical microelectromechanical systems (BioMEMS). Topics include basics of nano- and microfabrication, soft-lithography, DNA arrays, protein arrays, electrophoresis, 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 [+]

Course Objectives:
1. Apply biophysical and chemical principles of biomedical devices, microsystems, clinical lab-on-a-chip, advanced biomolecular probes, etc.
2. Analyze forces and moments acting on human joints in orthopedic devices.
3. Design and analyze orthopedic devices using optimization theory.

Rules & Requirements
Prerequisites: CHEM 3A; PHYSICS 7A and PHYSICS 7B; and BIO ENG 104 or equivalent transport course

Orthopedic Biomechanics: 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.

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

BIO ENG 124 Basic Principles of Drug Delivery 3 Units
Terms offered: Fall 2023, Fall 2021, Fall 2020
This course focuses on providing students with the foundations needed to understand contemporary literature in drug delivery. Concepts in organic chemistry, biochemistry, and physical chemistry needed to understand current problems in drug delivery are emphasized.

Objectives & Outcomes

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

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

Rules & Requirements

Prerequisites: 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.

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 131, BIO ENG C131, or BIO ENG C131. A deficient grade in BIO ENG C131 may be removed by taking BIO ENG C131, 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 2023, Fall 2022, Fall 2021, Fall 2020
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.

Objectives & Outcomes

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

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

Rules & Requirements

Prerequisites: BioE 11 or Bio 1A (may be taken concurrently), 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 132 Genetic Devices 4 Units**  
Terms offered: Spring 2018, Fall 2014, Fall 2013  
This senior-level course is a comprehensive survey of genetic devices. These DNA-based constructs are comprised of multiple "parts" that together encode a higher-level biological behavior and perform useful human-defined functions. Such constructs are the engineering target for most projects in synthetic biology. Included within this class of constructs are genetic circuits, sensors, biosynthetic pathways, and microbiological functions.  
Genetic Devices: Read More [+]

**Objectives & Outcomes**

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

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

**Rules & Requirements**

Prerequisites: COMPSCI 61A, MATH 53, MATH 54, CHEM 3A, and BIO ENG 103; CHEM 3B or BIO ENG 11

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

**Hours & Format**

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

**Additional Details**

Subject/Course Level: Bioengineering/Undergraduate

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

Instructor: Anderson

Genetic Devices: Read Less [-]

**BIO ENG 133 Biomolecular Engineering 3 Units**  
Terms offered: Prior to 2007  
This is an introductory course of biomolecular engineering and is required for all CBE graduate students. Undergraduates with knowledge of thermodynamics and transport are also welcome. The topics include structures, functions, and dynamics of biomolecules; molecular tools in biotechnology; metabolic and signaling networks in cellular engineering; and synthetic biology and biomedical engineering applications.  
Biomolecular Engineering: Read More [+]

**Objectives & Outcomes**

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

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

**Rules & Requirements**

Prerequisites: BIO ENG 104; or CHM ENG 150A and CHM ENG 150B; or consent of instructor. A course in statistical mechanics and/or thermodynamics is recommended

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

**Hours & Format**

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

**Additional Details**

Subject/Course Level: Bioengineering/Undergraduate

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

Instructor: Schaffer

Biomolecular Engineering: Read Less [-]
**BIO ENG 134 Genetic Design Automation 4 Units**

Terms offered: Fall 2023, Fall 2022, Fall 2021

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.

**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 More [+]

---

**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.

**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
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.

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 More [+]

BIO ENG C137 Designing for the Human Body 4 Units
Terms offered: 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., protheses 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.

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.

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.

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., MCELLBIO 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 - 4 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 2023, Fall 2021, Fall 2020
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 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 2023, Fall 2022, Fall 2020
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 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; COMPSCI 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 2023, Fall 2021, Fall 2020

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 understand the assembly principle of biological materials, including collagen, 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 bio-nanotechnology.

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 - 2 hours of lecture per week

Additional Details

Subject/Course Level: Bioengineering/Undergraduate  
Grading/Final exam status: Letter grade. Final exam required.

Instructor: Herr

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: Herr

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

BIO ENG 163 Principles of Molecular and Cellular Biophotonics 4 Units
Terms offered: Fall 2022, Fall 2018, Fall 2017
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

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.

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 More [+]

BIO ENG C165 Medical Imaging Signals and Systems 4 Units
Terms offered: Fall 2023, Fall 2022, Fall 2021
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.

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

BIO ENG 168L Practical Light Microscopy 3 Units

Terms offered: Fall 2023, Fall 2022, Fall 2021

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.

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

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.

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.

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 [+]

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 [+]

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 [+]

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
10 weeks - 1.5-6 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 [-]