

# Bioengineering/ Materials Science and Engineering Joint Major

## Bachelor of Science (BS)

The joint major programs are designed for students who wish to undertake study in two areas of engineering in order to qualify for employment in either field or for positions in which competence in two fields is required. These curricula include the core courses in each of the major fields. While they require slightly increased course loads, they can be completed in four years. Both majors are shown on the student's transcript of record.

The Bioengineering/Materials Science and Engineering Joint Major is for students who have a keen interest in the field of biomaterials. Students will study the design and synthesis of novel materials that will define new paradigms in biomaterials from the molecular through macroscopic levels, and will also receive a broad-based learning experience that will include exposure to fundamental courses in engineering and life sciences. This joint major aims to allow the student to understand the interface between the two major fields. Students taking this double major will successfully compete for jobs in the field of biomaterials in the academe, industry, and government.

## Admission to the Joint Major

Admission directly to a joint major is closed to freshmen and junior transfer applicants. Students interested in a joint program may apply to change majors during specific times in their academic progress. Please see the College of Engineering joint majors website (<http://engineering.berkeley.edu/academics/majors-minors/joint-majors/>) for complete details.

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

## General Guidelines

1. All 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.

## Lower Division Requirements

MATH 1A	Calculus	4
MATH 1B	Calculus	4
MATH 53	Multivariable Calculus	4
MATH 54	Linear Algebra and Differential Equations	4
CHEM 1A & 1AL	General Chemistry and General Chemistry Laboratory <sup>1</sup>	5
or CHEM 4A	General Chemistry and Quantitative Analysis	
CHEM 3A & 3AL	Chemical Structure and Reactivity and Organic Chemistry Laboratory <sup>1</sup>	5
or CHEM 12A	Organic Chemistry	
PHYSICS 7A	Physics for Scientists and Engineers	4
PHYSICS 7B	Physics for Scientists and Engineers	4
BIO ENG 10	Introduction to Biomedicine for Engineers	4
BIO ENG 11	Engineering Molecules 1	3
BIO ENG 26	Introduction to Bioengineering	1
ENGIN 7	Introduction to Computer Programming for Scientists and Engineers	4
or COMPSI 6	The Structure and Interpretation of Computer Programs	
MAT SCI 45	Properties of Materials	3
MAT SCI 45L	Properties of Materials Laboratory	1

<sup>1</sup> CHEM 4A and CHEM 12A are intended for students majoring in chemistry or a closely-related field.

## Upper Division Requirements

Please note that technical courses listed below fulfill only one requirement.

BIO ENG 102	Biomechanics: Analysis and Design	4
BIO ENG 103	Engineering Molecules 2	4
BIO ENG 104	Biological Transport Phenomena	4
BIO ENG C118	Biological Performance of Materials	4
MAT SCI 102	Bonding, Crystallography, and Crystal Defects	3
MAT SCI 103	Phase Transformations and Kinetics	3
MAT SCI 104 & 104L	Materials Characterization and Materials Characterization Laboratory	4
MAT SCI 130	Experimental Materials Science and Design	3
or BIO ENG 11	Tissue Engineering Lab	
MAT SCI 151	Polymeric Materials	3
BIO ENG 110	Biomedical Physiology for Engineers	4
or BIO ENG 11	Cell Engineering	
ENGIN 40	Engineering Thermodynamics	3-4
or CHEM 120B	Physical Chemistry	
MAT SCI Electives: Select two courses from the following: <sup>1</sup>		6-7
MAT SCI 111	Properties of Electronic Materials [4]	
MAT SCI 112	Corrosion (Chemical Properties) [3]	
MAT SCI 113	Mechanical Behavior of Engineering Materials [3]	
MAT SCI 130	Experimental Materials Science and Design [3]	
BIO ENG Elective: Select one of the following: <sup>1</sup>		3-4
BIO ENG 110	Biomedical Physiology for Engineers [4]	
BIO ENG 111	Functional Biomaterials Development and Characterization [4]	

BIO ENG 114	Cell Engineering [4]	
BIO ENG 115	Tissue Engineering Lab [4]	
BIO ENG C117	Structural Aspects of Biomaterials [4]	
BIO ENG 121	BioMEMS and Medical Devices [4]	
BIO ENG 124	Basic Principles of Drug Delivery [3]	
BIO ENG 150	Introduction of Bionanoscience and Bionanotechnology [4]	
Bioengineering Design Project or Research: Select one of the following:		3-4
BIO ENG 121L	BioMems and BioNanotechnology Laboratory [4]	
BIO ENG 140L	Synthetic Biology Laboratory [4]	
BIO ENG 168L	Practical Light Microscopy [3]	
BIO ENG 192	Senior Design Projects [4]	
BIO ENG H194	Honors Undergraduate Research [3,4]	
BIO ENG 196	Undergraduate Design Research [4]	
Ethics requirement, select one of the following: <sup>2</sup>		3-4
BIO ENG 100	Ethics in Science and Engineering [3]	
ENGIN 125	Ethics, Engineering, and Society [3]	
ENGIN/IAS 157AC	Engineering, The Environment, and Society [4]	
ESPM 161	Environmental Philosophy and Ethics [4]	
ESPM 162	Bioethics and Society [4]	
HISTORY C182C/ ISF C100G/ STS C100	Introduction to Science, Technology, and Society [4]	
L & S 160B	Effective Personal Ethics for the Twenty-First Century [3]	
PHILOS 104	Ethical Theories [4]	
PHILOS 107	Moral Psychology [4]	

<sup>1</sup> Cannot be a course you have taken to fulfill another requirement.

<sup>2</sup> The Ethics requirement will also fulfill one Humanities/Social Sciences requirement. See College Requirements tab.

## 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 (<http://engineering.berkeley.edu/academics/undergraduate-guide/>) as they complete degree requirements.
7. Complete the lower division program before enrolling in upper division engineering courses.

## Humanities and Social 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. Follow these guidelines to fulfill this requirement:

1. Complete a minimum of six courses from the approved Humanities/Social Sciences (H/SS) lists (<http://engineering.berkeley.edu/hssreq/>).
2. Courses must be a minimum of 3 semester units (or 4 quarter units).
3. Two of the six courses must fulfill the College's Reading and Composition (R&C) requirement. These courses must be taken for a letter grade (C- or better required). 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. Please see the Reading and Composition Requirement (<http://guide.berkeley.edu/archive/2020-21/undergraduate/colleges-schools/engineering/reading-composition-requirement/>) page for a complete list of R&C courses available and a list of exams that can be applied toward the R&C Part A requirement. Students can also use the Class Schedule (<https://classes.berkeley.edu/>) to view R&C courses offered in a given semester. Note: Only R&C Part A can be fulfilled with an AP, IB, or A-Level exam score. Test scores do not fulfill R&C Part B for College of Engineering students.
4. The four additional courses must be chosen from the five areas listed in #13 below. These four courses may be taken on a pass/no pass basis.
5. Special topics courses of 3 semester units or more will be reviewed on a case-by-case basis.
6. Two of the six courses must be upper division (courses numbered 100-196).
7. One of the six courses must satisfy the campus American Cultures (<http://guide.berkeley.edu/archive/2020-21/undergraduate/colleges-schools/engineering/american-cultures-requirement/>) (AC) requirement. Note that any American Cultures course of 3 units or more may be used to meet H/SS.
8. A maximum of two exams (Advanced Placement, International Baccalaureate, or A-Level) may be used toward completion of the H/SS requirement. View the list of exams (<http://engineering.berkeley.edu/academics/undergraduate-guide/exams/>) that can be applied toward H/SS requirements.
9. No courses offered by any engineering department other than BIO ENG 100, COMPSCI C79, ENGIN 125, ENGIN 157AC, ENGIN 185, and MEC ENG 191K may be used to complete H/SS requirements.
10. Language courses may be used to complete H/SS requirements. View the list of language options (<http://guide.berkeley.edu/>

archive/2020-21/undergraduate/colleges-schools/engineering/approved-foreign-language-courses/).

11. Courses may fulfill multiple categories. For example, CY PLAN 118AC satisfies both the American Cultures requirement and one upper division H/SS requirement.
12. Courses numbered 97, 98, 99, or above 196 may not be used to complete any H/SS requirement.
13. The College of Engineering uses modified versions of five of the College of Letters and Science (L&S) breadth requirements lists to provide options to our students for completing the H/SS requirement. The five areas are:

- Arts and Literature
- Historical Studies
- International Studies
- Philosophy and Values
- Social and Behavioral Sciences

Within the guidelines above, choose courses from any of the Breadth areas listed above. (Please note that you *cannot* use courses on the Biological Science or Physical Science Breadth list to complete the H/SS requirement.) To find course options, go to the Class Schedule (<http://classes.berkeley.edu/>), (<http://classes.berkeley.edu/search/class/>) select the term of interest, and use the Breadth Requirements filter.

## 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 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 (Grade) Requirements

- Minimum overall and semester grade point averages of 2.00 (C average) are required of engineering undergraduates. 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.

## Unit Requirements

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

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

## Normal Progress

Students in the College of Engineering must enroll in a full-time program and make normal progress (<https://engineering.berkeley.edu/students/undergraduate-guide/policies-procedures/scholarship-progress/#ac12282>) each semester toward the bachelor's degree. The continued enrollment of students who fail to achieve minimum academic progress shall be subject to the approval of the dean. (Note: Students with official accommodations established by the Disabled Students' Program, with health or family issues, or with other reasons deemed appropriate by the dean may petition for an exception to normal progress rules.)

## University of California Requirements

Entry Level Writing (<https://www.ucop.edu/elwr/>)

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

American History and American Institutions (<http://guide.berkeley.edu/archive/2020-21/undergraduate/education/#universityrequirementstext>)

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

## Campus Requirement

American Cultures (<http://guide.berkeley.edu/archive/2020-21/undergraduate/education/#campusrequirementstext>)

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.

The American Cultures requirement and courses constitute an approach that responds directly to the problem encountered in numerous disciplines of how better to present the diversity of American experience to the diversity of American students whom we now educate.

Faculty members from many departments teach American Cultures courses, but all courses have a common framework. The courses focus on themes or issues in United States history, society, or culture; address theoretical or analytical issues relevant to understanding race, culture, and ethnicity in American society; take substantial account of groups drawn from at least three of the following: African Americans, indigenous peoples of the United States, Asian Americans, Chicano/Latino Americans, and European Americans; and are integrative and comparative in that students study each group in the larger context of American society, history, or culture.

This is not an ethnic studies requirement, nor a Third World cultures requirement, nor an adjusted Western civilization requirement. These courses focus upon how the diversity of America's constituent cultural traditions have shaped and continue to shape American identity and experience.

Visit the Class Schedule (<http://classes.berkeley.edu/>) or the American Cultures website (<http://americancultures.berkeley.edu/>) for the specific American Cultures courses offered each semester. For a complete list of approved American Cultures courses at UC Berkeley and California Community Colleges, please see the American Cultures Subcommittee's website (<https://academic-senate.berkeley.edu/committees/amcult/>). See your academic adviser if you have questions about your responsibility to satisfy the American Cultures breadth requirement.

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

Freshman			
	Fall Units	Spring Units	
CHEM 1A & CHEM 1AL, or CHEM 4A <sup>1</sup>		5 CHEM 3A & CHEM 3AL, or CHEM 12A <sup>1</sup>	5
MATH 1A		4 MATH 1B	4
BIO ENG 10 <sup>7</sup>		4 PHYSICS 7A	4
BIO ENG 26		1 Reading and Composition Part B Course <sup>6</sup>	4
Reading and Composition Part A Course <sup>6</sup>	4		
	18		17
Sophomore			
	Fall Units	Spring Units	
MATH 53		4 MATH 54	4
PHYSICS 7B		4 BIO ENG 11	3
ENGIN 7 or COMPSI 61A		4 MAT SCI 45 <sup>8</sup>	3
Humanities/Social Sciences course <sup>6</sup>		3-4 MAT SCI 45L <sup>E</sup>	1
		Humanities/Social Sciences course <sup>6</sup>	3-4
	15-16		14-15

Junior			
	Fall Units	Spring Units	
BIO ENG 102		4 BIO ENG 104	4
BIO ENG 103		4 MAT SCI 103	3
MAT SCI 102		3 ENGIN 40 or CHEM 120B	3-4
BIO ENG 100 or Humanities/Social Sciences course with ethics content <sup>2,6</sup>		3-4 BIO ENG 110 or 114	4
	14-15		14-15
Senior			
	Fall Units	Spring Units	
BIO ENG 115 or MAT SCI 130		3-4 Bioengineering Design Project or Research <sup>4</sup>	3-4
BIO ENG C118		4 MAT SCI Elective <sup>3</sup>	3-4
MAT SCI Elective <sup>3</sup>		3-4 BIO ENG Elective <sup>5</sup>	3-4
Humanities/Social Sciences course <sup>6</sup>		3-4 MAT SCI 104 & 104L	4
		MAT SCI 151	3
	13-16		16-19
Total Units: 121-131			

- <sup>1</sup> CHEM 4A and CHEM 12A are intended for students majoring in chemistry or a closely-related field. Note: Prerequisites to CHEM 12A include CHEM 1A and 1AL and 1B (or 4A and 4B).
- <sup>2</sup> Students must take one course with ethics content. This may be fulfilled within the Humanities/Social Sciences requirement by taking one of the following courses: BIO ENG 100 (<http://guide.berkeley.edu/archive/2020-21/search/?P=BIO%20ENG%20100>), ENGIN 125 (<http://guide.berkeley.edu/archive/2020-21/search/?P=ENGIN%20125>), ENGIN 157AC (<http://guide.berkeley.edu/archive/2020-21/search/?P=ENGIN%20157AC>)/IAS 157AC (<http://guide.berkeley.edu/archive/2020-21/search/?P=IAS%20157AC>), ESPM 161 (<http://guide.berkeley.edu/archive/2020-21/search/?P=ESPM%20161>), ESPM 162 (<http://guide.berkeley.edu/archive/2020-21/search/?P=ESPM%20162>), HISTORY C182C (<http://guide.berkeley.edu/archive/2020-21/search/?P=HISTORY%20C182C>)/ISF C100G/STS C100, L&S 160B (<http://guide.berkeley.edu/archive/2020-21/search/?P=L%20%26%20S%20160B>), PHILOS 104 (<http://guide.berkeley.edu/archive/2020-21/search/?P=PHILOS%20104>), PHILOS 107 (<http://guide.berkeley.edu/archive/2020-21/search/?P=PHILOS%20107>).
- <sup>3</sup> Students must choose two of the following MAT SCI Electives: MAT SCI 111, MAT SCI 112, MAT SCI 113, MAT SCI 130.
- <sup>4</sup> Bioengineering Design Project or Research: Choose one of the following: BIO ENG 121L, BIO ENG 140L, BIO ENG 168L, BIO ENG 192, BIO ENG 193, BIO ENG 194, BIO ENG 195, BIO ENG 196, BIO ENG 197, BIO ENG 198, BIO ENG 199, BIO ENG 200, BIO ENG 201, BIO ENG 202, BIO ENG 203, BIO ENG 204, BIO ENG 205, BIO ENG 206, BIO ENG 207, BIO ENG 208, BIO ENG 209, BIO ENG 210, BIO ENG 211, BIO ENG 212, BIO ENG 213, BIO ENG 214, BIO ENG 215, BIO ENG 216, BIO ENG 217, BIO ENG 218, BIO ENG 219, BIO ENG 220, BIO ENG 221, BIO ENG 222, BIO ENG 223, BIO ENG 224, BIO ENG 225, BIO ENG 226, BIO ENG 227, BIO ENG 228, BIO ENG 229, BIO ENG 230, BIO ENG 231, BIO ENG 232, BIO ENG 233, BIO ENG 234, BIO ENG 235, BIO ENG 236, BIO ENG 237, BIO ENG 238, BIO ENG 239, BIO ENG 240, BIO ENG 241, BIO ENG 242, BIO ENG 243, BIO ENG 244, BIO ENG 245, BIO ENG 246, BIO ENG 247, BIO ENG 248, BIO ENG 249, BIO ENG 250, BIO ENG 251, BIO ENG 252, BIO ENG 253, BIO ENG 254, BIO ENG 255, BIO ENG 256, BIO ENG 257, BIO ENG 258, 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- <sup>6</sup> The Humanities/Social Sciences (H/SS) requirement includes two approved Reading & Composition (R&C) courses and four additional approved courses, with which a number of specific conditions must be satisfied. R&C courses must be taken for a letter grade (C- or better required). The first half (R&C Part A) must be completed by the end of the freshman year; the second half (R&C Part B) must be completed by no later than the end of the sophomore year. The remaining courses may be taken at any time during the program. See [engineering.berkeley.edu/hss](https://engineering.berkeley.edu/hss) (<https://engineering.berkeley.edu/academics/undergraduate-guide/degree-requirements/humanities-and-social-sciences/>) for complete details and a list of approved courses.
- <sup>7</sup> Junior transfer admits are exempt from completing BIOENG 10.
- <sup>8</sup> MAT SCI 45/45L can be taken in either the Fall or Spring semesters. Both offerings deliver the same fundamental content. The Fall offering draws more examples from hard materials (e.g. semiconductors, metals and ceramics), whereas the Spring offering will draw more examples from soft materials (e.g. polymers and biomaterials).

## Bioengineering

### 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

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.

## Materials Science

### Measured Curricular Outcomes

1. Be able to apply general math, science and engineering skills to the solution of engineering problems.
2. Be aware of the social, safety and environmental consequences of their work, and be able to engage in public debate regarding these issues.
3. Be able to apply core concepts in materials science to solve engineering problems.
4. Be knowledgeable of contemporary issues relevant to materials science and engineering.

5. Be able to select materials for design and construction.
6. Understand the importance of life-long learning.
7. Be able to design and conduct experiments, and to analyze data.
8. Understand the professional and ethical responsibilities of a materials scientist and engineer.
9. Be able to work both independently and as part of a team.
10. Be able to communicate effectively while speaking, employing graphics, and writing.
11. Possess the skills and techniques necessary for modern materials engineering practice.

### Educational Objectives for Graduates

Stated succinctly, graduates from the program will have the following skills:

1. Know the fundamental science and engineering principles relevant to materials.
2. Understand the relationship between nano/microstructure, characterization, properties and processing, and design of materials.
3. Have the experimental and computational skills for a professional career or graduate study in materials.
4. Possess a knowledge of the significance of research, the value of continued learning, and environmental/social issues surrounding materials.
5. Be able to communicate effectively, to work in teams and to assume positions as leaders.

## Bioengineering/Materials Science and Engineering

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

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

Terms offered: Fall 2021, Fall 2020, Fall 2019

This course is intended for lower division students interested in acquiring a foundation in biomedicine with topics ranging from evolutionary biology to human physiology. The emphasis is on the integration of engineering applications to biology and health. The specific lecture topics and exercises will include the key aspects of genomics and proteomics as well as topics on plant and animal evolution, stem cell biomedicine, and tissue regeneration and replacement. Medical physiology topics include relevant engineering aspects of human brain, heart, musculoskeletal, and other systems.

Introduction to Biomedicine for Engineers: Read More [+]

### Objectives & Outcomes

**Student Learning Outcomes:** The goal is for undergraduate engineering students to gain sufficient biology and human physiology fundamentals so that they are better prepared to study specialized topics, e.g., biomechanics, imaging, computational biology, tissue engineering, biomonitoring, drug development, robotics, and other topics covered by upper division and graduate courses in UC Berkeley departments of Molecular and Cell Biology, Integrative Biology, Bioengineering, Electrical Engineering and Computer Science, Mechanical Engineering, and courses in the UC San Francisco Division of Bioengineering.

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Conboy, Kumar, Johnson

Introduction to Biomedicine for Engineers: Read Less [-]

## BIO ENG 11 Engineering Molecules 1 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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 2021, Fall 2020, Spring 2020

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

Freshmen Seminar: Read More [+]

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

**Grading/Final exam status:** Offered for pass/not pass grade only. Final Exam To be decided by the instructor when the class is offered.

Freshmen Seminar: Read Less [-]

## MAT SCI 24 Freshman Seminar 1 Unit

Terms offered: Spring 2020, Spring 2019, Spring 2018

The Freshman 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. Freshman seminars are offered in all campus departments, and topics vary from department to department and semester to semester. Enrollment limited to 20 freshmen.

Freshman Seminar: Read More [+]

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/  
Undergraduate

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

Freshman Seminar: Read Less [-]

## BIO ENG 25 Careers in Biotechnology 1 Unit

Terms offered: Spring 2021, Spring 2020, Spring 2019

This introductory seminar is designed to give freshmen and sophomores an opportunity to explore specialties related to engineering in the pharmaceutical/biotech field. A series of one-hour seminars will be presented by industry professionals, professors, and researchers.

Topics may include biotechnology and pharmaceutical manufacturing; process and control engineering; drug inspection process; research and development; compliance and validation; construction process for a GMP facility; project management; and engineered solutions to environmental challenges. This course is of interest to students in all areas of engineering and biology, including industrial engineering and manufacturing, chemical engineering, and bioengineering.

Careers in Biotechnology: Read More [+]

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

Careers in Biotechnology: Read Less [-]

## BIO ENG 26 Introduction to Bioengineering 1 Unit

Terms offered: Fall 2021, Fall 2020, Fall 2019

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 [-]

## MAT SCI 45 Properties of Materials 3 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

Application of basic principles of physics and chemistry to the engineering properties of materials. Emphasis on establishing structure, property, processing, and performance interrelationships in metals, ceramics, and polymers. While core concepts are fully covered each semester, examples and contextualization in Fall editions focuses on metals, ceramics, and functional/electronic properties and in Spring editions on polymers and soft-materials.

Properties of Materials: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Students should have completed high school AP or honors chemistry and physics

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructors:** Martin, Messersmith

Properties of Materials: Read Less [\[-\]](#)

## MAT SCI 45L Properties of Materials Laboratory 1 Unit

Terms offered: Fall 2021, Spring 2021, Fall 2020

This course presents laboratory applications of the basic principles introduced in the lecture-based course MSE45 – Properties of Materials. Properties of Materials Laboratory: Read More [\[+\]](#)

### Rules & Requirements

**Credit Restrictions:** Students will receive no credit for MSE 45L after taking E45L

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructors:** Martin, Messersmith

Properties of Materials Laboratory: 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 2021, Spring 2021, Fall 2020

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

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

### Rules & Requirements

**Prerequisites:** Consent of instructor

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

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

### Hours & Format

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

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

### Additional Details

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

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

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



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

Terms offered: Spring 2020, Fall 2019, Spring 2019

Supervised independent study for lower division students.

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

### Rules & Requirements

**Prerequisites:** Freshman or sophomore standing and consent of instructor

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

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

### Hours & Format

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

### Summer:

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

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

### Additional Details

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

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

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

## BIO ENG 100 Ethics in Science and Engineering 3 Units

Terms offered: Fall 2021, Spring 2021, Fall 2020

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Lam, Hayley

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

## BIO ENG 101 Instrumentation in Biology and Medicine 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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

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

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

### Objectives & Outcomes

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

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

### Rules & Requirements

**Prerequisites:** EECS 16A, EECS 16B, MATH 53, MATH 54, PHYSICS 7A, and PHYSICS 7B; or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Conolly

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

## BIO ENG 102 Biomechanics: Analysis and Design 4 Units

Terms offered: Fall 2020, Fall 2019, Fall 2018

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 [\[-\]](#)

## MAT SCI 102 Bonding, Crystallography, and Crystal Defects 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Bonding in solids; classification of metals, semiconductors, and insulators; crystal systems; point, line, and planar defects in crystals; examples of crystallographic and defect analysis in engineering materials; relationship to physical and mechanical properties.

Bonding, Crystallography, and Crystal Defects: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** MAT SCI 45

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructor:** Chrzan

Bonding, Crystallography, and Crystal Defects: Read Less [\[-\]](#)

## BIO ENG 103 Engineering Molecules 2 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

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 [-]

## MAT SCI 103 Phase Transformations and Kinetics 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

The nature, mechanisms, and kinetics of phase transformations and microstructural changes in the solid state. Atom diffusion in solids. Phase transformations through the nucleation and growth of new matrix or precipitate phases. Martensitic transformations, spinodal decomposition. The use of phase transformations to control microstructure.

Phase Transformations and Kinetics: Read More [+]

### Rules & Requirements

**Prerequisites:** MAT SCI 102 and ENGIN 40

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

Phase Transformations and Kinetics: Read Less [-]

## BIO ENG 104 Biological Transport Phenomena 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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 [-]

## MAT SCI 104 Materials Characterization 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

This 3-unit course will cover basic principles and techniques used for the characterization of engineering materials. The course is designed to introduce undergraduate students to the basic principles of structural, chemical and property characterization techniques. The course is grounded in modern x-ray diffraction and electron microscopy techniques for characterization of the chemical and structural properties of a material. The course introduces the fundamental theoretical framework for diffraction, spectrometry and imaging methods.

Materials Characterization: Read More [+]

### Objectives & Outcomes

**Course Objectives:** Materials characterization lies at the heart of understanding the property-structure-processing relationships of materials. The goal of the course is to prepare undergraduate students from materials science to understand the basic principles behind material characterization tools and techniques. More specifically, this class will provide students (1) a thorough introduction to the principles and practice of diffraction, (2) introductory exposure to a range of common characterization methods for the determination of structure and composition of solids. A successful student will learn (1) the theory of x-ray and electron diffraction, (2) basic elements of electron microscopy, (3) basic aspects of optical and scanning probe techniques.

### Rules & Requirements

**Prerequisites:** MAT SCI 102. A basic knowledge of structure, bonding and crystallography will be assumed

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/ Undergraduate

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

**Instructors:** Scott, Minor

Materials Characterization: Read Less [-]

## MAT SCI 104L Materials Characterization Laboratory 1 Unit

Terms offered: Spring 2021, Spring 2020

This 1-unit laboratory course covers X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM), as well as lab writeup protocols and academic integrity. Students will get hands-on experience using the XRD, SEM and TEM equipment to perform microstructural characterization of materials. Students will also design and run their own project on a topic of their choosing.

Materials Characterization Laboratory: Read More [+]

### Objectives & Outcomes

**Course Objectives:** Practical experience on the most common materials characterization equipment for structural and chemical analysis of materials. Introduction to laboratory procedures and independent projects.

### Rules & Requirements

**Prerequisites:** MAT SCI 102; and MAT SCI 104 must be taken concurrently. A basic knowledge of structure, bonding and crystallography will be assumed. Undergraduate student in engineering, physics or chemistry

### Hours & Format

**Fall and/or spring:** 15 weeks - 1.5 hours of laboratory and 1 hour of discussion per week

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/ Undergraduate

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

**Instructors:** Scott, Minor

Materials Characterization Laboratory: Read Less [-]

## BIO ENG 105 Engineering Devices 1 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

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 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 2021, Spring 2020, Spring 2019

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

Robotic Manipulation and Interaction: Read More [+]

### Rules & Requirements

**Prerequisites:** EECS C106A / BIO ENG C106A, or consent of the instructor

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Bajcsy, Sastry

**Also listed as:** EECS C106B

Robotic Manipulation and Interaction: Read Less [-]

## BIO ENG 110 Biomedical Physiology for Engineers 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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

Biomedical Physiology for Engineers: Read More [+]

### Objectives & Outcomes

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

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

### Rules & Requirements

**Prerequisites:** BIO ENG 10; and BIO ENG 11 or BIOLOGY 1A; and MATH 54 recommended

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Kumar

Biomedical Physiology for Engineers: Read Less [-]

## BIO ENG 111 Functional Biomaterials Development and Characterization 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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

Functional Biomaterials Development and Characterization: Read More [+]

### Objectives & Outcomes

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

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** SW Lee

Functional Biomaterials Development and Characterization: Read Less [-]

## MAT SCI 111 Properties of Electronic Materials 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Introduction to the physical principles underlying the electric properties of modern solids with emphasis on semiconductors; control of defects and impurities through physical purification, bulk and thin film crystal growth and doping processes, materials basis of electronic and optoelectronic devices (diodes, transistors, semiconductor lasers) and optical fibers; properties of metal and oxide superconductors and their applications. Properties of Electronic Materials: Read More [+]

### Rules & Requirements

**Prerequisites:** PHYSICS 7A, PHYSICS 7B, and PHYSICS 7C; or PHYSICS 7A, PHYSICS 7B and 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:** Materials Science and Engineering/Undergraduate

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

**Instructors:** Dubon, Wu, Yao

Properties of Electronic Materials: Read Less [-]

## MAT SCI 112 Corrosion (Chemical Properties) 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

Electrochemical theory of corrosion. Mechanisms and rates in relation to physiochemical and metallurgical factors. Stress corrosion and mechanical influences on corrosion. Corrosion protection by design, inhibition, cathodic protection, and coatings.

Corrosion (Chemical Properties): Read More [+]

### Rules & Requirements

**Prerequisites:** MAT SCI 45 and ENGIN 40

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructor:** Devine

Corrosion (Chemical Properties): Read Less [-]

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

Terms offered: Spring 2021, Spring 2020, Spring 2019

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

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

### Objectives & Outcomes

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

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

### Rules & Requirements

**Prerequisites:** BIO ENG 102; or MEC ENG C85 / CIV ENG C30; or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Mofrad

**Also listed as:** MEC ENG C115

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

## BIO ENG 113 Stem Cells and Technologies 4 Units

Terms offered: Fall 2015, Fall 2014, Fall 2013

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

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

### Rules & Requirements

**Prerequisites:** 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

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

## MAT SCI 113 Mechanical Behavior of Engineering Materials 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

This course covers elastic and plastic deformation under static/dynamic loads. Prediction/prevention of failure by yielding, fracture, fatigue, wear and environmental effects are addressed. Design issues of materials selection for load-bearing applications are discussed. Case studies of engineering failures are presented. Topics include engineering materials, structure-property relationships, mechanical behavior of metals, ceramics, polymers and composites, complex stress/strain states, stress concentrations, multiaxial loading, plasticity, yield criteria, dislocations, strengthening mechanisms, creep, fracture mechanics and fatigue.

Mechanical Behavior of Engineering Materials: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** CIV ENG C30/MEC ENG C85 and MAT SCI 45

**Credit Restrictions:** Students will receive no credit for 113 after taking C113 or Mechanical Engineering C124. Deficiency in C113 or Mechanical Engineering C124 maybe removed by taking 113.

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructor:** Ritchie

Mechanical Behavior of Engineering Materials: [Read Less](#) [-]

## BIO ENG 114 Cell Engineering 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2018

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 2021, Spring 2021, Fall 2020

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.

Cell and Tissue Engineering: Read More [+]

### Objectives & Outcomes

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

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

### Rules & Requirements

**Prerequisites:** 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 [-]

## MAT SCI 117 Properties of Dielectric and Magnetic Materials 3 Units

Terms offered: Spring 2021, Spring 2017, Spring 2011

Introduction to the physical principles underlying the dielectric and magnetic properties of solids. Processing-microstructure-property relationships of dielectric materials, including piezoelectric, pyroelectric, and ferroelectric oxides, and of magnetic materials, including hard- and soft ferromagnets, ferrites and magneto-optic and -resistive materials. The course also covers the properties of grain boundary devices (including varistors) as well as ion-conducting and mixed conducting materials for applications in various devices such as sensors, fuel cells, and electric batteries.

Properties of Dielectric and Magnetic Materials: Read More [+]

### Rules & Requirements

**Prerequisites:** PHYSICS 7A, PHYSICS 7B, and PHYSICS 7C; or PHYSICS 7A, PHYSICS 7B, and consent of instructor. MAT SCI 111 is recommended

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

Properties of Dielectric and Magnetic Materials: Read Less [-]



## BIO ENG C117 Structural Aspects of Biomaterials 4 Units

Terms offered: Fall 2020, Spring 2019, Spring 2018

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

Structural Aspects of Biomaterials: Read More [+]

### Rules & Requirements

**Prerequisites:** BIOLOGY 1A and MAT SCI 45; CIV ENG 130, CIV ENG 130N, or BIO ENG 102

**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 2021, Fall 2020, Fall 2019

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

Biological Performance of Materials: Read More [+]

### Objectives & Outcomes

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

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

### Student Learning Outcomes:

Apply math, science & engineering principles to the understanding of soft materials, surface chemistry, DLVO theory, protein adsorption kinetics, viscoelasticity, mass diffusion, and molecular (i.e., drug) delivery kinetics.

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

Apply core concepts in materials science to solve engineering problems related to the selection biomaterials, especially in devices where the material-tissue or material-solution interface dominates performance.

Develop an understanding of the social, safety and medical consequences of biomaterial use and regulatory issues associated with the selection of biomaterials in the context of the silicone breast implant controversy and subsequent biomaterials crisis.

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

- Understanding of the origin of surface forces and interfacial free energy, and how they contribute to the development of the biomaterial interface and ultimately biomaterial performance.

### Rules & Requirements

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

## MAT SCI C118 Biological Performance of Materials 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

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

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

### Objectives & Outcomes

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

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### 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.

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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. BIO ENG 102 and BIO ENG 104 are recommended

## BIO ENG C119 Orthopedic Biomechanics 4 Units

Terms offered: Fall 2020, Fall 2019, Spring 2019

Statics, dynamics, optimization theory, composite beam theory, beam-on-elastic foundation theory, Hertz contact theory, and materials behavior. Forces and moments acting on human joints; composition and mechanical behavior of orthopedic biomaterials; design/analysis of artificial joint, spine, and fracture fixation prostheses; musculoskeletal tissues including bone, cartilage, tendon, ligament, and muscle; osteoporosis and fracture-risk predication of bones; and bone adaptation. MATLAB-based project to integrate the course material.

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

### Rules & Requirements

**Prerequisites:** MEC ENG C85 / CIV ENG C30 or BIO ENG 102 (concurrent enrollment OK). Proficiency in MatLab or equivalent. Prior knowledge of biology or anatomy is not assumed

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Keaveny

**Also listed as:** MEC ENG C176

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

## MAT SCI 120 Materials Production 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Economic and technological significance of metals and other materials. Elementary geology (composition of lithosphere, mineralization). Short survey of mining and mineral processing techniques. Review of chemical thermodynamics and reaction kinetics. Principles of process engineering including material, heat, and mechanical energy balances. Elementary heat transfer, fluid flow, and mass transfer. Electrolytic production and refining of metals. Vapor techniques for production of metals and coatings.

Materials Production: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** ENGIN 40, MEC ENG 40, CHM ENG 141, CHEM 120B, or equivalent thermodynamics course

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

Materials Production: Read Less [\[-\]](#)

## BIO ENG 121 BioMEMS and Medical Devices 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Biophysical and chemical principles of biomedical devices, bionanotechnology, bionanophotonics, and biomedical microelectromechanical systems (BioMEMS). Topics include basics of nano- and microfabrication, soft-lithography, DNA arrays, protein arrays, electrokinetics, electrochemical, transducers, microfluidic devices, biosensor, point of care diagnostics, lab-on-a-chip, drug delivery microsystems, clinical lab-on-a-chip, advanced biomolecular probes, etc. BioMEMS and Medical Devices: Read More [+]

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Lee, Streets

BioMEMS and Medical Devices: Read Less [-]

## MAT SCI 121 Metals Processing 3 Units

Terms offered: Spring 2019, Spring 2015, Spring 2014

The principles of metals processing with emphasis on the use of processing to establish microstructures which impart desirable engineering properties. The techniques discussed include solidification, thermal and mechanical processing, powder processing, welding and joining, and surface treatments.

Metals Processing: Read More [+]

### Rules & Requirements

**Prerequisites:** MAT SCI 45

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructor:** Gronsky

Metals Processing: Read Less [-]

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

Terms offered: Fall 2021, Spring 2020, Spring 2019

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

BioMems and BioNanotechnology Laboratory: Read More [+]

### Objectives & Outcomes

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Liepmann

BioMems and BioNanotechnology Laboratory: Read Less [-]

## MAT SCI 122 Ceramic Processing 3 Units

Terms offered: Fall 2012, Fall 2011, Fall 2010

Powder fabrication by grinding and chemical methods, rheological behavior of powder-fluid suspensions, forming methods, drying, sintering, and grain growth. Relation of processing steps to microstructure development.

Ceramic Processing: Read More [ + ]

### Rules & Requirements

**Prerequisites:** MAT SCI 45 and ENGIN 40

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/ Undergraduate

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

Ceramic Processing: Read Less [ - ]

## MAT SCI 123 ELECTRONIC MATERIALS PROCESSING 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

This 4-unit course starts with a brief review of the fundamentals of solid-state physics including bands and defects in semiconductors and oxides, and then moves to bulk semiconductor crystals growth and processing including doping, diffusion and implantation, and then to thin film deposition and processing methods, and finishes with a discussion of materials analysis and characterization. Recent advances in nanomaterials research will also be introduced.

ELECTRONIC MATERIALS PROCESSING: Read More [ + ]

### Objectives & Outcomes

**Course Objectives:** To prepare students a) for work in semiconductor processing facilities and b) for graduate studies related to thin film processing and relevant materials science topics.

To present the relevant materials science issues in semiconductor and oxide processing.

To provide an introduction into the principles of thin film processing and related technologies.

**Student Learning Outcomes:** Basic knowledge of gas kinetics and vacuum technology, including ideal gas, gas transport theory, definition, creation and measurement of vacuum.

Knowledge of electrical and optical properties of thin films.

Knowledge of the formation of p-n junction to explain the diode operation and its I-V characteristics. Understanding of the mechanisms of Hall Effect, transport, and C-V measurements, so that can calculate carrier concentration, mobility and conductivity given raw experimental data. The ability to describe major growth techniques of bulk, thin film, and nanostructured semiconductors, with particular emphasis on thin film deposition technologies, including evaporation, sputtering, chemical vapor deposition and epitaxial growths.

To have basic knowledge of doping, purification, oxidation, gettering, diffusion, implantation, metallization, lithography and etching in semiconductor processing.

To have basic knowledge of electronic material characterization methods: x-ray diffraction, SEM and TEM, EDX, Auger, STM and AFM, Rutherford Back Scattering and SIMS, as well as optical methods including photoluminescence, absorption and Raman scattering.

To understand the concepts of bands, bandgap, to distinguish direct and indirect bandgap semiconductors. Understanding of free electron and hole doping of semiconductors to determine Fermi level position.

To understand the effect of defects in semiconductors, so that can describe their electronic and optical behaviors, and the methods to eliminate and control them in semiconductors.

### Rules & Requirements

**Prerequisites:** MAT SCI 111, PHYSICS 7C, or consent of instructor

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/ Undergraduate

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

**Instructors:** Wu, Yao

ELECTRONIC MATERIALS PROCESSING: Read Less [ - ]

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

Terms offered: Fall 2021, Fall 2020, Fall 2019

This course focuses on providing students with the foundations needed to understand contemporary literature in drug delivery. Concepts in organic chemistry, biochemistry, and physical chemistry needed to understand current problems in drug delivery are emphasized.

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

### Objectives & Outcomes

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Murthy

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

## MAT SCI 125 Thin-Film Materials Science 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

Deposition, processing, and characterization of thin films and their technological applications. Physical and chemical vapor deposition methods. Thin-film nucleation and growth. Thermal and ion processing. Microstructural development in epitaxial, polycrystalline, and amorphous films. Thin-film characterization techniques. Applications in information storage, integrated circuits, and optoelectronic devices. Laboratory demonstrations.

Thin-Film Materials Science: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Upper division or graduate standing in Engineering, Physics, Chemistry, or Chemical Engineering; and MAT SCI 45. PHYSICS 111A or PHYSICS 141A recommended

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructor:** Dubon

Thin-Film Materials Science: [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 [ - ]

## MAT SCI 130 Experimental Materials Science and Design 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

This course provides a culminating experience for students approaching completion of the materials science and engineering curriculum. Laboratory experiments are undertaken in a variety of areas from the investigations on semiconductor materials to corrosion science and elucidate the relationships among structure, processing, properties, and performance. The principles of materials selection in engineering design are reviewed.

Experimental Materials Science and Design: Read More [ + ]

### Rules & Requirements

**Prerequisites:** Senior standing or consent of instructor

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

Experimental Materials Science and Design: Read Less [ - ]

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

Terms offered: Fall 2018, Fall 2017, Fall 2016

Topics include computational approaches and techniques to gene structure and genome annotation, sequence alignment using dynamic programming, protein domain analysis, RNA folding and structure prediction, RNA sequence design for synthetic biology, genetic and biochemical pathways and networks, UNIX and scripting languages, basic probability and information theory. Various "case studies" in these areas are reviewed; web-based computational biology tools will be used by students and programming projects will be given. Computational biology research connections to biotechnology will be explored.

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

### Objectives & Outcomes

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Holmes

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

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

Terms offered: Fall 2021, Fall 2020, Fall 2019

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Holmes

**Also listed as:** CMPBIO C131

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

## BIO ENG 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 2021, Fall 2020, Fall 2019

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

### Objectives & Outcomes

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** J. Christopher Anderson

Genetic Design Automation: Read Less [-]

## BIO ENG 135 Frontiers in Microbial Systems Biology 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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

Frontiers in Microbial Systems Biology: Read More [+]

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Arkin, Bischofs-Pfeifer, Wolf

Frontiers in Microbial Systems Biology: Read Less [-]

## MAT SCI 136 Materials in Energy Technologies 4 Units

Terms offered: Fall 2021, Fall 2019, Fall 2017

In many, if not all, technologies, it is materials that play a crucial, enabling role. This course examines potentially sustainable technologies, and the materials properties that enable them. The science at the basis of selected energy technologies are examined and considered in case studies.

Materials in Energy Technologies: Read More [+]

### Rules & Requirements

**Prerequisites:** Junior or above standing in Materials Science and Engineering or related field

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/ Undergraduate

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

**Formerly known as:** Materials Science and Engineering 126

Materials in Energy Technologies: Read Less [-]

## BIO ENG C136L Laboratory in the Mechanics of Organisms 3 Units

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

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

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

### Rules & Requirements

**Prerequisites:** INTEGBI 135 or consent of instructor. For Electrical Engineering and Computer Sciences students: EL ENG 105, EL ENG 120 or COMPSCI 184

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

### Hours & Format

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

### Additional Details

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

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

**Formerly known as:** Integrative Biology 135L

**Also listed as:** EL ENG C145O/INTEGBI C135L

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



## BIO ENG C137 Designing for the Human Body 4 Units

Terms offered: Fall 2019, Fall 2018, Fall 2017

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

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

### Objectives & Outcomes

**Course Objectives:** The purpose of this course is twofold:

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

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

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

Working knowledge of design considerations for creating a device to protect or aid the human body, force transfer and distribution, data analysis, and FDA approval process for new devices. Understanding of basic concepts in orthopaedic biomechanics and the ability to apply the appropriate engineering concepts to solve realistic biomechanical problems, knowing clearly the assumptions involved. Critical analysis of current literature and technology.

### Rules & Requirements

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

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

### Hours & Format

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

## MAT SCI 140 Nanomaterials for Scientists and Engineers 3 Units

Terms offered: Spring 2020, Spring 2015, Spring 2013

This course introduces the fundamental principles needed to understand the behavior of materials at the nanometer length scale and the different classes of nanomaterials with applications ranging from information technology to biotechnology. Topics include introduction to different classes of nanomaterials, synthesis and characterization of nanomaterials, and the electronic, magnetic, optical, and mechanical properties of nanomaterials.

Nanomaterials for Scientists and Engineers: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** PHYSICS 7C and MAT SCI 45. MAT SCI 102 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:** Materials Science and Engineering/ Undergraduate

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

**Instructor:** Minor

Nanomaterials for Scientists and Engineers: [Read Less](#) [-]

## BIO ENG 140L Synthetic Biology Laboratory 4 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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

Synthetic Biology Laboratory: Read More [+]

### Objectives & Outcomes

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

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

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

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Anderson

Synthetic Biology Laboratory: Read Less [-]

## BIO ENG 143 Computational Methods in Biology 4 Units

Terms offered: Fall 2011, Fall 2010, Fall 2009

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

### Rules & Requirements

**Prerequisites:** MATH 53 and MATH 54. Programming experience preferred but not required

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Head-Gordon

Computational Methods in Biology: Read Less [-]

## BIO ENG 144 Introduction to Protein Informatics 4 Units

Terms offered: Spring 2017, Fall 2008, Fall 2007

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

Introduction to Protein Informatics: [Read More](#) [+]

### Objectives & Outcomes

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

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

### Rules & Requirements

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

**Credit Restrictions:** BioE 244 or BioE C244L/PMB C244

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Sjolander

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

Introduction to Protein Informatics: [Read Less](#) [-]

## BIO ENG 144L Protein Informatics Laboratory 3 Units

Terms offered: Fall 2008

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Sjolander

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

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

## BIO ENG 145 Introduction to Machine Learning for Computational Biology 4 Units

Terms offered: Spring 2021, Spring 2020, Fall 2017

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

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

This course builds on existing skills to introduce methodologies for probabilistic modeling, statistical learning, and dimensionality reduction, while grounding these methods in understanding genomic information.

Introduction to Machine Learning for Computational Biology: Read More [+]

### Objectives & Outcomes

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

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

Students completing this course should have stronger programming skills.

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Lareau

Introduction to Machine Learning for Computational Biology: Read Less [-]

## BIO ENG C145L Introductory Electronic Transducers Laboratory 3 Units

Terms offered: Fall 2014, Fall 2013, Fall 2012

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

Introductory Electronic Transducers Laboratory: Read More [+]

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Derenzo

**Also listed as:** EL ENG C145L

Introductory Electronic Transducers Laboratory: Read Less [-]

## BIO ENG C145M Introductory Microcomputer Interfacing Laboratory 3 Units

Terms offered: Spring 2013, Spring 2012, Spring 2011

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

Introductory Microcomputer Interfacing Laboratory: Read More [+]

### Rules & Requirements

**Prerequisites:** EE 16A & 16B

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Derenzo

**Also listed as:** EL ENG C145M

Introductory Microcomputer Interfacing Laboratory: Read Less [-]

## BIO ENG 147 Principles of Synthetic Biology 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

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

Principles of Synthetic Biology: Read More [+]

### Objectives & Outcomes

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

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

### Rules & Requirements

**Prerequisites:** MATH 53 and MATH 54; and BIO ENG 103 or consent of instructor

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Arkin

Principles of Synthetic Biology: Read Less [-]

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

Terms offered: Fall 2020, Fall 2018, Fall 2017

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 150 Introduction of Bionanoscience and Bionanotechnology 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

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

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

### Objectives & Outcomes

#### Course Objectives: I.

Basic building blocks and governing forces: This part is intended to enhance the understanding of the structures and properties of biological basic building blocks and their governing forces to assemble the biological materials. This part covers the chemical structures of amino acids, ribonucleic acids, hydrocarbonates, and lipids, and their physical properties depending on the chemical and physical structures. In addition, governing forces (hydrogen bonding, ionic interaction, van der Waals interaction, hydrophobic interactions, etc) to assemble the basic building blocks to form nanostructures will be covered. Tools and methodologies to analyze the chemical structure of the molecules will be introduced. Quantitative analysis of the properties of biological basic building blocks will also be addressed.

#### II.

Case study of the molecular level structures of biological materials. This part is intended to study the examples of biological molecules to enhance understanding the assembly principle of biological materials, including collagens, keratins, spider webs, silks, bio-adhesives as protein based robust materials, bones, sea shells, diatoms, sponges, and, other biominerals as hierarchical nanostructures, and butterfly wings and insect eyes, other periodic structures for optical applications. Through the case study, we will learn how natural materials are designed to solve the challenging problem to be faced in the natural environments and exploit their design principle to develop novel functional materials and devices.

#### III.

Case study of the artificial nanomaterials and devices inspired by biological nature. This part is intended to enhance understanding the recently developed nanostructures and devices to mimic the natural biological materials and organisms. Hybrid functional nanomaterials and devices, such as biological basic building blocks conjugated with inorganic nanocomponents, such as quantum dots, nanowires, nanotubes will be discussed to fabricate various devices including, bio-sensor, bio-nano electronic materials and devices, bio-computing. Nano medicine and bio imaging will also be covered.

The goal is for the bioengineering students to gain sufficient chemical and physical aspects of biological materials through the case study of spider webs, silks, sea shells, diatoms, bones, and teeth, as well as recently developed self-assembled nanostructures inspired by nature.

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

## MAT SCI C150 Introduction to Materials Chemistry 3 Units

Terms offered: Fall 2021, Spring 2021, Spring 2020, Spring 2019

The application of basic chemical principles to problems in materials discovery, design, and characterization will be discussed. Topics covered will include inorganic solids, nanoscale materials, polymers, and biological materials, with specific focus on the ways in which atomic-level interactions dictate the bulk properties of matter.

Introduction to Materials Chemistry: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** CHEM 104A. CHEM 104B recommended

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/ Undergraduate

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

**Also listed as:** CHEM C150

Introduction to Materials Chemistry: [Read Less](#) [-]

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

Terms offered: Spring 2015, Spring 2014, Spring 2013

Introduction and in-depth treatment of theory relevant to fluid flow in microfluidic and nanofluidic systems supplemented by critical assessment of recent applications drawn from the literature. Topics include low Reynolds Number flow, mass transport including diffusion phenomena, and emphasis on electrokinetic systems and bioanalytical applications of said phenomena.

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

### Objectives & Outcomes

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

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

### Student Learning Outcomes: 1.

To introduce students to the governing principles of fluid flow in microfluidic and nanofluidic regimes, with emphasis on phenomena relevant to bioanalytical devices.

2.

To provide students with an understanding of scaling laws that define the performance of microfluidic and nanofluidic systems.

3.

To provide students with a detailed investigation of applications that do and do not benefit from miniaturization.

4.

To give students adequate didactic background for critical assessment of literature reports and conference presentations regarding advances in the topical areas of microfluidics and nanofluidics.

### Rules & Requirements

**Prerequisites:** BIO ENG 11 or CHEM 3B; BIO ENG 104, MEC ENG 106, or consent of instructor

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Herr

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

## MAT SCI 151 Polymeric Materials 3 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

This course is designed for upper division undergraduate and graduate students to gain a fundamental understanding of the science of polymeric materials. Beginning with a treatment of ideal polymeric chain conformations, it develops the thermodynamics of polymer blends and solutions, the modeling of polymer networks and gels, the dynamics of polymer chains, and the morphologies of thin films and other dimensionally-restricted structures relevant to nanotechnology.

Polymeric Materials: Read More [ + ]

### Rules & Requirements

**Prerequisites:** CHEM 1A or MAT SCI 45. MAT SCI 103 is recommended

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

**Instructor:** Xu

Polymeric Materials: Read Less [ - ]

## BIO ENG 153 Biotechnology Entrepreneurship: Impact, History, Therapeutics R&D, Entrepreneurship & Careers 2 Units

Terms offered: Spring 2021, Spring 2020, Spring 2019

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

### Objectives & Outcomes

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

To educate students on careers in the biopharmaceutical industry

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

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

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

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

The history of the biotech industry

The impact of the biopharmaceutical industry on medicine and society

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

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

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

### Rules & Requirements

**Prerequisites:** Consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Kirn

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

## BIO ENG C157 Nanomaterials in Medicine 3 Units

Terms offered: Fall 2021, Fall 2020

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

Nanomaterials in Medicine: Read More [+]

### Objectives & Outcomes

**Course Objectives:** To identify an existing or unmet clinical need and identify a nanomedicine that can provide a solution

To learn about chemical approaches used in nanomaterial synthesis and surface modification.

To learn how to read and critique the academic literature.

To understand the interaction of nanomaterials with proteins, cells, and biological systems.

### Rules & Requirements

**Prerequisites:** MAT SCI 45 or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Messersmith

**Also listed as:** MAT SCI C157

Nanomaterials in Medicine: Read Less [-]

## MAT SCI C157 Nanomaterials in Medicine 3 Units

Terms offered: 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:** Materials Science and Engineering/  
Undergraduate

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

**Instructor:** Messersmith

**Also listed as:** BIO ENG C157

Nanomaterials in Medicine: Read Less [ - ]

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

Terms offered: Fall 2018, Fall 2017, Fall 2016

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

Principles of Molecular and Cellular Biophotonics: Read More [ + ]

### Rules & Requirements

**Prerequisites:** CHEM 3A and PHYSICS 7B; and BIO ENG 102 or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Marriott

Principles of Molecular and Cellular Biophotonics: Read Less [ - ]

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

Terms offered: Spring 2020, Spring 2019, Spring 2018

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

Molecular and Cellular Biophotonics Laboratory: Read More [ + ]

### Rules & Requirements

**Prerequisites:** BIO ENG 163 (may be taken concurrently)

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Marriott

Molecular and Cellular Biophotonics Laboratory: Read Less [ - ]

## BIO ENG 164 Optics and Microscopy 4 Units

Terms offered: Fall 2010, Fall 2009, Fall 2008

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

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

### Rules & Requirements

**Prerequisites:** PHYSICS 7A and PHYSICS 7B; or PHYSICS 8A and PHYSICS 8B

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Fletcher

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

## BIO ENG C165 Medical Imaging Signals and Systems 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Conolly

**Also listed as:** EL ENG C145B

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

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

Terms offered: Spring 2021

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

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

### Objectives & Outcomes

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

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

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

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

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

To discuss imaging ethics in the context of data interpretation

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

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

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Vandsburger

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

## BIO ENG 168L Practical Light Microscopy 3 Units

Terms offered: Fall 2021, Fall 2020, Fall 2017

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 2021

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

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

### Objectives & Outcomes

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

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

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

### Rules & Requirements

**Prerequisites:** BIO ENG 105; and BIO ENG 101 or EECS 16A and EECS 16B; or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Yartsev

Interface Between Neuroethology & Neural Engineering: Read Less [\[-\]](#)

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

Terms offered: Fall 2015, Fall 2014, Fall 2013

After an introduction to the different aspects of our global energy consumption, the course will focus on the role of biomass. The course will illustrate how the global scale of energy guides the biomass research. Emphasis will be placed on the integration of the biological aspects (crop selection, harvesting, storage and distribution, and chemical composition of biomass) with the chemical aspects to convert biomass to energy. The course aims to engage students in state-of-the-art research.

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

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

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

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

## BIO ENG 190 Special Topics in Bioengineering 1 - 4 Units

Terms offered: Fall 2021, Spring 2020, Fall 2017

This course covers current topics of research interest in bioengineering. The course content may vary from semester to semester.

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

### Rules & Requirements

**Prerequisites:** Consent of instructor

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

### Hours & Format

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

### Additional Details

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

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

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

## BIO ENG 192 Senior Design Projects 4 Units

Terms offered: Fall 2021, Fall 2020, Fall 2019

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

Senior Design Projects: Read More [+]

### Rules & Requirements

**Prerequisites:** Senior standing

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Herr

Senior Design Projects: Read Less [-]

## BIO ENG H194 Honors Undergraduate Research 3 or 4 Units

Terms offered: 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 [-]

## MAT SCI H194 Honors Undergraduate Research 1 - 4 Units

Terms offered: Fall 2016, Spring 2016, Fall 2015

Students who have completed a satisfactory number of advanced courses with a grade-point average of 3.3 or higher may pursue original research under the direction of one of the members of the staff. A maximum of 3 units of H194 may be used to fulfill technical elective requirements in the Materials Science and Engineering program or double majors (unlike 198 or 199, which do not satisfy technical elective requirements). Final report required.

Honors Undergraduate Research: Read More [+]

### Rules & Requirements

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

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

### Hours & Format

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

**Summer:** 8 weeks - 1.5-7.5 hours of independent study per week

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/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 [\[-\]](#)

## MAT SCI 195 Special Topics for Advanced Undergraduates 1 Unit

Terms offered: Spring 2012, Spring 2011, Spring 2010

Group study of special topics in materials science and engineering.

Selection of topics for further study of underlying concepts and relevant literature, in consultation with appropriate faculty members.

Special Topics for Advanced Undergraduates: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Upper division standing and good academic standing. (2.0 gpa and above)

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

Special Topics for Advanced Undergraduates: 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 2021, Spring 2021, Spring 2020

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

Directed Group Study for Advanced Undergraduates: Read More [\[+\]](#)

### Rules & Requirements

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

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

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

### Hours & Format

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

### Summer:

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

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

### Additional Details

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

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

Directed Group Study for Advanced Undergraduates: Read Less [\[-\]](#)

## MAT SCI 198 Directed Group Studies for Advanced Undergraduates 1 - 4 Units

Terms offered: Spring 2019, Fall 2018, Spring 2016

Group studies of selected topics.

Directed Group Studies for Advanced Undergraduates: Read More [\[+\]](#)

### Rules & Requirements

**Prerequisites:** Upper division standing in Engineering

### Hours & Format

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

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

Directed Group Studies 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 [\[-\]](#)

## MAT SCI 199 Supervised Independent Study 1 - 4 Units

Terms offered: Fall 2021, Summer 2021, Spring 2021

Supervised independent study. Enrollment restrictions apply; see the Introduction to Courses and Curricula section of this catalog.

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

### Rules & Requirements

**Prerequisites:** Consent of instructor and major adviser

**Credit Restrictions:** Course may be repeated for a maximum of four units per semester.

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

### Hours & Format

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

### Summer:

6 weeks - 1-5 hours of independent study per week

8 weeks - 1-4 hours of independent study per week

### Additional Details

**Subject/Course Level:** Materials Science and Engineering/Undergraduate

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

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