

# 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 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 technical courses (courses in engineering, mathematics, chemistry, physics, statistics, biological sciences, and computer science) 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 or CHEM 4A	General Chemistry and General Chemistry Laboratory <sup>1</sup> General Chemistry and Quantitative Analysis	4
CHEM 3A & 3AL or CHEM 112A	Chemical Structure and Reactivity and Organic Chemistry Laboratory <sup>1</sup> Course Not Available	5
PHYSICS 7A	Physics for Scientists and Engineers	4
PHYSICS 7B	Physics for Scientists and Engineers	4
BIOLOGY 1A & 1AL	General Biology Lecture and General Biology Laboratory	5
BIO ENG 10	Introduction to Biomedicine for Engineers	4
BIO ENG 24	Freshmen Seminar	1
ENGIN 7 or COMPSI 61A	Introduction to Computer Programming for Scientists and Engineers The Structure and Interpretation of Computer Programs	4
ENGIN 45	Properties of Materials	3
ENGIN 45L	Properties of Materials Laboratory	1

<sup>1</sup> CHEM 4A and CHEM 112A 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 104	Biological Transport Phenomena	4
BIO ENG 116 or BIO ENG C117 or BIO ENG 111	Cell and Tissue Engineering Structural Aspects of Biomaterials Functional Biomaterials Development and Characterization	4
BIO ENG C118	Biological Performance of Materials	4
MAT SCI 102	Bonding, Crystallography, and Crystal Defects	3
MAT SCI 104	Materials Characterization	4
MAT SCI 130 or BIO ENG 115	Experimental Materials Science and Design Cell Biology for Engineers	3
MAT SCI 151 or CHM ENG C17	Polymeric Materials Polymer Science and Technology	3
MCELLBI C100A/ CHEM C130	Biophysical Chemistry: Physical Principles and the Molecules of Life	4
or MCELLBI 102	Survey of the Principles of Biochemistry and Molecular Biology	4
BIO ENG 110 or BIO ENG 113	Biomedical Physiology for Engineers Stem Cells and Technologies	4
ENGIN 115 or CHEM 120B	Engineering Thermodynamics Physical Chemistry	4
Select two courses from the following:		6-8
BIO ENG 121	BioMEMS and Medical Devices	

BIO ENG 150	Introduction of Bionanoscience and Bionanotechnology	
MAT SCI 111	Properties of Electronic Materials	
MAT SCI 112	Corrosion (Chemical Properties)	
MAT SCI 113	Mechanical Behavior of Engineering Materials	
Upper division Technical elective, select one of the following: <sup>1</sup>		3-4
BIO ENG 111	Functional Biomaterials Development and Characterization	
BIO ENG 113	Stem Cells and Technologies	
BIO ENG 116	Cell and Tissue Engineering	
BIO ENG C117	Structural Aspects of Biomaterials	
BIO ENG 121	BioMEMS and Medical Devices	
BIO ENG H194	Honors Undergraduate Research	
BIO ENG 196	Undergraduate Design Research	
MAT SCI 103	Phase Transformations and Kinetics	
MAT SCI 111	Properties of Electronic Materials	
MAT SCI 112	Corrosion (Chemical Properties)	
MAT SCI 113	Mechanical Behavior of Engineering Materials	
Bioengineering Design Project or Research, select one of the following:		3-4
BIO ENG 121L	BioMems and BioNanotechnology Laboratory	
BIO ENG 140L	Synthetic Biology Laboratory	
BIO ENG 168L	Practical Light Microscopy	
BIO ENG 192	Senior Design Projects	
BIO ENG H194	Honors Undergraduate Research	
BIO ENG 196	Undergraduate Design Research	
Ethics requirement, select one of the following: <sup>2</sup>		3-4
ANTHRO 156B	Culture and Power	
BIO ENG 100	Ethics in Science and Engineering	
ENGIN 125	Ethics, Engineering, and Society	
ENGIN 157AC	Engineering, The Environment, and Society	
ESPM 161	Environmental Philosophy and Ethics	
ESPM 162	Bioethics and Society	
IAS 157AC	Engineering, The Environment, and Society	
MEC ENG 191AC	Cases and Conflicts in Engineering Ethics	
PHILOS 2	Individual Morality and Social Justice	
PHILOS 104	Ethical Theories	
PHILOS 107	Moral Psychology	
PB HLTH 116	Seminar on Social, Political, and Ethical Issues in Health and Medicine	

<sup>1</sup> The Technical elective 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 (<http://coe.berkeley.edu/students/guide/departments>) 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), required of the major or not, must be taken on a letter graded basis (unless they are only offered P/NP).
5. Entering freshmen are allowed a maximum of eight semesters to complete their degree requirements. Entering junior transfers are allowed a maximum of four semesters to complete their degree requirements. (Note: junior transfers admitted missing three or more courses from the lower division curriculum are allowed five semesters.) Summer terms are optional and do not count toward the maximum. Students are responsible for planning and satisfactorily completing all graduation requirements within the maximum allowable semesters.
6. Adhere to all college policies and procedures (<http://engineering.berkeley.edu/academics/undergraduate-guide>) as they complete degree requirements.
7. Complete the lower division program before enrolling in upper division engineering courses.

## Humanities and Social Science (H/SS) Requirement

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

1. Complete a minimum of six courses from the approved Humanities/Social Sciences (H/SS) lists (<http://coe.berkeley.edu/hssreq>).
2. Courses must be a minimum of 3 semester units (or 4 quarter units).
3. Two of the six courses must fulfill the college's Reading and Composition (R&C) requirement. These courses must be taken for a letter grade (C- or better required) and must be completed by no later than the end of the sophomore year (fourth semester of enrollment). The first half of R&C, the "A" course, must be completed by the end of the freshman year; the second half of R&C, the "B" course, must be completed by no later than the end of the sophomore year. View a detailed lists of courses (<http://ls-advise.berkeley.edu/requirement/rccourses.html>) that fulfill Reading and Composition requirements, or use the College of Letters and Sciences search engine (<http://ls-breadth.berkeley.edu>) to view R&C courses offered in a given semester.
4. The four additional courses must be chosen within College of Engineering guidelines from the H/SS lists (see below). These courses may be taken on a Pass/Not Passed basis (P/NP).
5. Two of the six courses must be upper division (courses numbered 100-196).
6. One of the six courses must satisfy the campus American Cultures requirement. For detailed lists of courses that fulfill American Cultures requirements, visit the American Cultures (<http://guide.berkeley.edu/archive/2016-17/undergraduate/colleges-schools/engineering/american-cultures-requirement>) site.
7. A maximum of two exams (Advanced Placement, International Baccalaureate, or A-Level) may be used toward completion of the H/SS requirement. View the list of exams (<http://>

engineering.berkeley.edu/academics/undergraduate-guide/exams-ap-ib-level-and-transfer-credit-information) that can be applied toward H/SS requirements.

8. Courses may fulfill multiple categories. For example, if you complete CY PLAN 118AC (<http://guide.berkeley.edu/search/?P=CY%20PLAN%20118AC>) that would satisfy the American Cultures requirement and one upper division H/SS requirement.
9. No courses offered by any engineering department other than BIO ENG 100 (<http://guide.berkeley.edu/search/?P=BIO%20ENG%20100>), COMPSCI C79 (<http://guide.berkeley.edu/search/?P=COMPSCI%20C79>), ENGIN 125 (<http://guide.berkeley.edu/search/?P=ENGIN%20125>), ENGIN 157AC (<http://guide.berkeley.edu/search/?P=ENGIN%20157AC>), MEC ENG 191K (<http://guide.berkeley.edu/search/?P=MEC%20ENG%20191K>) and MEC ENG 191AC (<http://guide.berkeley.edu/search/?P=MEC%20ENG%20191AC>) may be used to complete H/SS requirements.
10. Foreign language courses may be used to complete H/SS requirements. View the list of language options (<http://ls-advice.berkeley.edu/requirement/fl.html>) .
11. Courses numbered 97, 98, 99, or above 196 may not be used to complete any H/SS requirement
12. The College of Engineering uses modified versions of five of the College of Letters and Science (L&S) breadth requirements lists to provide options to our students for completing the H/SS requirement. No courses on the L&S Biological Sciences or Physical Sciences breadth lists may be used to complete H/SS requirements. Within the guidelines above, choose courses from any of the lists below.
  - Arts and Literature (<http://guide.berkeley.edu/archive/2016-17/undergraduate/colleges-schools/letters-science/breadth-requirement-arts-literature>)
  - Foreign Language (<http://ls-advice.berkeley.edu/requirement/fl.html>)
  - Historical Studies (<http://guide.berkeley.edu/archive/2016-17/undergraduate/colleges-schools/letters-science/breadth-requirement-historical-studies>)
  - International Studies (<http://guide.berkeley.edu/archive/2016-17/undergraduate/colleges-schools/letters-science/breadth-requirement-international-studies>)
  - Philosophy and Values (<http://guide.berkeley.edu/archive/2016-17/undergraduate/colleges-schools/letters-science/breadth-requirement-philosophy-values>)
  - Social and Behavioral Studies (<http://guide.berkeley.edu/archive/2016-17/undergraduate/colleges-schools/letters-science/breadth-requirement-social-behavioral-sciences>)

## Class Schedule Requirements

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

- A student's proposed schedule must be approved by a faculty adviser (or on approval from the dean or a designated staff adviser) each semester prior to enrolling in courses.

## Minimum Academic (Grade) Requirements

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

## Unit Requirements

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

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

## Normal Progress

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

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	Spring
CHEM 1A & CHEM 1AL, or CHEM 4A <sup>1</sup>	4	CHEM 3A & CHEM 3AL, or CHEM 112A <sup>1</sup> 5
MATH 1A	4	MATH 1B 4
BIO ENG 10	4	PHYSICS 7A 4
BIO ENG 24	1	ENGIN 7 or COMPSCI 61A 4
Reading and Composition course from List A	4	
	17	17

Sophomore				
	Fall	Units	Spring	Units
MATH 53		4	MATH 54	4
PHYSICS 7B		4	BIOLOGY 1A & 1AL	5
ENGIN 45		3	Humanities/ Social Sciences course	3-4
ENGIN 45L		1		
Reading and Composition course from List B		4		
		16		12-13
Junior				
	Fall	Units	Spring	Units
BIO ENG 102		4	BIO ENG 104	4
BIO ENG 110 or 113 <sup>2</sup>		4	MAT SCI 104	4
MAT SCI 102		3	MCELLBI C100A or 102 <sup>2</sup>	4
CHEM 120B or ENGIN 115		3-4	BIO ENG 100 or Humanities/ Social Sciences course with ethics content <sup>3</sup>	3-4
		14-15		15-16
Senior				
	Fall	Units	Spring	Units
BIO ENG 115 or MAT SCI 130		3-4	BIO ENG 116, C117, or 111	4
BIO ENG C118		4	MAT SCI 111, 112, 113, BIO ENG 121, or BIO ENG 150 <sup>4</sup>	3-4
MAT SCI 111, 112, 113, BIO ENG 121, or BIO ENG 150 <sup>4</sup>		3-4	Bioengineering Design Project or Research <sup>5</sup>	3-4
MAT SCI 151 or CHM ENG C178		3	Technical Elective <sup>6</sup>	3-4
Humanities/Social Sciences course		3-4	Humanities/ Social Sciences course	3-4
		16-19		16-20

Total Units: 123-133

<sup>1</sup> CHEM 4A and CHEM 112A are intended for students majoring in chemistry or a closely-related field.

<sup>2</sup> BIO ENG 110 is offered in fall semester. BIO ENG 113 is offered in spring semester. If you take choose to take BIO ENG 110, take MCELLBI C100A or MCELLBI 102 in spring. If you take BIO ENG 113, take MCELLBI C100A or MCELLBI 102 in fall.

<sup>3</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: ANTHRO 156B, BIO ENG 100, ENGIN 125, ENGIN 157AC, ESPM 161, ESPM 162, IAS 157AC, L & S 160B, MEC ENG 191AC, PHILOS 2, PHILOS 104, PHILOS 107, PB HLTH 116. (PB HLTH 116 taken prior to Fall 15 fulfills Ethics requirement only.)

<sup>4</sup> Two courses from this list must be completed: one in the fall semester and one in the spring semester.

<sup>5</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 H194, BIO ENG 196.

<sup>6</sup> Technical elective: Choose one of the following: BIO ENG 111, BIO ENG 113, BIO ENG 116, BIO ENG C117, BIO ENG 121, BIO ENG H194, BIO ENG 196, MAT SCI 103, MAT SCI 111, MAT SCI 112, MAT SCI 113. The Technical elective cannot be a course you have taken to fulfill another requirement.

## Bioengineering/Materials Science and Engineering

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

Terms offered: Fall 2017, Fall 2016, Fall 2015

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

Introduction to Biomedicine for Engineers: Read More [+]

#### Hours & Format

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

#### Additional Details

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

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

**Instructors:** Conboy, Kumar

Introduction to Biomedicine for Engineers: Read Less [-]

## BIO ENG 11 Engineering Molecules 1 3 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

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

Engineering Molecules 1: [Read More](#) [+]

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** Chemistry 3A

### Hours & Format

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

### Additional Details

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

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

Engineering Molecules 1: [Read Less](#) [-]

## BIO ENG 24 Freshmen Seminar 1 Unit

Terms offered: Spring 2018, Spring 2017, Fall 2016

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

Freshmen Seminar: [Read More](#) [+]

### Hours & Format

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

### Additional Details

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

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

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

## MAT SCI 24 Freshman Seminar 1 Unit

Terms offered: Spring 2018, Spring 2017, Spring 2016

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 2018, Spring 2017, Spring 2016

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

Careers in Biotechnology: [Read More](#) [+]

### Rules & Requirements

**Repeat rules:** Course may be repeated for credit.

### 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 2017

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

Introduction to Bioengineering: Read More [+]

### Objectives Outcomes

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** T. Johnson, H. Lam

Introduction to Bioengineering: Read Less [-]

## MAT SCI 45 Properties of Materials 3 Units

Terms offered: Spring 2018, Fall 2017

Application of basic principles of physics and chemistry to the engineering properties of materials. Special emphasis devoted to relation between microstructure and the mechanical properties of metals, concrete, polymers, and ceramics, and the electrical properties of semiconducting materials. Sponsoring Department: Materials Science and Engineering Properties of Materials: Read More [+]

### Rules & Requirements

**Prerequisites:** Physics 7A (may be taken concurrently)

**Credit Restrictions:** Students will receive no credit for MSE 45 after taking E45

### 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: Spring 2018, Fall 2017

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 as topic varies. 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: Spring 2018, Fall 2017, Spring 2017

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

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

### Rules & Requirements

**Prerequisites:** Consent of instructor

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

**Repeat rules:** Course may be repeated for credit.

### 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 2018, Fall 2017, Spring 2017

Supervised independent study for lower division students.

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

### Rules & Requirements

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

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

**Repeat rules:** Course may be repeated for credit.

### 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 2017, Fall 2016, Fall 2015

The goal of this semester course is to present the issues of professional conduct in the practice of engineering, research, publication, public and private disclosures, and in managing professional and financial conflicts.

The method is through historical didactic presentations, case studies, presentations of methods for problem solving in ethical matters, and classroom debates on contemporary ethical issues. The faculty will be drawn from national experts and faculty from religious studies, journalism, and law from the UC Berkeley campus.

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Lam, Hayley

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

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

Terms offered: Spring 2018, Spring 2017, Spring 2016

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

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

Instrumentation in Biology and Medicine: Read More [+]

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** EI Eng 16A & 16B, Math 53, 54, Physics 7A-7B, or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Conolly

Instrumentation in Biology and Medicine: Read Less [-]

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

Terms offered: Fall 2017, Fall 2016, Fall 2015

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

Biomechanics: Analysis and Design: Read More [+]

### Objectives Outcomes

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

Topics include:

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

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

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

### Rules & Requirements

**Prerequisites:** Math 53, 54; Physics 7A

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Mofrad

Biomechanics: Analysis and Design: Read Less [-]



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

Terms offered: Fall 2017, Fall 2016, Fall 2015

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:** Engineering 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 2017, Fall 2016

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

Engineering Molecules 2: Read More [+]

### Objectives Outcomes

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Head-Gordon

Engineering Molecules 2: Read Less [-]

## MAT SCI 103 Phase Transformations and Kinetics 3 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

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:** 102 and Engineering 115

### 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 2018, Spring 2017, Spring 2016

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

Biological Transport Phenomena: Read More [+]

### Rules & Requirements

**Prerequisites:** Mathematics 53, 54, and Physics 7A

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Johnson

Biological Transport Phenomena: Read Less [-]

## MAT SCI 104 Materials Characterization 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

Physical and chemical characterization of materials: Diffraction, imaging, and spectroscopy using optical, electron, and X-ray methods for bulk and surface analysis. Measurement of mechanical and physical properties. Project laboratory focusing on mechanical, chemical, electrical, and magnetic properties of materials, and materials characterization. Field trips.

Materials Characterization: Read More [+]

### Rules & Requirements

**Prerequisites:** 102

### Hours & Format

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

**Instructor:** Gronsky

Materials Characterization: Read Less [-]

## BIO ENG C106A Introduction to Robotics 4 Units

Terms offered: Fall 2017

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

Introduction to Robotics: Read More [ + ]

### Rules & Requirements

**Prerequisites:** Electrical Engineering 120 or equivalent, consent of instructor

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Bajcsy

**Also listed as:** EECS C106A

Introduction to Robotics: Read Less [ - ]

## BIO ENG C106B Robotic Manipulation and Interaction 4 Units

Terms offered: Spring 2018

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

Robotic Manipulation and Interaction: Read More [ + ]

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Bajcsy, Sastry

**Also listed as:** EECS C106B

Robotic Manipulation and Interaction: Read Less [ - ]

## BIO ENG 110 Biomedical Physiology for Engineers 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

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

Biomedical Physiology for Engineers: Read More [+]

### Objectives Outcomes

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Kumar

Biomedical Physiology for Engineers: Read Less [-]

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

Terms offered: Spring 2018, Spring 2017, Spring 2016

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

Functional Biomaterials Development and Characterization: Read More [+]

### Objectives Outcomes

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

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** SW Lee

Functional Biomaterials Development and Characterization: Read Less [-]

## MAT SCI 111 Properties of Electronic Materials 4 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

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-7B-7C or Physics 7A-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 2018, Spring 2017, Spring 2016

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:** Engineering 45 and Engineering 115

### 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 2016, Spring 2015, Spring 2014

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

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

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** Math 54; Physics 7A; BioE102 or MEC85 or instructor's consent

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Mofrad

**Also listed as:** MEC ENG C115

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



## BIO ENG 113 Stem Cells and Technologies 4 Units

Terms offered: Fall 2015, Fall 2014, Fall 2013

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

Stem Cells and Technologies: Read More [+]

### Rules & Requirements

**Prerequisites:** 10 and Biology 1A, or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Conboy

Stem Cells and Technologies: Read Less [-]

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

Terms offered: Fall 2017, Fall 2016, Fall 2015

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

Mechanical Behavior of Engineering Materials: Read More [+]

### Rules & Requirements

**Prerequisites:** C30/Mechanical Engineering C85 and Engineering 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 2017, Fall 2016

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

Cell Engineering: Read More [+]

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** Bio1A or Bio Eng 11; or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Conboy

Cell Engineering: Read Less [-]

## BIO ENG 115 Cell Biology for Engineers 4 Units

Terms offered: Spring 2018, Fall 2017, Spring 2017

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

Cell Biology for Engineers: Read More [+]

### Objectives Outcomes

**Course Objectives:** • To introduce a variety of basic cellular biology laboratory techniques, and develop a conceptual and theoretical understanding of the reliability and limitations of these tools.

• To support students in developing a research question, defining project goals and designing experiments that can be addressed within the constraints of the course.

• To engage students in applying their knowledge and research to others in professional activities such as presentations and papers.

**Student Learning Outcomes:** Students will gain an understanding of:

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Lam, Hayley, Irina Conboy

Cell Biology for Engineers: Read Less [-]

## BIO ENG 116 Cell and Tissue Engineering 4 Units

Terms offered: Spring 2016, Spring 2015, Spring 2014

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

Cell and Tissue Engineering: Read More [+]

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** BioE 103 or equivalent, BioE 104

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Li

Cell and Tissue Engineering: Read Less [-]

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

Terms offered: Spring 2017, Spring 2011, Fall 2010

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-7B-7C or Physics 7A-7B and consent of instructor; 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: Spring 2018, Spring 2016, Fall 2013

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

Structural Aspects of Biomaterials: Read More [+]

### **Rules & Requirements**

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

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

### **Hours & Format**

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

### **Additional Details**

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

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

**Instructor:** Pruitt

**Also listed as:** MEC ENG C117

Structural Aspects of Biomaterials: Read Less [-]

## BIO ENG C118 Biological Performance of Materials 4 Units

Terms offered: Fall 2017, Fall 2015, Fall 2014

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

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

### Objectives Outcomes

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

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

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

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

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

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

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

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

### Rules & Requirements

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

### Hours & Format

## MAT SCI C118 Biological Performance of Materials 4 Units

Terms offered: Fall 2017, Fall 2015, Fall 2014

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

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

### Objectives Outcomes

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

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

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

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

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

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

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

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

### Rules & Requirements

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

### Hours & Format

## BIO ENG C119 Orthopedic Biomechanics 4 Units

Terms offered: Fall 2017, Fall 2016, Fall 2015

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Keaveny

**Also listed as:** MEC ENG C176

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

## MAT SCI 120 Materials Production 3 Units

Terms offered: Fall 2017, Fall 2016, Fall 2015

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:** Engineering 115, Mechanical Engineering 40, Chemical Engineering 141, Chemistry 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: Spring 2018, Spring 2017, Spring 2016

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

### Rules & Requirements

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

### Hours & Format

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

### Summer:

6 weeks - 7.5 hours of lecture per week

8 weeks - 5.5 hours of lecture per week

10 weeks - 4.5 hours of lecture per week

### Additional Details

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

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

**Instructor:** L. Lee

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

## MAT SCI 121 Metals Processing 3 Units

Terms offered: Spring 2015, Spring 2014, Spring 2013

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:** Engineering 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 2016, Fall 2015, Spring 2015

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

BioMems and BioNanotechnology Laboratory: Read More [+]

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** BioE 103 or equivalent, BioE 104

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** D. Liepmann

BioMems and BioNanotechnology Laboratory: Read Less [-]

## 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:** Engineering 45, 115

### 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: Fall 2017, Fall 2016, Fall 2015

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:** MSE 111 or 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 2017, Fall 2016, Fall 2015

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

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

### Rules & Requirements

**Prerequisites:** BioE 103 or equivalent

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Murthy

Basic Principles of Drug Delivery: Read Less [-]

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

Terms offered: Spring 2016, Spring 2015, Fall 2014

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, and chemical engineering; Engineering 45 required; 111 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:** EE 120 or equivalent, consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Bajcsy

**Formerly known as:** Electrical Engineering C125/Bioengineering C125

**Also listed as:** EL ENG C106A

Introduction to Robotics: Read Less [-]

## BIO ENG C125B Robotic Manipulation and Interaction 4 Units

Terms offered: Spring 2017, Spring 2016

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructors:** Bajcsy, Sastry

**Also listed as:** EL ENG C106B

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

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

Terms offered: Fall 2017, Fall 2016, Fall 2015

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 2017, Fall 2016, Fall 2015

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Holmes

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

## BIO ENG 132 Genetic Devices 4 Units

Terms offered: Spring 2018, Fall 2014, Fall 2013

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

Genetic Devices: Read More [ + ]

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** Engineering 7 or Computer Science 61A, Mathematics 54, Chemistry 3A, and BioE 103 or equivalent

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Anderson

Genetic Devices: Read Less [ - ]

## BIO ENG 133 Biomolecular Engineering 3 Units

Terms offered: Prior to 2007

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

Biomolecular Engineering: Read More [ + ]

### Objectives Outcomes

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Schaffer

Biomolecular Engineering: Read Less [ - ]



## BIO ENG 134 Genetic Design Automation 4 Units

Terms offered: Fall 2017

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

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** CS61B; BioEng 103 or equivalent

### Hours & Format

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

### Additional Details

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

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

**Instructor:** J. Christopher Anderson

Genetic Design Automation: Read Less [-]

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

Terms offered: Spring 2017, Fall 2009

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

Frontiers in Microbial Systems Biology: Read More [+]

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

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

Frontiers in Microbial Systems Biology: Read Less [-]

## MAT SCI 136 Materials in Energy Technologies 4 Units

Terms offered: Fall 2017, Fall 2015, Fall 2011

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

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

### Hours & Format

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

### Additional Details

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

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

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

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

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

## BIO ENG C137 Designing for the Human Body 3 Units

Terms offered: Fall 2017

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

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

### Objectives Outcomes

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

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

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

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

Terms offered: Spring 2015, Spring 2013, Spring 2012

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:** 102 or equivalent recommended; Physics 7C and Engineering 45 required

### Hours & Format

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

### Additional Details

**Subject/Course Level:** 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: Fall 2015, Spring 2015, Fall 2014

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

Synthetic Biology Laboratory: [Read More](#) [+]

### Rules & Requirements

**Prerequisites:** Molecular biology, basic chemistry and biochemistry, and differential equations; or consent of instructor

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Anderson

Synthetic Biology Laboratory: [Read Less](#) [-]

## BIO ENG 143 Computational Methods in Biology 4 Units

Terms offered: Fall 2011, Fall 2010, Fall 2009

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Head-Gordon

Computational Methods in Biology: Read Less [-]

## BIO ENG 144 Introduction to Protein Informatics 4 Units

Terms offered: Spring 2017, Fall 2008, Fall 2007

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

Introduction to Protein Informatics: Read More [+]

### Objectives Outcomes

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Sjolander

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

Introduction to Protein Informatics: Read Less [-]

## BIO ENG 144L Protein Informatics Laboratory 3 Units

Terms offered: Fall 2008

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Sjolander

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

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

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

Terms offered: Fall 2017

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

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

### Objectives Outcomes

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** K. Sjolander

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



## BIO ENG C145L Introductory Electronic Transducers Laboratory 3 Units

Terms offered: Fall 2014, Fall 2013, Fall 2012

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Derenzo

**Also listed as:** EL ENG C145L

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

## BIO ENG C145M Introductory Microcomputer Interfacing Laboratory 3 Units

Terms offered: Spring 2013, Spring 2012, Spring 2011

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Derenzo

**Also listed as:** EL ENG C145M

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

## BIO ENG 147 Principles of Synthetic Biology 4 Units

Terms offered: Fall 2016, Fall 2015, Fall 2014

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

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

### Objectives Outcomes

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Arkin

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

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

Terms offered: Fall 2017, Fall 2016, Fall 2015

This course will cover metabolic engineering and the various synthetic biology approaches for optimizing pathway performance. Use of metabolic engineering to produce biofuels and general "green technology" will be emphasized since these aims are currently pushing these fields. The course is meant to be a practical guide for metabolic engineering and the related advances in synthetic biology as well the related industrial research and opportunities.

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

### Objectives Outcomes

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

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

### Rules & Requirements

**Prerequisites:** Chem 3A, BioE 103 or equivalent

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Dueber

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

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

Terms offered: Fall 2017, Fall 2016, Fall 2015

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

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

### Objectives Outcomes

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

## MAT SCI C150 Introduction to Materials Chemistry 3 Units

Terms offered: Spring 2018, Spring 2017, Spring 2015, Spring 2014, Spring 2012

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:** 104A; 104B 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.

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Herr

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

## MAT SCI 151 Polymeric Materials 3 Units

Terms offered: Spring 2018, Spring 2017, Spring 2016

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:** Chemistry 1A or Engineering 5. 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 163 Principles of Molecular and Cellular Biophotonics 4 Units

Terms offered: Fall 2017, Fall 2016, Fall 2015

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Marriott

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

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

Terms offered: Spring 2018, Spring 2017, Spring 2015

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

Molecular and Cellular Biophotonics Laboratory: Read More [+]

### Rules & Requirements

**Prerequisites:** Bioengineering 163 and ok to take concurrently

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Marriott

Molecular and Cellular Biophotonics Laboratory: Read Less [-]

## BIO ENG 164 Optics and Microscopy 4 Units

Terms offered: Fall 2010, Fall 2009, Fall 2008

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

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

### Rules & Requirements

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Fletcher

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

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

Terms offered: Fall 2017, Fall 2016, Fall 2015

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

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

### Rules & Requirements

**Prerequisites:** Electrical Engineering 16A and 16B

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Conolly

**Also listed as:** EL ENG C145B

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

## BIO ENG 168L Practical Light Microscopy 3 Units

Terms offered: Fall 2017, Spring 2015, Fall 2013

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

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

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Fletcher

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

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

Terms offered: Fall 2015, Fall 2014, Fall 2013

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

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

### Rules & Requirements

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

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

### Hours & Format

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

### Additional Details

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

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

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

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

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

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

Terms offered: Fall 2017, Fall 2016, Spring 2016

This course covers current topics of research interest in bioengineering.

The course content may vary from semester to semester.

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

### Rules & Requirements

**Prerequisites:** Consent of instructor

**Repeat rules:** Course may be repeated for credit.

### 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 2017, Fall 2016, Fall 2015

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

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

### Rules & Requirements

**Prerequisites:** Senior standing

### Hours & Format

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

### Additional Details

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

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

**Instructor:** Herr

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



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

Terms offered: Spring 2016, Fall 2015, Spring 2015

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

Honors Undergraduate Research: Read More [\[+\]](#)

### Rules & Requirements

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

**Repeat rules:** Course may be repeated for a maximum of 8 units. Course may be repeated for a maximum of 8 units.

### Hours & Format

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

#### Summer:

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

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

### Additional Details

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

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

Honors Undergraduate Research: Read Less [\[-\]](#)

## 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.

### 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: Not yet offered

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.

### 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 4 Units

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

Undergraduate Design Research: [Read More](#) [+]

### Rules & Requirements

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

**Repeat rules:** Course may be repeated for credit once. Course may be repeated for a maximum of 8 units.

### Hours & Format

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

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

### Additional Details

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

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

Undergraduate Design Research: [Read Less](#) [-]

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

Terms offered: Spring 2018, Fall 2017, Spring 2017

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.

### 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 2016, Fall 2015, Spring 2015

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 2016, Spring 2016, Fall 2015

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.

### 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 2016, Spring 2016, Fall 2015

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.

### 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 [\[-\]](#)