

Fourth Year

Ay 31	Written Communication	-	-	3
Ay 102	Physics of the Interstellar Medium	-	9	-
	Astronomy or Physics Electives	18	18	18
	HSS Electives	9	9	9
	Electives	18-24	9-15	15-21
		45-51	45-51	45-51

An ability to present one's work is vital to a successful career in research and teaching. Ay 30 satisfies the oral communications requirement, but for further development, students are *also* urged to sign up for Ay 141 in their junior and senior years. Ay 31 satisfies the written communication requirement. Students are encouraged (but not required) to undertake research leading to a senior thesis; credit for this work is provided through Ay 78. Nonthesis research credits may be earned through Ay 142 with a maximum of 9 units per term. Computational skills may be acquired through Ph 20–21 and/or ACM 106, or equivalent classes.

Suggested Electives

The student may elect any course offered in any division in a given term, provided that he or she has the necessary prerequisites for that course. The following courses are useful to work in various fields of astronomy and astrophysics: ACM 95, ACM 106, APh 23/24, Ay 105, Ay 121–127, EE 45, EE 91, EE/Ae 157, Ge/Ay 11 c, Ge 103, Ge/Ch 128, Ge 131, Ge/Ay 132, 133, 137, Ma 4, Ma 12, Ma 112, Ph 20–22, Ph 77, 101, 127, 129, 136, 199 (this is not necessarily a complete list).

Bioengineering Option

The undergraduate bioengineering option provides a foundation for graduate studies in the application of engineering principles to the design, analysis, construction, and manipulation of biological systems, and in the discovery and application of new engineering principles inspired by the properties of biological systems. Students are required to complete core requirements in biomechanics, biomolecular engineering, cellular engineering, and physical biology of the cell.

Each student must specialize by selecting one of four tracks emphasizing the principles and experimental methods of a subdiscipline of bioengineering.

- The devices track prepares students for graduate research in the design and fabrication of devices for manipulating, imaging, analyzing, or regulating biological systems.
- The mechanics track prepares students for graduate research in elucidating the role of forces and flows in biological development, function and disease, and in exploiting this understanding to engi-

neer biological and nonbiological mechanical systems based on these principles.

- The synthetic biology track prepares students for graduate research in the fundamentals of biological circuit design at the molecular, cellular, and multicellular levels, emphasizing both the physical and information-processing aspects of biological circuits.
- The self-guided track is intended to provide flexibility for students that wish to prepare for graduate research in an area of bioengineering that is not well served by a predefined track.

Each track culminates in a design lab that features the design and construction of a novel experimental system appropriate to the track. Students should notify the registrar of their track selection by the end of the third term of the first year. Students should present a plan for satisfying all degree requirements to their academic advisor by the end of the third term of the second year.

In addition to the Institute Core requirements, bioengineering students must satisfy requirements that provide additional grounding in physical chemistry, molecular biology, cell biology, experimental cell biology, mathematical methods, and computational methods.

Undergraduate research is encouraged both during the academic year and through participation in summer research programs.

Students with a grade point average lower than 1.9 will not be allowed to continue in the option except with special permission from the option representative.

Option Requirements

- BE 1, BE/Bi 105, BE/APh 161, ChE/BE 163, ChE/BE 169.
- BE track: Satisfy the requirements for one of four 72-unit tracks. Track electives must be approved by the academic advisor as relevant to the selected track.
 - Devices track: APh/EE 9 ab, EE 45, EE 111, EE 151, EE/BE 185, BE/EE 189, 9 units of track electives.
 - Mechanics track: ME 19 a, ME 35 a, BE 152, Ae/APh 104 ab, BE 104 c, 18 units of track electives.
 - Synthetic biology track: Ch 41 a; Bi/Ch 110; CDS 110 a or ChE 105; BE/CS/CNS/Bi 191; ChE 130; 21–24 units of track electives.
 - Self-guided track: Students may choose to present a proposal for a self-guided track to the Bioengineering Undergraduate Committee (comprising the option representative and one BE faculty member representing each of the three established tracks). The proposed track should provide grounding in the principles and experimental techniques of a subfield of bioengineering and should culminate with a design lab.
- Biology: Bi 8, Bi 9 (based on placement exams administered by the biology option, students with sufficient background may choose to take Bi/Ch 111 instead of Bi 8 and Bi/Ch 113 instead

of Bi 9). One advanced biology course selected from Bi/Ch 111, Bi/Ch 113, Bi 114, Bi 117, Bi 122, Bi 145ab, Bi/CNS 150.

4. Chemistry: Ch 24 ab.
5. Mathematical and computational methods: ACM 95 ab; ACM 95 c (devices and mechanics tracks) or ACM/EE 116 (synthetic biology track); 9 units selected from CS 1–3, CS 11, Ph 20–22, ACM 11.
6. Experimental methods: Bi 10, one advanced biology lab class selected from BE/APh 162, Bi 180, Bi 227, ChE 130, track-specific lab requirements (see Requirement 2).
7. E 10, E 11.
8. Courses satisfying option requirements must be taken for grades (except when courses are only available on a pass/fail basis). Passing grades must be earned in a total of 486 units.

Typical Course Schedule

		<i>Units per term</i>		
		<i>1st</i>	<i>2nd</i>	<i>3rd</i>
<i>First Year</i>				
Ph 1 abc	Freshman Physics	9	9	9
Ma 2 abc	Freshman Mathematics	9	9	9
Ch 1 ab	General Chemistry	6	9	-
Ch 3 a	Fundamental Techniques of Experimental Chemistry	6	-	-
Bi 8	Introduction to Molecular Biology	-	9	-
Bi 9	Cell Biology	-	-	9
Bi 10	Cell Biology Lab	-	-	6
BE 1	Frontiers in Bioengineering	-	1	-
	Menu Course	-	-	9
	HSS Electives	9	9	-
	PE	-	-	3
		39	46	45
<i>Second Year</i>				
Ph 2 ab	Sophomore Physics	9	9	-
Ma 2 ab	Sophomore Mathematics	9	9	-
Ch 24 ab	Intro. to Biophysical Chemistry	-	9	9
BE/Bi 105	Introduction to Biomechanics	-	-	9
	General and Track Electives	x	x	x
	HSS Electives	x	x	x
Devices track	APh/EE 9 ab	6	6	-
	EE 45	-	12	-
Mechan. track	ME 19 a	9	-	-
	ME 35 a	9	-	-
Syn. bio track	Ch 41 a	9	-	-
		42-45	42-45	42-45

Third Year

ACM 95 ab	Intro. Methods of Applied Math	12	12	-
ChE/BE 163	Intro. to Biomolecular Engineering	9	-	-
BE/APh 161	Physical Biology of the Cell	-	9	-
ChE/BE 169	Biomolecular Cell Engineering	-	-	9
E 10	Technical Seminar Presentations	x	x	x
	Computational Methods Req.	x	x	x
	HSS Electives	x	x	x
	General and Track Electives	x	x	x
Devices track	EE 111	9	-	-
	ACM 95 c	-	-	12
	BE/EE 189	-	-	12
Mechan. track	Ae/APh 104 ab	9	9	-
	BE 104 c	-	-	9
	ACM 95 c	-	-	12
Syn. bio track	Bi/Ch 110	12	-	-
	ACM/EE 116	9	-	-
	ChE 130	-	-	9
		42-45	42-45	42-45

Fourth Year

E 11	Written Technical Communication	x	x	x
	HSS Electives	x	x	x
	Advanced Biology and Biology Lab Req.	x	x	x
	General and Track Electives	x	x	x
Devices track	EE 151	-	9	-
	EE/BE 185	-	-	9
Mechan. track	BE 152	-	9	-
Syn. bio track	CDS 110 a or ChE 105	x	-	x
	BE/CS/CNS/Bi 191 a	-	9	-
		42-45	42-45	42-45

Suggested Track Electives

Devices track

BE 98, BE 99, EE 112, EE 113, EE 114 ab, ACM/EE 116, EE/BE 166.

Mechanics track

BE 98, BE 99, ME 19 b, ME 35 bc, ME 71, Ae/APh/CE/ME 101 abc, Ae/APh/CE/ME 102 abc, BE 141, BE 142, BE 153, Ae/BE 242, BE/Ae 243, BE 251.

Synthetic biology track

BE 98, BE 99, CS 21, ACM 116, ChE/Ch 148, ChE/Ch 164, ChE/Ch 165, Bi 250 c, BE 251.

Biology Option

The undergraduate option in biology is designed to build on a solid foundation in mathematics and physical science by providing an introduction to the basic facts, concepts, problems, and methodologies of biological science. The option serves as a basis for grad-