

ENVIRONMENTAL SCIENCE AND ENGINEERING MINOR (ESE)

The ESE minor is intended to supplement one of Caltech's undergraduate degrees. It is designed for students who wish to broaden their studies beyond their major to include environmental science and engineering. Students completing the ESE minor requirements will have the phrase "minor in environmental science and engineering" added to their transcripts.

ESE Minor Requirements

1. Complete 27 units of ESE 1, 101, 102, or 103
2. Complete 27 additional units of ESE courses (which may include up to 18 units of research under ESE 90, including the required written report).

Except for research courses, all ESE courses to be applied to fulfill the minor requirements must be taken for grades, and students must maintain a minimum grade average of B- in this ESE coursework. Courses that are used to satisfy the ESE minor requirements cannot be used to satisfy course requirements in the major.

GEOLOGICAL AND PLANETARY SCIENCES (GPS)

(Geology, Geobiology, Geochemistry, Geophysics, Planetary Science)

The aim of this undergraduate program is to provide thorough training in the geological and planetary sciences and, wherever possible, to integrate these studies with courses in mathematics, physics, chemistry, and biology taken during the student's earlier years at the Institute. Active involvement in research, particularly during the summer, is encouraged. For geologists, field work is important because it provides firsthand experience with geological phenomena that can never be satisfactorily grasped or understood solely from classroom or laboratory treatment. Options are offered in geology, geobiology, geochemistry, geophysics, and planetary science. Electives permit students to follow lines of special interest in related scientific and engineering fields. Those who do well in the basic sciences and at the same time have a compelling curiosity about the earth and the other planets are likely to find their niche in these options, especially if they enjoy grappling with complex problems involving many variables. Most students majoring in the earth and planetary sciences now pursue further training at the graduate level.

Under the geobiology option, a student can be associated with either the biology or the GPS division. This association formally will only affect which course the students elect to satisfy the Institute-wide oral presentation requirement; all other geobiology option requirements are independent of GPS or biology affiliation. In practice, however, we expect that students' affiliation with one division or another will significantly shape their choice of elective courses.

For students beginning their junior year, it is possible to complete the requirements for geochemistry, geophysics, and planetary science options within two years, but there are benefits from starting with the Ge 11 sequence in the sophomore year. Because Ge 120 ab may not be offered every year, students in the geology option may also need to take Ge 106 and Ge 120 a in winter and spring term of their sophomore year in order to prepare for Ge 120 b the following summer.

GPS Double Majors

For students simultaneously pursuing a degree in a second option, courses taken as required courses for that option can also be counted as Ge electives where appropriate. However, courses that count toward the electives requirement in the other option cannot simultaneously be counted toward satisfying the elective requirement in GPS.

GPS Option Requirements

Geology Option Requirements

1. Ge 11 ab, Ge/Ay 11 c or Ge 11 d¹, and any writing class and oral presentation class that satisfies the Institute scientific requirements².
2. Ma 2 and one choice from: Ma 3, Ge/ESE 118, or Ge/Ay 117.
3. Ph 2 a or Ph 12, a plus an additional quarter of sophomore-level physics (Ph 2 b, 2 c, 12 b, or 12 c).
4. Either ACM 95 ab or the combination of a full-year chemistry sequence (Ch 41 abc or Ch 21 abc).
5. Ge 106, 114 ab, 115 ab, 120 ab³.
6. Ge 111 ab or Ge 11 d.
7. Ge 112 or Ge 125.
8. Elective courses in Ge or cross-listed with Ge to bring the total option units up to 210 (selected in consultation with adviser and approved by the option representative).

¹ No class may be used to simultaneously satisfy more than one of these requirements.

² For example, SEC 10 and one of SEC 11, SEC 12, SEC 13, or can be satisfied by En/Wr 84.

³ If Ge 120b is not offered, a suitable 3-5 week field camp may be substituted.

GPS Typical Course Schedules

		Units per term		
		1st	2nd	3rd

Second Year

Ma 2 & 3	Sophomore mathematics	9	9	-
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Ph 2 a & c	Sophomore physics	9	-	9
Ge 11 abc	Intro. To Earth and Planetary Sci.	9	9	9
Ge 106	Intro. to Structural Geology	-	9	-
Ge 120a	Field Geology Intro.	-	-	9
	HSS electives	9	9	9
	Total	36	36	36

Summer

Ge 120 b	Field Geology Camp	-	-	15
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Third year

ACM 95 ab	Intro. Methods of Applied Math.	-	12	12
Ge 112	Sedimentology and Stratigraphy	12	-	-
Ge 114 ab	Mineralogy	12	-	-
Ge 115 a	Petrology and Petrography	-	9	-
Ge 111 ab	Applied Geophysics	-	6	9
	HSS electives	9	9	9
	Total	33	36	30

Fourth Year

	Geology electives	9	9	9
Ge 115 b	Petrology and Petrography	-	9	-
	HSS electives	9	9	9
	Scientific Writing	-	-	3
SEC 10	Oral Presentation	-	-	3
	Total	18	27	24

Geobiology Option Requirements

1. Ge 11 abc.
2. Bi 8, 9.
3. Ma 2 and one course in statistics and data analysis (Ma 3, Bi/CNS/NB 195, Ge/Ay 117, or Ge/ESE 118).
4. Two quarters of sophomore-level physics (Ph2a, b, c, or 12a, b, or c).
5. Ch 41 abc and Bi/Ch 110.
6. Any writing class that satisfies the Institute scientific writing requirement ¹; or Bi 24.

7. At least 9 units of laboratory instruction from: Bi 10, Ch 7, Ch 8, Ch 15, Ge 116, or Ge 120ab².
8. Any six courses from the geobiology core: Bi 117, Bi 122, ESE/Bi 166, ESE/ Bi 168, Ge/ESE/Bi 178, Ge 112, Ge/ESE 143, or Ge 124 ab.
9. 27 units of geobiology electives in geology, biology, chemistry, and/or environmental engineering to be chosen in consultation with adviser³.

¹For example, one of SEC 11, SEC 12, SEC 13 or En/Wr 84; with the approval of their adviser, students may also petition to do independent writing with a faculty member under Ge 40.

²May also be satisfied by units from other courses that have a laboratory component, or substitute thesis research or independent laboratory research, all with approval of option representative.

³May include any courses listed above that are not being used to fulfill a separate requirement.

		<i>Units per term</i>		
		<i>1st</i>	<i>2nd</i>	<i>3rd</i>
<i>Second Year</i>				
Ma 2 & other	Sophomore mathematics	9	9	-
Ph 2 a, c	Sophomore physics	9	-	9
Ge 11 abc	Intro. to Earth and Planetary Sci.	9	9	9
Bi/BE 24	Writing and oral presentation	-	-	6
Bi 8	Introduction to Molecular Biology	-	9	-
Bi 9	Cell Biology	-	-	9
Bi 10	Cell Biology Laboratory	-	-	6
	HSS electives	9	9	9
	Total	36	36	48
<i>Third Year</i>				
Bi/Ch 110	Intro. to Biochemistry	12	-	-
Ge 124 ab	Paleomagnetism	-	-	15
	Scientific Writing	-	3	-
Ch 41 abc	Organic Chemistry	9	9	9
	HSS electives	9	9	9
	Geobiology electives	-	9	-
	Total	30	30	42

Fourth Year

ESE/Bi 166	Microbial Physiology	9	-	-
ESE/Bi 168	Microbial Metabolic Diversity	-	9	-
Ge/ESE/Bi 178	Microbial Ecology	-	-	9
Ge 143	Organic Geochemistry	-	-	9
Bi 122	Genetics	9	-	-
Ge 112	Sedimentology and Stratigraphy	12	-	-
Ge 116	Analytical Laboratory Techniques	-	9	-
	HSS electives	9	9	9
	Geobiology electives	-	-	9
	Total	39	27	36

Geochemistry Option Requirements¹

1. Ge 11 ab, Ge/Ay 11 c or Ge 11 d, Ge 109, and a science writing course.²
2. Ma 2 and one choice from: Ma 3, Ge/ESE 118, Ge/Ay 117, Ph 2c, or Ch 21c.
3. Ph 2 a or Ph 12 a plus an additional quarter of sophomore-level physics (Ph 2 b, Ph 2 c, Ph 12 b, or Ph 12 c).
4. Either ACM 95 ab or the combination of a full-year chemistry sequence (Ch 21 abc or Ch 41 abc) plus Ge/ESE 118.
5. Three courses from the list below:
Ge 114 ab (counts as one course), Ge 116, Ge 140 a, Ge 140 b, Ge/ESE 140 c, Ch 21 a, Ch 41 a, ESE/Ge/Ch 171, Ge/ESE 143, Ge/ESE 149.
6. A total of 105 units from this and item 5 that include at least four courses in the Ge-option:
Ch electives: Ch 4 a, b, Ch 5 a, b, Ch 6 a, b, Ch 7, Ch 8, Ch/ChE 9, Ch 14, Ch 15, Ch 21 b, c, Ch 41 b, c, Ch 102.
7. *ChE electives:* ChE 63 a, b. *ESE electives:* ESE 103, Ge/ESE 154, ESE/Ge/Ch 172, ESE/Ch 175, ESE/Ch 176.
Ge electives: Ge 40, Ge 106, Ge 112, Ge 115 a, b, Ge 120 a, b, Ge/Ch 127, Ge/Ch 128, Ge/Ay 132, Ge 191, Ge 212, Ge 214, Ge 215.
APh electives: APh 17 a, b, c.
MS electives: MS 105, MS 115, MS 125, MS 131, MS 133, MS 142, MS/ME 161

¹ No class may be used to simultaneously satisfy more than one of these requirements.

² For example, SEC 11, SEC 12, SEC 13, or En/Wr 84.

Units per term**1st 2nd 3rd***Second Year*

Ge 11 abc	Intro. to Earth and Planetary Sci.	9	9	9
	Scientific Writing	-	-	3
Ge 109	Oral Presentation (GeCh option)	-	-	6
	Geochemistry core or electives	9	9	9
Ph 2 ab	Sophomore Physics	9	9	-
Ma 2 & other	Sophomore Mathematics	9	9	-
	HSS electives	9	9	9
	Total	45	45	33

Third Year

ACM 95 ab	Intro. Methods of Applied Math.	-	12	12
	HSS electives	9	9	9
	Geochemistry core or electives	18	18	18
		27	39	39

Fourth Year

	HSS electives	9	9	9
	Geochemistry electives	9	9	9
	Total	18	18	18

Geophysics Option Requirements

1. Ge 11 a, Ge 11 b or Ge 11/Ay c, SEC 10 and a science writing course.¹
2. Ge 111 ab, Ge 11 d
3. Ph 2 a or Ph 12 a, Ph 2b or 12b, and one of the following: Ph 2c, Ph 12c, ME 11a, APh 17a, Ch 21c, Ch 25.
4. Ma 2
5. One of Ma 3, Ge/Ay 117, Ge/ESE 118
6. ACM 95 ab
7. 36 units of advanced science courses selected in consultation with adviser and approved by the option representative. Appropriate choices include (but are not limited to): up to 18

units of Me 11 and 12, ME 65, 66, AM 125 abc, Ae/Ge/ME 160, Ph 106 abc, MS 115, MS 133, MS/ME/MedE 116.

8. 36 units of geophysics electives (selected in consultation with adviser and approved by the option representative). Appropriate choices include (but are not limited to): up to 9 units of Ge 40 and Ge 41abc, Ge 161–168, Ge 261, Ge 263, ME/Ge/Ae 266ab.

¹ For example, SEC 11, SEC 12, SEC 13, or En/Wr 84.

		<i>Units per term</i>		
		<i>1st</i>	<i>2nd</i>	<i>3rd</i>
<i>Second Year</i>				
Ge 11 abc	Intro. to Earth and Planetary Sciences	9	9	9
	Scientific Writing	-	-	3
SEC 10	Oral Presentation	-	-	3
Ph 2 abc	Sophomore Physics	9	9	9
Ma 2 & Ma 3	Sophomore Mathematics	9	9	-
	HSS electives	9	9	9
		<hr/>	<hr/>	<hr/>
		36	36	33
<i>Third Year</i>				
ACM 95 ab	Intro. to Methods of Applied Math.	-	12	12
	Advanced Science Electives	9	9	9
	HSS electives	9	9	9
Ge 111 ab	Applied Geophysics Seminar	-	6	9
Ge 11 d	Geophysics	-	9	-
	Total	18	45	39
<i>Fourth Year</i>				
	Geophysics electives	18	18	9
	HSS electives	9	9	9
	Total	27	27	18

Planetary Science Option Requirements

1. Ma 2 and one of Ma 3, Ge/Ay 117, or Ge/ESE 118.
2. Ph2 a or 12 a, Ph 2 b or 12 b, and one of the following: Ph 2 c, Ph 12 c, APh 17 a, Ch 21 c, Ch 25, ME 11 a.

3. Ge 11 ab, Ge/Ay 11 c, 3 units of oral presentation (SEC 10 or 3 units of Ge 109, including an oral presentation at planetary sciences seminar), and a science writing course.¹
4. ACM 95 ab.
5. 45 units of advanced science courses selected in consultation with adviser and planetary science option representatives. Appropriate choices include (but are not limited to): Ae/APh/CE/ME 101 abc, Ae/Ge/ME 160 ab, Ch 21 abc, Ph 101, 106 abc, 125 abc, Ge/ESE 118, ME 12 abc, APh 17 abc, Ay 20, 21, 101, 102, ChE 63 ab, Ch 6 ab, CS 1-3, Ma 112 ab, ME 11 abc, 65, 66, AM 125 abc.
6. 63 units selected from Ge 11 d, Ge 40, 41, 102, Ge/Ay 117, Ge/Ch 128, Ge 131, Ge/Ay 132, Ge/Ay 133, Ge/Ay 137, Ge/Ay 159, ESE 101-103, Ge/ESE 150, Ge 151, Ge/EE/ESE 157 c, ESE 130, Ge/ESE 139.

¹ For example, SEC 11, SEC 12, SEC 13, or En/Wr 84.

		<i>Units per term</i>		
		<i>1st</i>	<i>2nd</i>	<i>3rd</i>
<i>Second Year</i>				
Ge 11 abc	Intro. to Earth and Planetary Sci.	9	9	9
	Scientific Writing	-	-	3
Ph 2 abc	Sophomore Physics	9	9	9
Ma 2, 3	Sophomore Mathematics	9	9	-
	HSS electives	9	9	9
	Total	36	36	30
<i>Third Year</i>				
ACM 95 ab	Intro. Methods of Applied Math.	-	12	12
	HSS electives	9	9	9
	Advanced science	9	9	9
	Planetary science	9	9	9
	Total	27	39	39
<i>Fourth Year</i>				
	HSS electives	9	9	9
	Planetary science	9	9	9

Additional science and engineering	9	9	9
Total	27	27	27

GPS Division Minor Requirements

The minors in the GPS Division are intended for non-GPS undergraduates to supplement a major degree with knowledge of earth and planetary science. Students may complete a minor in either Geobiology, Geochemistry, Geology, Geophysics, Planetary Sciences or a general GPS minor, and will have the phrase "minor in [the appropriate option]" added to their transcript. Any student interested in a minor in GPS is urged to contact the appropriate option representative in the division.

1. Ge 11 a and Ge 11 b.
2. One of Ge/Ay 11 c or Ge 11 d.
3. 27 units of 100-level or higher GPS courses, excluding Ge 109, which must be approved by the appropriate option representative.

HISTORY OPTION AND MINOR (H)

Students who choose the history option will learn how to *do* history—how to think critically about past societies and their development, how to read evidence closely, and how to express arguments in writing. With the guidance of a faculty adviser in history, students taking the option will explore the range of human experience in the realms of politics, culture, religion, and economics, as well as science and technology. They will learn both to challenge and revise existing historical narratives and question their own ideas and assumptions about the past. Students will develop the writing skills that will enable them to use historical sources to make effective arguments, and they will receive extensive feedback on their writing from their adviser and from other faculty members.

The history option thus provides science and engineering students with an important supplement to the scientific training and technical skills they acquire in other courses and options. It will help them to understand the world of human beings and human behavior outside of science with which they will interact and which their scientific work will affect; to set themselves and their work as scientists and engineers in this wider context; and to communicate what they are doing to a wider public as well as to their colleagues. In addition, it offers excellent preparation for careers in business, administration, law, journalism, or public affairs, as well as a solid foundation for graduate work in history.

History majors must take at least 99 units of history courses (which may include a freshman humanities course in history) during their four years as undergraduates. Of these, 27 must be in the senior tutorial (H 99 abc). All courses to be counted toward the