Environmental Chemistry: ESE 142, ESE/Ge/Ch 171, ESE/Ch/Ge 175;
Environmental Physics: ESE 130-138, ESE/Ge 139.

The 36 units of elective courses must include courses from at least two of the above three groups.

The remaining units of graduate work can be fulfilled by a combination of elective courses in ESE or related disciplines, reading or laboratory courses (ESE 100), and research (ESE 105, 300). Of the total required 135 units, no more than 45 units may be in research. No more than 27 research units may be taken during the first year of graduate study. Exceptions may be granted by petition.

Ph.D. Qualifying Examination. The Ph.D. qualifying examination must be taken during the first term of the student’s second year of residency. This examination consists principally of an oral defense of two research propositions, each advised by a different faculty member. Written abstracts must be submitted for both propositions, and one of them must be described in the form of a research report or proposal. The qualifying exam also covers the material of the ESE core courses and of the elective courses the student has taken. In preparation for the qualifying examination, students are encouraged to register for nine units of research (ESE 105) in their second and third terms of residency.

Advancement to Candidacy. Students advance to candidacy by obtaining approval of a Ph.D. thesis proposal from their Thesis Advisory Committee. Advancement to candidacy is expected to occur before the end of the third year of residency.

Thesis and Final Examination. Copies of the completed thesis must be provided to the examining committee two weeks before the final oral examination. The final oral examination focuses on the work of the thesis and, according to Institute regulations, must be held at least two weeks before the degree is conferred.

Subject Minor
Students majoring in another option at the Institute may elect a subject minor in environmental science and engineering. They must obtain approval from the ESE Academic Officer for a course of study containing at least 45 units of advanced ESE courses.

Geological and Planetary Sciences
Aims and Scope of the Graduate Program
Students in the Division of Geological and Planetary Sciences study the earth and planets to understand their origin, constitution, and development, and the effect of the resulting physical and chemical characteristics on the history of life, on the environment, and on humanity. Broad training in the fundamental sciences enriched by more specialized course work within the division forms the basis of the educational program. Students are encouraged to
work with complex and often incomplete data sets, to undertake research in natural settings such as in the field or at sea, and to use the many modern laboratory facilities available within the division. Programs of study and research are pursued in environmental science and engineering, geology, geobiology, geochemistry, geophysics, and planetary science. The curriculum is flexible so that students with diverse degrees in science and engineering may carry out graduate work within the division. Interdisciplinary studies are encouraged and students may carry out academic and research programs within and between different divisions. The objective is to train students for future employment in academic research, government, and industry.

Admission and Entrance Procedures. Only students who intend to work full-time toward the Doctor of Philosophy (Ph.D.) degree are admitted. The application submission deadline for the GPS Division is January 1. The admission process follows Institute regulations. Applicants are required to submit Graduate Record Examination (GRE) scores for the general test. Individual option requirements for GRE subject tests are specified below:

- Environmental Science and Engineering—Not required.
- Geobiology—Submit the scores for any subject test.
- Geochemistry—Strongly recommended but not required.
- Geology—Not required.
- Geophysics—Not required.
- Planetary Science—Strongly recommended but not required.

Applicants from non-English-speaking nations are required to submit Test of English as a Foreign Language (TOEFL) scores.

Based on their applications and interests, students enter one of the major subject options of the division and are given an academic adviser who is a professorial faculty member associated with the option. The six options are environmental science and engineering, geobiology, geochemistry, geology, geophysics, and planetary science. Students may later change options, but must first obtain approval from the new option. Each student must plan to satisfy the requirements for the Ph.D. degree in one option.

Entering students in the week preceding the beginning of instruction for the first term meet with their option representatives to discuss their preparation in the basic sciences and select a series of courses that will best prepare them for research in their chosen field while meeting the requirements set forth below.

First-year graduate students are encouraged to register for at least nine units of research (Ge 297) in each term of residence. The primary objective is to communicate to the students the excitement of discovery based on original investigations and to provide a broad scope of research aims. An important byproduct can be the formulation of propositions for the Ph.D. qualifying oral examination or orientation toward Ph.D. research.
Advising and Thesis Supervision. The option representative for each incoming student will act as the academic adviser in the first term. An academic adviser will be assigned by the start of second term. This appointed adviser will continue as mentor with broad responsibility for a student’s academic welfare throughout the graduate program. During the second year, after passing the qualifying examination, each student should identify a professor as thesis adviser, who will normally provide a graduate research assistantship and the opportunity for continuing research. In consultation with the two faculty advisers, each student then forms a Thesis Advisory Committee (TAC), composed of at least four Caltech professors (chaired by the academic adviser). External scientists closely involved in the student’s research may also be appointed. Members of the TAC serve as advisers, counselors, and resources, and its membership may be changed if a student’s research interests change.

The thesis advisory committee meets with the student at least once each year for a progress review, and informally whenever the student needs or requests assistance or guidance. In addition, the faculty members in each option have their own systems for annual evaluations of student progress. A few months before completion of the thesis dissertation, the thesis examining committee will be chosen, usually including the members of the thesis advisory committee.

All students are urged to consult with division faculty in the following sequence if they have any problems: thesis and academic advisers, thesis advisory committee, option representative, academic officer, and division chair. If these division personnel cannot resolve a problem, then the student should turn to Institute offices.

Master's Degree
Students enrolled in the Ph.D. program may be awarded a master’s degree when they have satisfied the basic Institute requirement of 135 units. These courses must be numbered 100 or higher, and must be part of those used to satisfy the Ph.D. requirement in one of the options of the division. Specifically required are Ge 109 and two courses from the list Ge 101, Ge 102, Ge 103, Ge 104, or ESE 101.

An application for admission to candidacy for an M.S. degree must be submitted to the Graduate Office according to the academic calendar in the Caltech Catalog (see pages 4–5).

Doctoral Degree
Division Requirements. For a Ph.D. degree, the student must 1) pass the qualifying oral examination, 2) satisfy course requirements of the division and of an option, and 3) complete a thesis and successfully defend it in a final oral examination. Admission to candidacy occurs after the student has satisfied the first two requirements and has been accepted for thesis research by a division faculty member, who then becomes the student’s thesis adviser.

Special Regulations/Geological and Planetary Sciences
The qualifying examination consists of oral and written defense of two research propositions, supplemented by a written description of one of them. Students are encouraged to consult with various faculty members concerning their ideas on propositions, but the material submitted must represent the work of the student. There must be a different faculty member associated with each of the two propositions. The exam is normally taken early in the first term of the second year of residence and is administered by the qualifying examination committee, which has members from the six options of the division. A more detailed outline of the qualifying examination is available on the division website.

Before the end of the second year, the thesis advisory committee will be selected, as outlined above.

The division encourages students to engage in research early in their graduate careers. Students making normal progress will submit papers to refereed journals that have been approved by a faculty member of the division. Doctoral candidates must complete a thesis and submit it in final form by May 10 of the year in which the degree is to be conferred. The final oral examination for the doctorate by the thesis examining committee will be scheduled no sooner than two weeks following submission of the thesis (approved by the thesis adviser) and, in conformity with Institute regulations, it must be scheduled at least two weeks before the degree is to be conferred.

Candidates are expected to publish the major results of their thesis work. The published papers should have a California Institute of Technology address. Published papers may be included in the thesis.

By the end of the first academic year (third term): submission by the student of (1) tentative titles of propositions for review by the qualifying examination committee and (2) a list of courses planned to satisfy the Ph.D. requirement, for review by the option.

By the end of the second academic year: (1) passage of oral exam; (2) approval by the option of courses planned to satisfy candidacy requirements; (3) submission of a tentative thesis topic and adviser, and thesis advisory committee.

By the end of the third academic year: (1) satisfactory completion of course requirements; (2) satisfactory completion of other requirements including selection of thesis topic and adviser, and thesis advisory committee; (3) admission to candidacy. A student who has not been admitted to candidacy by the end of the third year will need permission of the academic officer to register.

By the end of the fourth academic year: satisfactory progress toward completion of thesis.

After completing the fifth academic year, the student must formally petition to register for each subsequent year. Financial aid will normally not be extended beyond the sixth year.

The student’s program and progress will be reviewed annually by his or her option and by the thesis advisory committee. In cases...
where, in the opinion of the faculty in the option, the student is clearly not showing adequate progress, they may recommend to the division chair that the student be denied permission to continue in the Ph.D. program based upon their overall assessment of the student’s performance.

Basic Division Course Requirement. During the first year, every graduate student will take two of the seven basic introductory courses Ge 101–104 and ESE 101–103, in areas in which the student has not had substantial training. Also required is one term of Ge 109. These should be completed during the first year. Throughout their graduate careers, students are expected to attend departmental seminars and seminar courses led by visiting scientists.

Requirements of the Major Subject Options

Geobiology. In addition to the general Institute and basic division requirements, candidates for the Ph.D. degree in geobiology must successfully complete a minimum of 90 units at the 100 or greater level, including Ge 104; either Bi/Ch 110 or ACM/ESE 118; and two courses from each of the following three subject menus:

Geology: Ge 106 ab, 112, 114 ab, 124.
Chemistry: ESE 142, Ge/ESE 143, 149, Ge 140, ESE/Ge/Ch 171, 172.
Biology: ESE/Bi 166, 168, Ge/ESE 170, Bi 117, ESE 103.

Other classes may be substituted for these menu requirements with the approval of the option representative. A student with substantial prior experience in geobiology (e.g., an M.S. degree) may use prior course work to substitute up to 45 of these units with the approval of the geobiology option representative. All students must have a basic knowledge of organic chemistry at the level of Ch 41 a. This requirement may be met by previous course work or through successful completion of this class.

Geochemistry. In addition to general Institute and basic division requirements, candidates for the Ph.D. degree in geochemistry are required to demonstrate an understanding of the field through a total of 90 units of course work at the 100 level or higher spread over four of the subdisciplines offered in the option: petrology/mineralogy, isotope geochemistry, cosmochemistry, water chemistry/oceans, atmospheres, and biogeochemistry. A student with substantial prior experience in some of the subdisciplines may use prior course work to substitute for up to 45 of these units with the approval of the geochemistry option representative. In the oral candidacy exam, the student will be subject to examination in all four of the chosen subdisciplines. All students must have a basic knowledge of chemistry at the level of Ch 21 and mathematics at the level of Ge 108.

Geology. The geology option requirements are (1) two of Ge 102, 103, 104, or ESE 101, which also satisfy the basic division requirement; (2) 36 units in 100-level science or engineering courses...

Special Regulations/Geological and Planetary Sciences
courses taken outside the GPS division, or in courses cross-listed with other divisions. Ch 21 abc may be included as part of these units, and other courses below the 100 level may be included at the discretion of the option representative. Students with a focus in planetary geology may use 100-level planetary science courses to fill this requirement; (3) 36 units of advanced field geology, in the form of three terms of Ge 121 abc taken from three different instructors; (4) an additional 18 units of 100- or 200-level courses within the GPS division. Courses that cannot be used to satisfy these requirements include research and reading courses, and certain courses constituting basic preparation in the field of geology, such as Ge 106, Ge 112, Ge 114 ab, and Ge 115 abc. A grade of C or better is required for all course work that satisfies these requirements. Knowledge of basic physics, mathematics, and data analysis at the level of Ge 108 and ACM/ESE 118 is required of all Ph.D. candidates in geology. Students entering the geology option with a master’s degree in a science or mathematics may be exempt from up to 45 units at the discretion of the option representative (exemptions from advanced field geology must be granted by the GPS field committee).

Geophysics. In addition to general Institute and basic division requirements, candidates for the Ph.D. degree in geophysics must successfully complete the following course requirements: two of Ge 101, 103, 104, or ESE 101; either Ae/Ge/ME 160 ab, APh 105 ab, MS 115 ab, or a subject equivalent; three of Ge 161, Ge 162, Ge 163, or Ge 164, and Ge 111 ab; and the choice between a minor in any field at Caltech or five additional 100- or 200-level science or mathematics courses. It is highly recommended that these courses be taken in the first year. To complete the course requirements, students have the choice between a minor in any field (for example, computational science and engineering, http://www.cse.caltech.edu) or five additional 100- or 200-level science or math courses. Students may substitute another course for a required course if they can demonstrate to an option representative that they have already had the material in the required course.

Planetary Science. In addition to general Institute and basic division requirements, candidates for the Ph.D. degree in planetary science must satisfy the following course requirements: Ge 101, Ge 102, and courses in planetary formation and dynamics (Ge/Ay 133), planetary atmospheres (Ge 150), planetary interiors (Ge 131), and planetary surfaces (Ge 151). In addition, students shall successfully complete 45 units of 100-level or higher courses in a coherent field of specialization. This requirement may be satisfied by completion of a subject minor or through a set of courses chosen in consultation with and approved by the adviser and the option representative. All candidates are expected to possess knowledge of physics and mathematics at the level of Ph 106 and ACM 95. This requirement may be met by previous course work or through successful completion of these classes.