

# School of Earth, Energy and Environmental Sciences

On February 11, 2015, the Stanford Board of Trustees approved the change of name for the school to become the School of Earth, Energy and Environmental Sciences. Prior to February 11, the school was named the School of Earth Sciences.

Courses offered by the School of Earth, Energy and Environmental Sciences are listed under the subject code EARTH on the Stanford Bulletin's ExploreCourses web site (<http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&catalog=&page=0&q=EARTH&filter-catalognumber-EARTH=on>). Courses offered by departments and programs of the school are linked on their separate sections, and are available at the ExploreCourses (<http://explorecourses.stanford.edu>) web site.

The School of Earth, Energy and Environmental Sciences includes the departments of Geological Sciences, Geophysics, Energy Resources Engineering (formerly Petroleum Engineering), and Earth System Science; and two interdisciplinary programs: the Earth Systems undergraduate B.S. and coterminal M.S. and M.A. programs, and the Emmett Interdisciplinary Program in Environment and Resources (E-IPER). The Earth Systems Program and E-IPER offer study in biophysical and social dimensions of environment and resources.

The aims of the school are:

1. to prepare students for careers in the fields of biogeochemistry, climate science, energy resource engineering, environmental science, geology, geochemistry, geomechanics, geophysics, geostatistics, hydrogeology, land science, oceanography, petroleum engineering, and petroleum geology
2. to conduct research in the Earth sciences
3. to provide opportunities for Stanford undergraduates to learn about the planet's history, to understand the energy and resource base that supports humanity, to appreciate the geological and geophysical hazards that affect human societies, and to understand the challenges and solutions related to the environment and sustainability.

To accomplish these objectives, the school offers a variety of programs adaptable to the needs of the individual student:

- four-year undergraduate programs leading to the degree of Bachelor of Science (B.S.)
- five-year programs leading to the coterminal Bachelor of Science and Master of Science (M.S.)
- five-year programs leading to the coterminal Bachelor of Science and Master of Arts (M.A.)
- graduate programs offering the degrees of Master of Science, Engineer, and Doctor of Philosophy.

Details of individual degree programs are found in the section for each department or program.

## Undergraduate Programs in the School of Earth, Energy and Environmental Sciences

Any undergraduate admitted to the University may declare a major in one of the school's departments or programs by contacting the appropriate department or program office.

Requirements for the B.S. degree are listed in each department or program section. Departmental academic advisers work with students to define a career or academic goal and assure that the student's curricular choices are appropriate to the pursuit of that goal. Advisers can help devise a sensible and enjoyable course of study that meets degree requirements and provides the student with opportunities to experience advanced courses, seminars, and research projects. To maximize such opportunities, students are encouraged to complete basic science and mathematics courses in high school or during their freshman year.

## Coterminal Master's Degrees in the School of Earth, Energy and Environmental Sciences

The Stanford coterminal degree program enables an undergraduate to embark on an integrated program of study leading to the master's degree before requirements for the bachelor's degree have been completed. This may result in more expeditious progress towards the advanced degree than would otherwise be possible, making the program especially important to Earth scientists because the master's degree provides an excellent basis for entry into the profession. The coterminal plan permits students to apply for admission to a master's program after earning 120 units, completion of six non-summer quarters, and declaration of an undergraduate major, but no later than the quarter prior to the expected completion of the undergraduate degree.

The student may meet the degree requirements in the more advantageous of the following two ways: by first completing the 180 units required for the B.S. degree and then completing the three quarters required for the M.S. or the M.A. degree; or by completing a total of 15 quarters during which the requirements for the two degrees are completed concurrently. In either case, the student has the option of receiving the B.S. degree upon meeting all the B.S. requirements or of receiving both degrees at the end of the coterminal program.

Students earn degrees in the same department or program, in two different departments, or even in different schools; for example, a B.S. in Physics and an M.S. in Geological Sciences. Students are encouraged to discuss the coterminal program with their advisers during their junior year. Additional information is available in the individual department offices.

University requirements for the coterminal master's degree are described in the "Coterminal Master's Program (<http://exploreddegrees.stanford.edu/cotermdegrees>)" section. University requirements for the master's degree are described in the "Graduate Degrees (<http://exploreddegrees.stanford.edu/graduatedegrees/#masterstext>)" section of this bulletin.

## Graduate Programs in the School of Earth, Energy and Environmental Sciences

### Admission to the Graduate Program

A student who wishes to enroll for graduate work in the school must be qualified for graduate standing in the University and also must be accepted by one of the school's four departments or one of the two interdisciplinary Ph.D. programs. One requirement for admission is submission of scores on the verbal and quantitative sections of the Graduate Record Exam. Admission to one department of the school does not guarantee admission to other departments.

## Faculty Adviser

Upon entering a graduate program, the student should report to the head of the department or program who arranges with a member of the faculty to act as the student's adviser. Alternatively, in several of the departments, advisers are established through student-faculty discussions prior to admission. The student, in consultation with the adviser(s), then arranges a course of study for the first quarter and ultimately develops a complete plan of study for the degree sought.

## Financial Aid

Detailed information on scholarships, fellowships, and research grants is available from the school's individual departments and programs. Applications should be filed by the various dates listed in the application packet for awards that become effective in Autumn Quarter of the following academic year.

*Dean:* Pamela A. Matson

*Associate Dean, Academic Affairs:* Stephan A. Graham

*Associate Dean, Multicultural Affairs:* Jerry M. Harris

*Associate Dean, Educational Initiatives:* Margot Gerritsen

*Assistant Dean, Academic Affairs:* Roni Holeton

*Assistant Dean, Multicultural Affairs:* Tenea M. Nelson

*Lecturers:* Sara Cina, Jennifer Saltzman

## Courses

### **EARTH 1. Current Research in the Earth and Environmental Sciences. 1 Unit.**

Primarily for freshmen and sophomores. An introduction to faculty and research areas in the School of Earth Sciences, including biogeochemistry, oceanography, paleobiology, geophysics, tectonics, geostatistics, soil science, hydrogeology, energy resources, earth surface processes, geochronology, volcanoes and earthquakes, and remote sensing. May be repeated for credit.

### **EARTH 2. CLIMATE AND SOCIETY. 3 Units.**

How and why is the climate changing? How might a changing climate affect human society? And what can we do to alter the course of climate change and adapt to any climatic changes that do occur? This course provides an introduction to the natural science and social science of climate change. The focus is on what science tells us about the causes, consequences, and solutions to climate change, as well as on how scientific progress is made on these issues.

### **EARTH 5. Geokids: Earth Sciences Education. 1 Unit.**

Service learning through the Geokids program. Eight weeks of supervised teaching to early elementary students about Earth sciences. Hands-on teaching strategies for science standards-based instruction.

### **EARTH 100. Research Preparation for Undergraduates. 1 Unit.**

For undergraduates planning to conduct research during the summer with faculty in the School of Earth Sciences. Readings, oral presentations, proposal development. May be repeated for credit.

### **EARTH 117. Earth Sciences of the Hawaiian Islands. 4 Units.**

Progression from volcanic processes through rock weathering and soil-ecosystem development to landscape evolution. The course starts with an investigation of volcanic processes, including the volcano structure, origin of magmas, physical-chemical factors of eruptions. Factors controlling rock weathering and soil development, including depth and nutrient levels impacting plant ecosystems, are explored next. Geomorphic processes of landscape evolution including erosion rates, tectonic/volcanic activity, and hillslope stability conclude the course. Methods for monitoring and predicting eruptions, defining spatial changes in landform, landform stability, soil production rates, and measuring biogeochemical processes are covered throughout the course. This course is restricted to students accepted into the Earth Systems of Hawaii Program.

Same as: EARTHSYS 117, ESS 117

### **EARTH 191. GES Field Trips. 1 Unit.**

Four- to seven-day field trips to locations of geologic and environmental interest. Includes trips offered during Thanksgiving and Spring breaks. May be repeated for credit. See <http://pangea.stanford.edu/GES/undergraduates/courses/>.

Same as: GS 191

### **EARTH 193. Natural Perspectives: Geology, Environment, and Art. 1 Unit.**

Multi-day field trip that combines exploration of regional geology, ecology, and environmental history with guided drawing exercises. Wequest;ll visit several sites of geologic and environmental interest, discuss their formation and significance, and use drawing as tool for close observation. Students will gain an understanding of the natural processes shaping California, acquire new skills and techniques for artistic expression, and gain an appreciation for how scientific and aesthetic perspectives complement and enhance one another in the study of nature. No previous scientific or artistic experience is required.

### **EARTH 202. PhD Students on the PhD. 1 Unit.**

This seminar is designed for coterms and upperclassmen who are considering pursuing a PhD in earth science fields but want to know what that path really entails. Consisting of small-group discussions with current PhD students, this course will feature conversations on a range of PhD research topics and will also delve into the substance of the PhD experience itself. We will explore PhD students' programs and career paths: the milestones, processes, and issues that guide their decisions and shape their PhD experiences. Discussion themes will be determined partly in advance and partly based on the interests of participants and could include topics such as choosing a PhD program or research question, interdisciplinarity, community engagement, or work/life balance.

### **EARTH 211. Software Development for Scientists and Engineers. 3 Units.**

Basic usage of the Python and C/C++ programming languages are introduced and used to solve representative computational problems from various science and engineering disciplines. Software design principles including time and space complexity analysis, data structures, object-oriented design, decomposition, encapsulation, and modularity are emphasized. Usage of campus wide Linux compute resources: login, file system navigation, editing files, compiling and linking, file transfer, etc. Versioning and revision control, software build utilities, and the LaTeX typesetting software are introduced and used to help complete programming assignments. Prerequisite: introductory programming course equivalent to CS 106A or instructor consent.

Same as: CME 211

**EARTH 214. Software Design in Modern Fortran for Scientists and Engineers. 3 Units.**

This course introduces software design and development in modern Fortran. Course covers the functional, object-oriented-, and parallel programming features introduced in the Fortran 95, 2003, and 2008 standards, respectively, in the context of numerical approximations to ordinary and partial differential equations; introduces object-oriented design and design schematics based on the Unified Modeling Language (UML) structure, behavior, and interaction diagrams; cover the basic use of several open-source tools for software building, testing, documentation generation, and revision control. Recommended: Familiarity with programming in Fortran 90, basic numerical analysis and linear algebra, or instructor approval.

Same as: CME 214

**EARTH 218. Communicating Science. 3 Units.**

For undergraduates and graduate students interested in teaching science in local schools. Inquiry-based science teaching methods. How to communicate scientific knowledge and improve presentations. Six weeks of supervised teaching in a local school classroom. Prerequisite: course in introductory biology, geology, chemistry, or marine sciences.

**EARTH 219. OPINION WRITING IN THE SCIENCES. 1 Unit.**

Part exposition, part reflection, part synthesis, research-driven opinion writing can be found everywhere from the op-ed pages of daily newspapers, to the commentary sections of journals such as Nature and Science, to the sort of wide-ranging reviews found in the New York Review of Books. In this course, advanced doctoral students will study the form, and work with the instructors to develop a publication-quality opinion essay on an aspect of their own field. Admission is limited and by application only. Contact thayden@stanford.edu.

**EARTH 251. Negotiation. 3 Units.**

Students learn to prepare for and conduct negotiations in a variety of arenas including getting a job, managing workplace conflict, negotiating transactions, and managing personal relationships. Interactive class. The internationally travelled instructor who has mediated cases in over 75 countries will require students to negotiate real life case studies and discuss their results in class. Application required before first day of class; see Coursework.

Same as: CEE 151, CEE 251

**EARTH 300. Earth Sciences Seminar. 1 Unit.**

Required for incoming graduate students except coterms. Research questions, tools, and approaches of faculty members from all departments in the School of Earth Sciences. Goals are: to inform new graduate students about the school's range of scientific interests and expertise; and introduce them to university and school resources. Panel discussions or faculty member presentations at each meeting. May be repeated for credit.

**EARTH 310. Computational Geosciences Seminar. 1 Unit.**

Weekly lectures focusing on high-performance computing in geoscientific research by experts from academia, national laboratories, industry, and doctoral students. May be repeated for credit.

**EARTH 400. Directed Research. 3 Units.**

Independent research for graduate student projects.

**EARTH 401. Curricular Practical Training. 1 Unit.**

Curricular Practical Training.