SCHOOL OF EARTH, ENERGY AND ENVIRONMENTAL SCIENCES

The School of Earth, Energy and Environmental Sciences (formerly the School of Earth Sciences) lists courses under the subject code EARTH on the Stanford Bulletin’s ExploreCourses web site. Courses offered by the School's departments and inter-departmental programs 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) with Ph.D. and joint M.S.

The aims of the school and its programs are:

1. to prepare students for careers in the fields of agricultural science and policy, biogeochemistry, climate science, energy resource engineering, environmental science and policy, environmental communications, geology, geobiology, geochemistry, geomechanics, geophysics, geostatistics, hydrogeology, land science, oceanography, paleontology, petroleum engineering, and petroleum geology;
2. to conduct disciplinary and interdisciplinary research on a range of questions related to Earth, its resources and its environment;
3. to provide opportunities for Stanford undergraduate and graduate students to learn about the planet's history, to understand the energy and resource bases that support humanity, to address the geological and geophysical, and human-caused hazards that affect human societies, and to understand the challenges and develop solutions related to 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.; 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://exploredegrees.stanford.edu/cotermdegrees)” section. University requirements for the master’s degree are described in the “Graduate Degrees (http://exploredegrees.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 the Emmett Interdisciplinary Ph.D. program. 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.

Dean: Pamela A. Matson
Associate Dean, Academic Affairs: Scott Fendorf
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: 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 1A. Know Your Planet: Research Frontiers. 1 Unit.
Planet Earth is our only home and so it is critical that we understand how it works, from large-scale geologic processes that shape our continents, to biological processes that produce the air we breathe, to the origins of the energy sources we rely on, to the impacts of the human societies we have created. This course provides an introduction to the cutting edge research of Stanford Earth faculty, who are leading the effort to ask and answers these critical questions about our planet. May be repeated for credit.

EARTH 1B. Know Your Planet: Big Earth. 1 Unit.
Interested in Big Data and how to apply it to global environmental and sustainability challenges? This course provides an introduction to Big Data and its applications in solving global challenges such as meeting global energy needs, food and water security, climate change, and natural hazards. The first half of the course will focus on foundational concepts of Big Data; the second half of the course will focus on applications of Big Data while introducing students to Stanford Earth alumni who are currently using these concepts in their work. May be repeated for credit.

EARTH 1C. Know Your Planet: Science Outside. 1 Unit.
One of the most important ways to learn about the world is to go out and explore it. Over the course of two day-long field trips during the weekend of May 13 & 14, students will learn and implement hands-on skills for conducting research "in the field," that is, outdoors in the natural environment. No previous field-work experience necessary. By focusing on the local geology, geomorphology, soils, ecology, and marine biology surrounding the Stanford campus, we will use careful observation, standard methods for data collecting, and analytical tools to answer fundamental questions about earth and ecosystem function. Along the way, we will also practice basic skills, from hiking to critical thinking, essential for conducting science outside of the controlled environment of the lab. This class is all about learning by doing, so be prepared to get your hands dirty and your feet wet while enjoying the sunshine and fresh air. In addition to the field weekend (May 13/14), this class also includes three mandatory evening meetings: a planning meeting (April 12), an overview and logistics meeting (May 10), and a report-out post-meeting (May 24). 100% Attendance at all meetings is required, no exceptions. Enrollment is limited to 20 students; preference given to freshmen and sophomores; to receive a course registration code, students must complete this form: http://web.stanford.edu/~rypett/EARTH_1C.fb.

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 10. Losing California: Design in the age of Climate Change. 1 Unit.
How will climate change impact the iconic view from the Golden Gate Bridge in 2025, 2050, 2100? Does an emotional attachment to a place motivate meaningful change to preserve it? How can visual or audio stories diminish the spatial and temporal remoteness of global change? During our weekend course we will learn about the science of global change and the ways in which the view from the Golden Gate Bridge may look dramatically different in the future as a result of changing temperatures and rainfall patterns, rising sea levels, shifts in flora and fauna, and decisions about the built environment. The course will consist of a weekend activity based at the Golden Gate Bridge on April 8 and 9th, followed by two follow-up meetings on campus on April 14 and April 28th. The course will be co-taught by faculty from the School of Earth, Energy and Environmental Sciences and the d.school. Apply by March 10. You can read more about the course and apply here: http://dschool.stanford.edu/losing-california/. Applicants will be selected to ensure a diversity of backgrounds. Course will be limited to 24 participants. Meeting times: nSat, April 8, 9:00am- 5:00pmSun, April 9, 9:00am- 5:00pmFri, April 14, 10:30am-12:20pmFri, April 28, 10:30am-12:20pmSan Francisco & Studio 1.

EARTH 14. Our National Parks. 2 Units.
Explore the history and natural science of three national parks proximal to Stanford. Under the guidance of instructors, students will work in teams to learn about chosen aspects of these parks, develop dynamic self-guided tours for public consumption, and implement (and publish) these tours using the XibitEd app for iPhones. Students will learn how to present their findings to a general, non-scientific audience, delineate physical locations at which storytelling will take place through the XibitEd system, and create and configure the content for the system. The course will culminate in the publishing of the experiential learning tours, as well as a weekend-long field trip to the Pinnacles National Park.
Same as: EARTH 114A, GS 14, GS 114A

EARTH 15. Living on the Edge. 1 Unit.
A weekend field trip along the Pacific Coast. Tour local beaches, geology, and landforms with expert guides from the School of Earth, Energy & Environmental Sciences. Enjoy a BBQ dinner and stay overnight in tents along the Santa Cruz coast. Get to know faculty and graduate students in Stanford Earth. Requirements: Two campus meeting and weekend field trip (Fall Quarter: Nov 5-6; Spring Quarter: April 8-9) to Pacific Coast. Enrollment limited to 25. Freshman have first choice. If you are interested in signing up for the course, complete this form: http://web.stanford.edu/~aferee/GSS.fb.
Same as: GS 5

EARTH 100. Research Preparation for Undergraduates. 1 Unit.
For undergraduates planning to conduct research during the summer with faculty in the School of Earth, Energy & Environmental Sciences. Readings, oral presentations, proposal development. May be repeated for credit.
EARTH 114A. Our National Parks. 2 Units.
Explore the history and natural science of three national parks proximal to Stanford. Under the guidance of instructors, students will work in teams to learn about chosen aspects of these parks, develop dynamic self-guided tours for public consumption, and implement (and publish) these tours using the XibitEd app for iPhones. Students will learn how to present their findings to a general, non-scientific audience, delineate physical locations at which storytelling will take place through the XibitEd system, and create and configure the content for the system. The course will culminate in the publishing of the experiential learning tours, as well as a weekend-long field trip to the Pinnacles National Park.
Same as: EARTHSYS 117, ESS 117

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 126X. Hard Earth: Stanford Graduate-Student Talks Exploring Tough Environmental Dilemmas. 1 Unit.
Stanford’s graduate students are a trove of knowledge – and, just as important, curiosity – about environmental sustainability. This seminar will feature talks by graduate students that explore the biggest, most bedeviling questions about environmental sustainability locally and around the world. The course will be structured as follows: every other week, we will hear hour-long graduate student talks about sustainability questions and their research, and on the off weeks, we will discuss the unanswered, debatable questions that relate to the previous week’s talk.
Same as: CEE 126X

EARTH 126Y. Hard Earth: Stanford Graduate-Student Talks Exploring Tough Environmental Dilemmas. 1 Unit.
Stanford’s graduate students are a trove of knowledge – and, just as important, curiosity – about environmental sustainability. This seminar will feature talks by graduate students that explore the biggest, most bedeviling questions about environmental sustainability locally and around the world. The course will be structured as follows: every other week, we will hear hour-long graduate student talks about sustainability questions and their research, and on the off weeks, we will discuss the unanswered, debatable questions that relate to the previous week’s talk.
Same as: CEE 126Y

EARTH 126Z. Hard Earth: Stanford Graduate-Student Talks Exploring Tough Environmental Dilemmas. 1 Unit.
Stanford’s graduate students are a trove of knowledge – and, just as important, curiosity – about environmental sustainability. This seminar will feature talks by graduate students that explore the biggest, most bedeviling questions about environmental sustainability locally and around the world. The course will be structured as follows: every other week, we will hear hour-long graduate student talks about sustainability questions and their research, and on the off weeks, we will discuss the unanswered, debatable questions that relate to the previous week’s talk.
Same as: CEE 126Z

EARTH 131. Pathways in Sustainability Careers. 1 Unit.
Interactive, seminar-style sessions expose students to diverse career pathways in sustainability. Professionals from a variety of careers discuss their work, their career development and decision-points in their career pathways, as well as life style aspects of their choices.
Same as: EARTHSYS 131

EARTH 183. California Desert Geologic Field Trip. 1 Unit.
Field seminar. Three class meetings during Winter quarter followed by a 6-day field trip over Spring Break to Mojave Desert, Death Valley, and Owens Valley. See stunning desert and mountain scenery, and examine geology that includes active faults, recent volcanoes, hot springs, ore deposits, rocks that have been stretched and melted deep in the earth’s crust, peaks carved by glaciers, vast ancient lakebeds that are now huge salt flats, shifting fields of sand dunes, and desert flora and fauna. Involves camping and some hiking. Enrollment limited to 25 students; preference given to freshmen and sophomores; additionally graduate students in the School of Earth, Energy & Environmental Sciences. Students interested in signing up for the course must complete this form: http://web.stanford.edu/~aferree/GS183.fb.
Same as: GS 183

EARTH 191. Stanford EARTH Field Courses. 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.
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 in the Eastern Sierra Nevada of California. We’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. Preference for freshmen and sophomores. If you are interested in signing up for the course, complete this pre-registration form: https://stanforduniversity.qualtrics.com/SE/?SID=SV_9RF2rDopROzwOxf.

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; students should enroll on Axess and complete the application on Coursework before March 18.
Same as: CEE 151, CEE 251

EARTH 280. Pursuing Sustainability: Managing Complex Social Environmental Systems. 3 Units.
This course provides a systems framework for understanding and managing social-ecological systems, with the ultimate goal of intergenerational well-being. It explores the role of natural, human, social, technological and knowledge capital assets in determining sustainability, and their trade-offs, feedbacks, non-linearities and other interactions within complex systems. Through case study analyses, the course illustrates why complex systems approaches are important and some of the failures that occur without them, and provides an overview of the tools, approaches, and strategies that assist with management of assets for sustainability goals. The course draws on readings from a variety of on-line sources as well as chapters and case studies provided in the required text. Consent of instructor required.

EARTH 281. Case Studies in Leading Change for Sustainability. 3 Units.
This course focuses on the practice of leading change for sustainability. Students learn mindsets, knowledge, and tools that enable them to develop their capacities and identities as change-makers in advancing intergenerational well-being. The course draws upon conceptual frameworks, case studies, hands-on exercises, class discussion and interactions with transformative leaders to deepen understanding of and capacity to influence decision-making, design strategy, engage partners, and foster transformative change and innovation across scales from self to complex systems. Readings include scholarly articles, business school case material, book chapters and cutting-edge tools developed by organizations that are leading change for sustainability. Consent of instructor required.

EARTH 282. Innovating Large Scale Sustainable Transformations. 4 Units.
This class establishes innovation of systemic transformations as a crucial leadership modality. It gives students the mindsets, theoretical frameworks, and hands-on experience in shaping innovative interventions that bring about scaled and profound transformations in the face of complex multi-factorial challenges. Students are immersed in the Deep Change Methodology, which combines systems thinking, strategy, design thinking, behavioral sciences, resilience theory, diffusion theory, decision theory, and a theoretical framework around scaled multistakeholder interventions. Tools and theories introduced in class will be used to structure large-scale transformations that simultaneously create sustainability and resilience on environmental, societal, and economic fronts. This project-based team-based class challenges students to find solutions for complex real world challenges. Consent of instructor required.

EARTH 284. Design Thinking for Sustainable Impact. 3-4 Units.
Design Thinking is an exceptionally versatile methodology that combines creativity, human centeredness, design skills, critical thinking, and hands-on building of solutions as an approach to rapidly tackle ill-defined challenges. This boot-camp class immerses students in the cognitive modes, theory, skill-sets, mind-sets, and tools associated with Design Thinking to solve real world challenges aimed at sustainable impact. This project based class gives students an immersive experience in theory, tools, and practice of design thinking in the context of sustainability challenges.

EARTH 300. Earth Sciences Seminar. 1 Unit.
Required for incoming graduate students except cotermers. 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 305. Teaching in the field: Basic skills for working with students in the field. 1 Unit.
This workshop series introduces the basics of teaching, working, and living in the field with students, from first aid to university policies to pedagogy. We will discuss skills and techniques necessary to keep students safe, to maximize their learning outcomes, and to promote best practices for field teaching, particularly within the natural sciences. We will meet twice per month in the evening (5-7pm) on 4/20, 4/27, 5/11, 5/25, 6/01. Location TBD. This workshop can be taken for 1 credit. Open to all Gradstudents.

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.