DNCE 260 (E-Z). Seminar in Dance History (4) Seminar, 3 hours; written work, 3 hours. Prerequisite(s): graduate standing; consent of instructor. Studies in E. Periods; F. Styles; G. National Forms; H. Individual Artists; I. Choreographies; J. Aesthetics; K. Dance Literature; L. Notation. Each segment is repeatable as its content changes.

DNCE 264. Oral History (4) Seminar, 3 hours; individual study, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Theory and practice of oral history as a research technique. Ethnographic, social history, and gender perspectives on oral history; methods for research preparation, interview procedures, transcription, editing, and legal responsibilities. Interview project and analytical paper required.

DNCE 267. Choreographies of Writing (4) Seminar, 3 hours; discussion, 1 hour. Prerequisite(s): graduate standing or consent of instructor. An analysis of the types of relationships that may exist between dance and text. Examines the methods and strategies for translating choreographed action into a written description of that action. Students' writing is a major focus of discussions.

DNCE 269. Laban Movement Analysis (4) Seminar, 3 hours; outside research, 1 hour; consultation, 1 hour; individual study, 1 hour. Prerequisite(s): DNCE 120; graduate standing or consent of instructor. An advanced survey focusing on applied research concepts and theories of the Laban Movement Analysis method of observing, recording, and analyzing human body movement. Special attention is given to motif score writing, applying Effort, Shape, and Space Harmony paradigms. Course is repeatable to a maximum of 12 units.

DNCE 280. Colloquium in Current Topics in Dance Research (2) Colloquium, 2 hours. Prerequisite(s): graduate standing or consent of instructor. Colloquia on current research topics in dance by students, faculty, and visiting scholars. Students who attend all colloquium and discussion sessions, and who write weekly review papers and a term paper receive a letter grade; other students receive a Satisfactory (S) or No Credit (NC) grade.

DNCE 290. Directed Studies (1-6) Outside research, 3-18 hours. Prerequisite(s): graduate standing; consent of instructor and Department Chair. To be taken to meet special curricular problems. Normally graded Satisfactory (S) or No Credit (NC) only, but students may petition the instructor for a letter grade for specialized topics pursued with close faculty supervision. Course is repeatable.

DNCE 291. Individual Study in Coordinated Areas (1-12) Outside research, 3-36 hours. Prerequisite(s): graduate standing; consent of instructor and graduate advisor. A program of study designed to advise and assist graduate students who are preparing for written and oral qualifying examinations. Does not count toward the unit requirement for the Ph.D. degree. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

DNCE 292. Concurrent Analytical Studies in Dance (1-4) Outside research, 3-12 hours. Prerequisite(s): graduate standing; consent of instructor and Graduate Advisor. To be taken concurrently with some 100-series course, but on an individual basis. Limited to research, criticism, and written work of a graduate order commensurate with the number of units elected. Normally graded Satisfactory (S) or No Credit (NC) only, but students may petition the instructor for a letter grade for specialized topics pursued with close faculty supervision. Course is repeatable.

DNCE 297. Directed Research (1-6) Outside research, 3-18 hours. Prerequisite(s): consent of instructor and graduate advisor. Individualized studies in specially selected topics in Dance under the direction of a faculty member. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

DNCE 298-I. Individual Internship (1-4) Internship, 3-12 hours; term paper, 3 hours; written work, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Individual study or apprenticeship with an appropriate professional individual or organization to gain experience and skill in activities related to dance studies. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 12 units.

DNCE 299. Research for the Thesis or Dissertation (1-12) Outside research, 3-36 hours. Prerequisite(s): consent of thesis or dissertation director. Research for and preparation of the thesis or dissertation. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

DNCE 301. Directed Studies in the Teaching of Dance (4) Seminar, 3 hours; consultation, 1 hour. Prerequisite(s): graduate standing or consent of instructor. An assessment of the field of dance studies as preparation for organizing and teaching general education courses. Analyzes current anthologies and other dance publications. Students create course syllabi and lesson plans and discuss a range of practical teaching issues. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 8 units.

DNCE 302. Teaching Practicum (1-4) Lecture, 1-4 hours. Prerequisite(s): graduate standing. Supervised teaching in upper-division Dance History and lower-division Dance courses. Must be taken at least once by all teaching assistants. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Earth Sciences

Subject abbreviation: GEO
College of Natural and Agricultural Sciences

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Majors

The Department of Earth Sciences offers B.S. degrees in Geology and Geophysics, and a B.A. degree in Geoscience Education. These degree programs are designed for students with a strong interest in various aspects of the Earth Sciences, and for students interested in secondary teaching with a science emphasis. The B.S. programs place substantial emphasis on fieldwork with field courses, field trips in all appropriate courses, and excursions between quarters. The B.A. degree places emphasis on the fundamentals of geoscience, with additional coursework in education.

Academic Advising

Undergraduate advising in the Department of Earth Sciences is designed to allow close professional contact with faculty and staff. Counseling on graduation, departmental requirements and enrollment is handled by the major's professional academic advisors housed in the CNAS Undergraduate Academic Advising Center and the faculty undergraduate advisor for each major.

Each student selects a faculty mentor who counsels the student on career goals and research opportunities. The department recommends that students meet with their faculty mentor at least once each quarter to clarify career objectives and revise the program of study so it is commensurate with the developing interests and objectives of the student.

Teaching Credential and B.A. in Geoscience Education

Teachers in the public schools in California must have a credential approved by the State Commission on Teacher Credentialing. The credential requires an undergraduate major, baccalaureate degree, and completion of a graduate credential program such as that offered by the Graduate School of Education at UCR.

Before admission and student teaching in a graduate credential program, the candidate must pass the California Basic Education Skills Test (CBEST) and demonstrate subject-matter proficiency by passing an examination. All candidates for a multiple subject credential to teach in the elementary grades must pass the Multiple Subjects, California Subject Exam for Teachers (CSET). Students are urged to start early, preferably as freshmen, selecting courses

most helpful for this career. Details and counseling on the Perpare to Teach Program, a program for the multiple subject credential, are available in the Office of Interdisciplinary Programs, 2417 Humanities and Social Sciences, (951) 827-2743. Details and counseling on other programs are available in the Department of Earth Sciences or the Graduate School of Education.

UCR does not yet have a state-approved subject matter undergraduate program for earth science majors who wish to teach at the secondary level. The Teaching Credential in Science, geoscience authorization, is required for teachers who want to teach earth science/geoscience in middle school and high school. Students who plan to get this credential must take the CSET exams in Geosciences and should make certain their academic program includes preparatory course work. The examination includes geoscience in depth and general science with introductory, college-level biology, chemistry, physics, and geoscience (geology, meteorology, oceanography, astronomy). CSET test guides are available at www.cset.nesinc.com.

Further information about courses, requirements, and examinations can be obtained in orientation meetings, the CalTEACH-SMI Office (1104 Pierce Hall) and the Graduate School of Education (1124 Sproul Hall).

Earth Science students interested in a secondary school science teaching career, who intend to obtain a Teaching Credential in Science, geoscience authorization, are encouraged to pursue the B.A. degree in Geoscience Education. This degree will best prepare such students for the state credentialing examinations, but is not intended for those students who wish to become professional geologists. Students who want to have the option to become either a professional geoscientist or to teach earth science in secondary schools should pursue both the B.S. in General Geology as well as the teaching credential from the Graduate School of Education.

Students in CNAS who intend to pursue a Teaching Credential in Science, with authorization in another science, should consider pursuing a Minor in Earth Sciences.

Geology Major

The department offers four options for the Geology major: General Geology, Geobiology, Geophysics, and Global Climate Change. Students who choose the Geology major study the structure, composition, processes, and history of the earth. In particular, the Geology major stresses features of the Earth's surface and interactions between its atmosphere, hydrosphere, biosphere, rocky crust, and interior.

General Geology Option Students entering the General Geology option study the nature, distribution, age, and origin of minerals, rocks, and their contained fossils, placed within a global framework of the Earth as an evolving geologic system. The option entails a broad range of geologic training including geology, geophysics, geochemistry, and paleontology. An emphasis is also placed on fieldwork (mapping, sampling) and thoughtful analysis of geologic data (including statistical and graphical analysis with computers). Though broadly based, the option provides the student some flexibility to pursue specific geologic areas of interest at the upper-division level. Graduates of the General Geology option are qualified to pursue almost any professional career in the Earth Sciences and are well-suited to tackle graduate research at the M.S. or Ph.D. level.

Global Climate Change Option The Global Climate Change option offers earth science training with an emphasis on modern and ancient evidence for global climate change and the effects of such processes on the planet. Links between human activities, organismal evolution, weathering, volcanism, plate tectonics, extraterrestrial events and the history of the atmosphere and oceans are examined. Ancient earth climate trends are studied as proxies for predicting future climate change. Students in this option receive training in climatology, oceanography, paleoecology, stratigraphy, earth resources and the global carbon cycle.

Geobiology Option The Geobiology option offers broad-based geological training combined with a special emphasis on paleontology and organism–time interactions. Students take the geology core but at the undergraduate upper-division level focus on courses related to the fossil record, evolution and biodiversity, sedimentology, stratigraphy, and biogeography. The graduate leaves with a marketable geology degree coupled with special insight into historical aspects of life's place and role on this planet.

Geophysics Option The Geophysics option allows a student to combine general geological training with geophysical techniques to image the Earth's interior. Students take the geology core but complete additional courses in physics, mathematics, geophysics, and geohydrology. Emphasis is placed on applications of geophysics to hydrological, environmental, and natural resource problems. Graduates are especially suited to enter professional employment in environmental geology and resource exploration or graduate programs in Earth Sciences. Students seeking to enter graduate programs in Geophysics should pursue the Geophysics major.

Geophysics Major

Students who choose the Geophysics major apply the principles and concepts of physics, mathematics, geology, and engineering to the study of the physical characteristics of the earth and other planets. They make measurements of gravity and magnetic fields, seismic waves, temperatures, and natural electric current. Geophysicists study these topics from the standpoint of the physics of solid bodies, gases, and fluids. Some geophysicists are field oriented, some laboratory oriented, some theoretical, and some combine these areas.

Geoscience Education Major

Students who chose the B.A. degree in Geoscience Education intend to teach earth science and general science at the secondary school level. Students receive Freshman- and Sophomore-level training in General Geology, training in introductory Biology, and Freshman-level training in Chemistry, Calculus, and Physics. They also take courses in Education that are required for state examinations and teacher credentialing in California. The B.A. in Geoscience Education degree is designed for prospective secondary science teachers; it will not lead to a career as a professional geologist.

Students who want to have the option to become either a professional geoscientist or to teach earth science in secondary school should pursue both the B.S. in General Geology as well as the teaching credential from the Graduate School of Education.

University Requirements

See Undergraduate Studies section.

College Requirements

See College of Natural and Agricultural Sciences, Colleges and Programs section.

Some of the following requirements for the major may also fulfill some of the college's breadth requirements. Consult with a department advisor for course planning.

Major Requirements

Geology Major

All courses in Geosciences that are prerequisites for other courses in the major must be passed with a grade of "C-" or better before proceeding in the sequence. For example, GEO 001 is a prerequisite for GEO 122.

The department offers four options to majors in Geology: General Geology, Geobiology, Geophysics, and Global Climate Change. All students majoring in Geology are normally required to take the core curriculum.

General Geology, Geobiology, Geophysics, and Global Climate Change Options

Core Requirements (77-79 units)

1. Lower-division requirements (58-59 units)
   a) GEO 001, GEO 002, GEO 003/ BIOL 010
   b) BIOL 002 or both BIOL 005A and BIOL 05LA
   c) Either CHEM 001A and CHEM 01LA or CHEM 01HA and CHEM 1HLA, either CHEM 001B and CHEM 01LB or CHEM 01HB and CHEM 01HLB, either CHEM 001C and CHEM 01LC or CHEM 01HC and CHEM 1HLC
   d) MATH 008B or MATH 009A, MATH 009B, MATH 009C
   e) PHYS 040A, PHYS 040B, PHYS 040C

2. Upper-division requirements (19-20 units)
   a) GEO 101, GEO 115, GEO 122
   b) STAT 100A or STAT 155

Global Climate Change Option (59 units)

1. Lower-division requirements (20 units)
   a) BIOL 005B, BIOL 005C
   b) GEO 009, GEO 010 and GEO 011
2. Upper-division requirements (39 units)
   a) GEO 118, GEO 136 or GEO 137, GEO 152 or GEO 153, GEO 157, GEO 160, GEO 169
   b) Fourteen (14) units of related upper-division course approved by the undergraduate advisor

General Geology Option (58 units)

1. GEO 100, GEO 116, GEO 118, GEO 123
2. GEO 102A (14 units in one quarter), or GEO 102A and GEO 102B (14 units in two quarters), or GEO 102A, GEO 102B, and GEO 102C (14 units in three quarters).
3. One course from GEO 157, GEO 160, GEO 161, GEO 162, GEO 169
4. One course from GEO 124, GEO 132, GEO 136, GEO 137
5. One course from GEO 140, GEO 144, GEO 145, GEO 147.
6. GEO 151 or GEO 152/BIOL 152
7. Eight (8) additional units of related upper-division courses approved by the undergraduate advisor

Geobiology Option (58 units)

1. BIOL 005B, BIOL 005C
2. GEO 100, GEO 116, GEO 118, GEO 123
3. GEO 102A (14 units in one quarter), or GEO 102A and GEO 102B (14 units in two quarters), or GEO 102A, GEO 102B, and GEO 102C (14 units in three quarters).
4. Three courses from GEO 151, GEO 152/ BIOL 152, GEO 160, GEO 169
5. Four (4) additional units of related upper-division courses approved by the undergraduate advisor

Geophysics Option (55 units)

1. MATH 046
2. PHYS 040D, PHYS 040E
3. GEO 116, GEO 118, GEO 132, GEO 140, GEO 144, and GEO 145 or GEO 147
4. Two additional 4-unit upper-division courses in Geosciences
5. Two upper-division physical science courses approved by the undergraduate advisor

Geophysics Major

The following are major requirements for the B.S. in Geophysics. All students majoring in Geophysics are normally required to take this core curriculum.

1. Lower-division requirements (71-72 units)
   a) Either CHEM 001A and CHEM 01LA or CHEM 01HA and CHEM 1HLA, either CHEM 001B and CHEM 01LB or CHEM 01HB and CHEM 01HLB, either CHEM 001C and CHEM 01LC or CHEM 01HC and CHEM 1HLC
   b) GEO 001
   c) MATH 008B or MATH 009A, MATH 009B, MATH 009C, MATH 010A, MATH 010B, MATH 046
   d) PHYS 040A, PHYS 040B, PHYS 040C, PHYS 040D, PHYS 040E
   e) CS 010
2. Upper-division requirements (67-71)
   a) GEO 115, GEO 116, GEO 140, GEO 145, GEO 122
   b) Three of GEO 144, GEO 147, GEO 157, PHYS 177
   c) PHYS 130A, PHYS 130B, PHYS 135A, PHYS 135B, PHYS 136
   d) Twelve (12) units of upper-division physical science courses, which may include up to 4 units of Senior Thesis (GEO 195A, GEO 195B, GEO 195C) or up to 4 units of independent internship (GEO 198-I).

Geoscience Education Major

The following are major requirements for the B.A. in Geoscience Education. All students majoring in Geoscience Education are normally required to take this core curriculum.

1. Lower-division Geoscience requirements (20 units)
   a. GEO 001, GEO 002, GEO 003/BIOL 010, GEO 004, GEO 010
2. Upper-division Geoscience requirements (26-30 units)
   a. GEO 115, GEO 122
   b. Four courses from: GEO 100, GEO 101, GEO 116, GEO 118, GEO 123, GEO 124, GEO 132, GEO 136, GEO 137, GEO 140, GEO 147, GEO 151, GEO 152/BIOL 152, GEO 157, GEO 160, GEO 168, GEO 169.
3. Mathematics requirements (12 units)
   a. MATH 009A, MATH 009B, MATH 009C
4. Natural Sciences requirements (28-31 units)
   a. BIOL 002, or BIOL 005A and BIOL 005LA
   b. CHEM 001A and CHEM 001LA, CHEM 001B and CHEM 001LB, CHEM 001C and CHEM 001LC
   c. PHYS 002A and PHYS 002B and PHYS 002C, or PHYS 040A and PHYS 040B and PHYS 040C
5. Humanities requirements (to count towards College requirement of 20 units for the B.A.)
   a. LING 020 or LING 021
6. Education requirements (41 units):
   a. EDUC 003, EDUC 004, EDUC 100B or equivalent, EDUC 104/MATH 104, EDUC 109, EDUC 110, EDUC 116, EDUC 139, EDUC 174, EDUC 177A

Minor

Students who wish to Minor in Geology, Geophysics or Global Climate Change must complete 20-28 units of organized upper division courses in Geosciences. A minimum of 16 of these units must be unique to the minor and cannot be used to satisfy major requirements. To satisfy prerequisites, additional preparatory coursework in Earth Sciences and other sciences (Biology, Chemistry, Mathematics, Physics) may be required.

Minor in Geology: GEO 001, GEO 115; plus 15-23 additional upper division Geosciences units.

Minor in Geophysics: GEO 001; GEO 140; plus 16-24 additional units taken from GEO 115, GEO 116, GEO 132, GEO 144, GEO 145, GEO 190, and GEO 199.

Minor in Global Climate Change: GEO 001 or GEO 002; GEO 011; GEO 160; plus 16-24 additional upper division Geoscience units.

Before submitting a petition for a Minor to the college, students interested in pursuing a Minor in Geology or Geophysics or Global Climate Change must consult with the undergraduate faculty advisor in Earth Sciences.

Graduate Programs

The department of Earth Sciences offers the M.S. and Ph.D. in Geological Sciences.

Graduate education in the Geological Sciences emphasizes general geology combined with specialization in fields such as evolutionary paleobiology, invertebrate and vertebrate paleontology, Quaternary geology, neotectonics, applied geophysics, geotectonics, crustal processes, geochemistry, groundwater, mineral deposits, stratigraphy, sedimentology, sedimentary geochemistry, basin analysis, landscape ecology, fire ecology, and natural resource conservation. Integrated field and laboratory studies are encouraged.

Admission An undergraduate degree in geology or geophysics is the normal preparation for graduate work; however, a degree from a related field of science or engineering is often appropriate. Applicants to graduate status must supply GRE General Test (verbal, quantitative, analytical) scores before admission.

Master's Degree

In addition to the general requirements listed under the Graduate Studies section of this catalog, the requirements for the M.S. degree in Geological Sciences, under the Plan 1 (Thesis), are as follows.

Admission Students must make up any deficiency in preparation. The background re-

quired is course preparation equivalent to the bachelor's degree in Geology or Geophysics at UCR. Courses taken to remedy background deficiencies are not applicable to the graduate degree. Such courses are designated in the letter of admission to the program sent by the dean of the Graduate Division to the student.

Biannual Reviews All students must undergo biannual reviews by the departmental Graduate Progress Committee. A student's progress is assessed in these reviews, and the committee may recommend changes in a student's plans after these reviews.

Course Work All students must enroll each quarter in the Graduate Seminar in Geosciences (GEO 250). Students must attend the weekly Hewett Club lecture series.

Students must complete a minimum of 36 units of course work in the major and related subjects and obtain advance approval of a coherent plan of study from the graduate advisor.

A maximum of 12 upper-division units beyond the requirements for the bachelor's degree may be applied to the 36-unit requirement. Students must complete a minimum of 12 units of graduate courses, which must include at least four graduate-level instructional courses taught by four different faculty members as approved by the graduate advisor.

Subject to the approval of the graduate advisor, a limited number of upper-division courses in the major and related sciences, if not required for the bachelor's degree and not taken previously, may be accepted for graduate credit.

Thesis and Final Oral Examination Before the end of the third quarter of study and before embarking on research, the student must submit a written thesis proposal to the graduate progress committee. After approval of the proposal, the student must submit a thesis based on original work for approval by a thesis committee. A maximum of 12 units of thesis research may be counted toward the 36-unit minimum.

Students present an open research seminar as a final oral examination, which is advertised to all the students and faculty in the Earth Sciences Department.

Normative Time to Degree 7 quarters

Global Climate and Environmental Change (GCEC) The GCEC MS track is a field and laboratory based multidisciplinary program focused on the evidence for and controls of past and present climate change. Candidates must complete the following:

Course Work Students must complete a minimum of 36 quarter units of graduate and upper-division undergraduate courses, and research credit from 1 and 2 (below). Other upper-division undergraduate and graduate classes outside may be substituted with consent of the Graduate Advisor. 24 of 36 credits must be graduate level.

1) Required Core courses: Geo 224 upon entry into the program, Geo 260 and Geo 212.
2) At least two additional disciplinary courses: GEO 221, GEO 226, GEO 239, GEO 249, GEO 251, GEO 255, GEO 264, GEO 265, GEO 268, GEO 301, OR ENSC 200, ENSC 218, ENSC 224, ENSC 225, ENSC 232.

Thesis Work Before the end of the third quarter students must nominate a faculty advisor and identify a thesis topic. Before embarking on research the student must submit a thesis proposal based on original work for approval by a thesis committee. A maximum of 8 units of research credit can be counted toward the 36 unit minimum. Students present an open research seminar as a final oral examination.

Doctoral Degree

The Department of Earth Sciences offers the Ph.D. in Geological Sciences. In addition to the general university requirements of the Graduate Division as found in the Graduate Studies section of this catalog, the Ph.D. in Geological Sciences normally requires the following.

Biannual Reviews All students meet with the Graduate Progress Committee during their first week at UCR to discuss general interests, goals, and plans. The committee recommends courses designed to prepare a student for research and to correct deficiencies in background. This committee also reviews a student's progress biannually and may recommend transfer to the master's program if normal progress is not maintained.

Course Work Students must complete at least four graduate-level instructional courses taught by four different faculty members as approved by the graduate advisor. Course work used in satisfaction of the M.S. degree may be accepted with the graduate advisor's approval. All students must enroll each quarter in the Graduate Seminar in Geosciences (GEO 250). Students are also required to attend the weekly Hewett Club lecture series.

Written and Oral Qualifying Examinations Students must write two research proposals. The proposal topics must be approved by an examination committee to ensure breadth. The committee reviews the proposals and, if acceptable, recommends proceeding to the oral qualifying examination. An oral examination committee appointed by the dean of the Graduate Division examines the adequacy of the student's preparation to conduct the proposed research. Advancement to candidacy in the Ph.D. program follows successful completion of the oral examination.

Dissertation and Final Oral Examination A dissertation normally evolves from one of the research proposals. The dissertation must present original scholarly work and be approved by a dissertation committee before the student may take the final oral examination. Students must have satisfactory performance on the final oral examination given by the dissertation committee. Major emphasis in this examination is on the dissertation and related topics.

Normative Time to Degree from the B.S. 17 quarters

Lower-Division Courses

GEO 001. The Earth's Crust and Interior (4) Lecture, 3 hours; laboratory, 3 hours; one 1-day field trip. An introduction to the physical development of the Earth. Emphasis will be on Earth materials (rocks and minerals), processes (weathering, erosion, mountain building), structures (folds and faults), and current theories regarding the Earth's crust and interior.

GEO 002. Earth's Climate through Time (4) Lecture, 3 hours; laboratory, 3 hours; one 2-day field trip. Prerequisite(s): none. An introduction to the history of Earth's changing climate and its relationship to the evolution of life on human to geologic time scales. Topics include the interrelationships among short- and long-term carbon cycling; plate tectonics; ocean and atmosphere circulation; and greenhouse gases through time.

GEO 003. Headlines in the History of Life (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): none. Evolution of life beginning with precellular life. Topics include the origin of sex, multicellularity, vertebrate classes, morphological specializations, adaptive radiations, extinction dynamics, and the biology of dinosaurs. Cross-listed with BIOL 010.

GEO 004. Natural Hazards and Disasters (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): ENGL 001A or equivalent (may be taken concurrently). Application of basic principles of climate and geology to recognition of natural hazards and their mitigation. Topics include fires, freezes, floods, winds, landslides, volcanic eruptions, earthquakes and tsunamis. Emphasis is on confronting hazards of concern to home-buyers, planners, and conservationists in the western United States, especially southern California.

GEO 005. Our Family of Planets (4) Lecture, 3 hours; discussion, 1 hour. An introduction to the comparative study of planets, moons and other solar system objects. Explores the physical, chemical and nuclear evolution of the cosmos, stars and solar systems. Addresses similarities and differences in appearances, orbital motions, compositions, conditions and histories of global change on planets and moons, including extra solar planets and life.

GEO 006. The Violent Universe (4) Lecture, 3 hours; discussion, 1 hour. An introduction to violent phenomena that power the universe, specifically phenomena that illustrate basic astrophysical principles. Topics include impacts in our planetary system: explosions of stars, bursts of star formation, galaxy collisions, black holes, quasars, cosmic jets, and the "Big Bang." Cross-listed with PHYS 006.

GEO 007. Minerals and Human Health (4) Lecture, 2 hours; discussion, 1 hour; field, 30 hours per quarter. Prerequisite(s): none. An introductory overview of the role of minerals in human life and industrial activities. Discusses basic concepts of mineralogy and modern methods of mineral studies. Topics include the impact of minerals on human health, the role of minerals in modern biotechnologies, asbestos and silica problems, occupational diseases caused by inhalation of mineral dust, and environmental protection in California.

GEO 008. Earthquake Country (4) Lecture, 3 hours; discussion, 1 hour. An introduction to the study of earth-

quakes and the problems of living in earthquake country. Why earthquakes occur, how they are recorded, and what the effects are on man and his structures. The scientific and social consequences of earthquake prediction.

GEO 009. Oceanography (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): none. A general introduction to the geological, physical, chemical, and biological processes related to the characteristics and evolution of the ocean system. Students gain an understanding of the important role oceans play in regulating climate and the cycling of elements on the Earth's surface and how the ocean system has been, and continues to be, one of the most important influences on life.

GEO 010. Earth Resources and Sustainability (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): none. An introduction to the occurrence, availability, marketing, and usage of metals, minerals, fossil fuels, nuclear fuels and other geologic resources, including both historic and recent trends. Addresses conflicts between modern society's need for increasingly scarce resources and mounting environmental problems. Also covers achieving sustainability through conservation, recycling, and substitution.

GEO 011. Global Climate Change (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): none. Application of the scientific method to critical issues of the global climate change debate. Provides an understanding of Earth's climate system and the feedback systems that regulate the climate "over long- and short-term" time scales. Includes general oceanic and atmospheric circulation patterns, the major reservoirs and mechanisms of exchange of the global carbon cycle, and the influence and origin of greenhouse gases.

GEO 050. Survey of Geoscience for Science Teachers (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): both CHEM 001A and CHEM 01LA or both CHEM 01HA and CHEM 1HLA; PHYS 002A or PHYS 040A. Prepares teachers of comprehensive courses in general science to integrate the geoscience component. Reviews fundamental concepts of geology, oceanography, and meteorology at the foundational level of the California Subject Examinations for Teachers in physical science. Emphasizes commonalities between related sciences.

Upper-Division Courses

GEO 100. Igneous and Metamorphic Petrology (5) Lecture, 3 hours; laboratory, 6 hours; four field trips. Prerequisite(s): GEO 115 and GEO 123 with grades of "C-" or better. An introduction to the nomenclature and classification of igneous and metamorphic rocks. Includes identification of the major rock-forming minerals and common rocks in hand samples and thin sections, as well as interpretation of rock fabrics and textures. Explores tectonic setting and the origins of major rock types.

GEO 101. Field Geology (5) Lecture, 2 hours; weekly 1-day field trips. Prerequisite(s): GEO 115 with a grade of "C-" or better or consent of instructor for concurrent enrollment. Introductory course in field geology. Covers methods of mapping igneous, metamorphic, and sedimentary rocks. Includes construction of planimetric and topographic maps, use of aerial photographs, and instruction in basic surveying techniques.

GEO 102A. Summer Field Geology (1-14) field, 30-420 hours per quarter. Prerequisite(s): GEO 100 and GEO 118 with grades of "C-" or better or consent of instructor. Covers geological mapping and interpretation, as well as writing of geological reports. May be undertaken as a one-, two-, or three-quarter course (GEO 102A, GEO 102B, GEO 102C). Total credit awarded for GEO 102A plus GEO 102B plus GEO 102C may not exceed 14 units. Graded In Progress (IP) until the last quarter is completed, at which time a final grade is assigned.

GEO 102B. Summer Field Geology (1-14) field, 30-420 hours per quarter. Prerequisite(s): GEO 102A. Covers geological mapping and interpretation, as well as writing of geological reports. May be undertaken as a one-, two-, or three-quarter course (GEO 102A, GEO 102B, GEO 102C). Total credit awarded for GEO 102A plus GEO 102B plus GEO 102C may not exceed 14 units. Graded In Progress (IP) until the last quarter is completed, at which time a final grade is assigned.

GEO 102C. Summer Field Geology (1-14) field, 30-420 hours per quarter. Prerequisite(s): GEO 102B. Covers geological mapping and interpretation, as well as writing of geological reports. May be undertaken as a one-, two-, or three-quarter course (GEO 102A, GEO 102B, GEO 102C). Total credit awarded for GEO 102A plus GEO 102B plus GEO 102C may not exceed 14 units. Graded In Progress (IP) until the last quarter is completed, at which time a final grade is assigned.

GEO 115. Geologic Maps and Landforms (5) Lecture, 2 hours; laboratory, 6 hours; field, 30 hours per quarter. Prerequisite(s): GEO 001 (may be taken concurrently); MATH 004 or MATH 005, or MATH 008A. Examines characteristic patterns of bedrock outcrops, surficial deposits, the related landforms, and their representation on maps. Covers unconformities, folds, faults, intrusions, alluvial fans, river terraces, and landforms indicative of glaciers, volcanoes, landslides, and earthquakes. Applies map information to resource and hazard evaluation.

GEO 116. Structural Geology (5) Lecture, 2 hours; laboratory, 6 hours; three .5-day field trips; two 1-day field trips. Prerequisite(s): GEO 115 with a grade of "C-" or better; PHYS 040A. Examines geological structures in the field. Covers the graphical solution of structural problems and laboratory map study, the genesis of rock structures and physics of rock deformation, and Mohr diagrams and elementary stress analysis.

GEO 118. Sedimentology and Stratigraphy (5) Lecture, 2 hours; laboratory, 6 hours; two 1-day and one 2-day field trips. Prerequisite(s): GEO 115 with a grade of "C-" or better. A study of the principles of sedimentology and the comparative study of the origins of sediments and sedimentary rocks from various modern and ancient clastic, carbonate, and mixed siliciclastic-carbonate depositional environments. Emphasizes field and stratigraphic relationships, as well as petrographic and hand specimen identification.

GEO 122. Introductory Mineralogy (5) Lecture, 3 hours; laboratory, 5 hours; two half-day and one 1-day field trips. Prerequisite(s): both CHEM 001B and CHEM 01LB or both CHEM 01HB and CHEM 1HLB (CHEM 001B, CHEM 01LB, CHEM 01HB, and CHEM 1HLB may be taken concurrently); GEO 001 with a grade of "C-" or better. A study of common and important minerals and their identification using structural and crystallographic methods. Stresses distinctive structural and chemical features, diagnostic physical and optical properties, and the growth and development of minerals in various geologic environments.

GEO 123. Analytical Mineralogy (5) Lecture, 3 hours; laboratory, 6 hours. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC; GEO 122 with a grade of "C-" or better. Advanced techniques in mineralogy. Covers optical crystallography, with an introduction to X-ray diffraction, electron microscopy, and other analytical techniques.

GEO 124. Advanced Petrogenesis (4) Lecture, 2 hours; laboratory, 6 hours; two 1-day field trips. Prerequisite(s): GEO 100 with a grade of "C-" or better. Explores advanced topics in the petrogenesis of igneous and metamorphic rocks in the Earth's crust and mantle. Examines field and structural relationships of crystalline rocks and how thermodynamics, experimental phase equilibria, and computer modeling are used to study petrogenesis. Each student completes a field and laboratory research project and prepares a written and oral report on the project.

GEO 132. Groundwater Geology (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): both CHEM 001B and CHEM 01LB or both CHEM 01HB and CHEM 1HLB; MATH 009B or MATH 09HB; PHYS 040A. Covers the nature and behavior of waters in geologic media; including the chemical nature of groundwaters and geothermal fluids; principles of fluid flow in sediments and rocks; chemical reactions between solutes and geologic media; geologic aspects of contaminant migration in groundwaters; behavior of geothermal fluids; elementary computer modeling of groundwater and geothermal fluid flow in geologic media.

GEO 136. Introduction to Molecular and Petroleum Geochemistry (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC or equivalents; GEO 001 with a grade of "C-" or better or GEO 002 with a grade of "C-" or better. Explores the global carbon cycle and the origin and fate of organic carbon molecules throughout Earth's history. Covers production and composition of biogenic matter and microbial, chemical and thermal processing of sedimentary organic matter, leading to oil, gas and coal formation. Addresses important applications to the petroleum and environmental sectors.

GEO 137. Environmental Geochemistry (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): both CHEM 001C and CHEM 01LC or both CHEM 01HC and CHEM 1HLC or equivalents; GEO 001 with a grade of "C-" or better or GEO 002 with a grade of "C-" or better. Examines the chemical principles of geologic processes at and near the Earth's surface. Topics include geochemical cycles of the elements during chemical interactions of the Earth's crust, hydrosphere, and atmosphere; applications of thermodynamics and kinetics to the study of low-temperature geologic processes; and the use of isotopic techniques in age dating and tracing geologic processes.

GEO 138. Soil Morphology and Classification (4) Lecture, 3 hours; laboratory, normally 3 hours; two 1-day field trips. Prerequisite(s): ENSC 100/SWSC 100 or ENSC 100H/SWSC 100H; GEO 001 or GEO 002; or consent of instructor. The study of soils as they occur in the field and their relations to current and past environmental conditions. Use of field and laboratory data to understand soil genesis, causes of soil variability, fundamentals of soil classification, and land use potentials. Laboratory emphasizes the description and interpretation of soils and landscapes in the field. Cross-listed with ENSC 138 and SWSC 138.

GEO 140. Introduction to the Physics of the Earth (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): GEO 001 with a grade of "C-" or better; MATH 009C or MATH 09HC; PHYS 040C. Application of classical physics to the study of the Earth. Origin of the Earth, its gravitational, geomagnetic, and geothermal characteristics, seismicity and the dynamics of the Earth's crust, plate tectonics, and continental drift.

GEO 144. Earthquake Seismology (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): MATH 010A, MATH 010B, MATH 046, PHYS 040A, PHYS 040B, PHYS 040C; or consent of instructor. Introduction to the theories and observations of earthquake seismology. Students use physical principles and mathematical techniques to study the earthquake process, wave propagation, and ground motion. The laboratory emphasizes computer-assisted analysis of various types of seismic data, as well as simple modeling techniques.

GEO 145. Shallow Subsurface Imaging (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): GEO 001 with a grade of "C-" or better; MATH 009A or MATH 09HA; MATH 009B or MATH 09HB; PHYS 002A or PHYS 040A; PHYS 002B or PHYS 040B; PHYS 002C or PHYS 040C; or consent of instructor. Covers techniques of geophysical investigation of the shallow subsurface as they apply to solving groundwater, environmental, archaeological, and engineering problems. Emphasizes methods, survey design, and interpretation with focus on case studies. Laboratory consists of both field training and computer exercises using geographic information systems for analysis of spatial data.

GEO 147. Active Tectonics and Remote Sensing (4) Lecture, 2 hours; discussion, 1 hour; laboratory, 3 hours. Prerequisite(s): GEO 001, GEO 115; or consent of instructor. A computer-based course that introduces active tectonics and the earthquake cycle and how they are studied using remote sensing data. Explores examples of actively deforming areas from around the world using computer visualization software and freely available data sources (satellite imagery, digital topography, GPS and earthquake data).

GEO 151. Principles of Paleontology (4) Lecture, 3 hours; laboratory, 3 hours; one 1-day field trip. Prerequisite(s): BIOL 010/GEO 003 with a grade of "C-" or better or BIOL 005C. Emphasis is on understanding fossils as living organisms. Topics include fundamentals of evolution and the fossil record, introductory morphometrics and biosystemic theory, functional morphology, and metazoan organization and classification.

GEO 152. Principles of Invertebrate Paleobiology and Paleoecology (4) Lecture, 2 hours; laboratory, 3 hours; three 1-day field trips. Prerequisite(s): BIOL 005C with a grade of "C-" or better or BIOL 010/GEO 003 with a grade of "C-" or better. Topics include evolution and the fossil record, paleoecology, classification theory; the nature of adaptive radiations, and extinctions. Cross-listed with BIOL 152.

GEO 153. Biodiversity through Time (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): BIOL 010/GEO 003 with a grade of "C-" or better or BIOL 005C. Focuses on the history of biodiversity and the responses of organisms to episodes of profound environmental change. Outlines the major features of evolutionary history chronicled by fossils, the dynamics of evolutionary radiations and extinctions, and the implications of paleontological data for current issues in biodiversity.

GEO 157. Introduction to Geographical Information Science (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): upper-division standing. Introduces the fundamental theory and application of geographical information science. Topics include geographic information systems, data structures, databases, and spatial data models. Explores various spatial data, including their coordinate systems, data acquisition, and associated errors. Introduces data analysis methods within geographical information systems.

GEO 160. Global Climate Change (4) Lecture, 3 hours; discussion, 1 hour. Prerequisite(s): PHYS 002C or PHYS 040C or consent of instructor. Surveys historical and paleoclimate change using basic principles on gas laws, radiant energy exchange, atmospheric circulation and oceanography, and use of proxy data. Topics include variability in modern climate, greenhouse gases, global warming, El Nino, Pacific decadal oscillation, ozone hole, volcanism, ice age climate and Milankovitch cycles. Also covers stable isotope profiles, plate tectonics, greenhouse climates, paleovegetation, modern species diversity, and snowball Earth.

GEO 161. Quaternary Paleoenvironmental Change (4) Lecture, 2 hours; laboratory, 2 hours; two 2-day field trips. Prerequisite(s): GEO 001 with a grade of "C-" or better or GEO 002 with a grade of "C-" or better. Examines geological evidence of environmental change throughout Quaternary times ("Ice Age") to provide a framework for understanding natural environmental change and for predicting future change.

GEO 162. Geomorphology (4) Lecture, 2 hours; laboratory, 6 hours; one 2-day field trip. Prerequisite(s): upper-division standing or consent of instructor. A study of surficial processes related to the development and evolution of landforms and landscapes at the Earth's surface. Emphasis is on weathering regimes, mass wasting and hillslope development, river process, and form. Examines erosional and depositional processes in tectonic, volcanic, arid, karst, glacial, and coastal landscapes.

GEO 167. Conservation Biogeography (4) Lecture, 3 hours; laboratory and field, 3 hours. Prerequisite(s): BIOL 005C with a grade of "C-" or better or BIOL 010/GEO 003 with a grade of "C-" or better. Application of biogeographic and ecological theories in the conservation of plants, animals, and wildlands. Topics include biological preserve design, ecological consequences of land development, and wildlife-habitat relationships.

GEO 168. Biogeography (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): BIOL 005C with a grade of "C-" or better or BIOL 010/GEO 003 with a grade of "C-" or better or consent of instructor. Analysis of world vegetation patterns, migrations, and ecological considerations at scales ranging from geologic to historical. Topics include plant migration, endemism, continental species patterns, ecological convergence, island biogeography, and world species diversity.

GEO 169. California Vegetation (4) Lecture, 3 hours; laboratory, 3 hours; two 1-day field trips. Prerequisite(s): BIOL 005C with a grade of "C-" or better or BIOL 010/GEO 003 with a grade of "C-" or better. Survey of the flora, distribution, and ecology of California ecosystems, including Mediterranean shrubland, conifer forests, desert scrub, valley forbfields, and exotic grasslands. Discusses vegetation in relation to climate, physiography, fire, landscape steady states, biological invasions, paleobotany, and broad-scale change due to land development, invasive species, grazing, and fire suppression.

GEO 190. Special Studies (1-5) Individual study, 3-15 hours. Prerequisite(s): upper-division standing; consent of instructor and department chair. Individual study to meet special curricular needs. Course is repeatable to a maximum of 9 units.

GEO 191. Undergraduate Seminar in Geological Sciences (1) Seminar, 1 hour. Prerequisite(s): open to upper division Geological Sciences majors only. For undergraduate students who desire formal participation in the weekly departmental seminar. In addition to attending the seminar, students must write abstracts describing two of the presentations. Graded Satisfactory (S) or No Credit (NC). May be repeated to a total of 6 units.

GEO 195A. Senior Thesis (3-5) hours per week to be established by supervisor. Prerequisite(s): senior status; consent of instructor. Preparation of a thesis based upon supervised field and/or laboratory research and literature review in the geological sciences. The thesis may be undertaken as a one-, two-, or three-quarter sequence. In the case of a two- or three-quarter sequence, the final grade will be deferred until completion of the last quarter. Total credits for GEO 195A, GEO 195B, and GEO 195C may not exceed 9 units.

GEO 195B. Senior Thesis (3-5) hours per week to be established by supervisor. Prerequisite(s): senior status; consent of instructor. Preparation of a thesis based upon supervised field and/or laboratory research and literature review in the geological sciences. The thesis may be undertaken as a one-, two-, or three-quarter sequence. In the case of a two- or three-quarter sequence, the final grade will be deferred until completion of the last quarter. Total credits for GEO 195A, GEO 195B, and GEO 195C may not exceed 9 units.

GEO 195C. Senior Thesis (3-5) Prerequisite(s): senior status; consent of instructor. Preparation of a thesis based upon supervised field and/or laboratory research and literature review in the geological sciences. The thesis may be undertaken as a one-, two-, or three-quarter sequence. In the case of a two- or three-quarter sequence, the final grade will be deferred until completion of the last quarter. Total credits for GEO 195A, GEO 195B, and GEO 195C may not exceed 9 units.

GEO 198-I. Independent Internship (1-12) Field, 3-36 hours. Prerequisite(s): consent of instructor, undergraduate advisor, and department chairman. Independent study in a surrogate job condition under non-university supervision. Internships are normally in public or private institutions such as planning departments, research labs, or industry. Position, task, method of reporting completion and accomplishments, and units must have prior agreement among student, instructor, and supervisor. One unit for every three hours per week spent in internship. Graded Satisfactory (S) or No Credit (NC).

Graduate Courses

GEO 203. Mineral Equilibria (4) Lecture, 4 hours. Prerequisite(s): GEO 137 or consent of instructor. Applications of thermodynamics and kinetics to evaluating equilibria among minerals and fluids in geological environments. Emphasis placed on equilibria in geothermal systems, ore deposits, metamorphic and igneous rock, and groundwater.

GEO 205. Geohydrology (4) Lecture, 3 hours; laboratory, 3 hours; one 1-day field trip. Prerequisite(s): GEO 132 or ENSC 163. Fluid flow in geologic media; resource evaluation; and relevant geologic hazards and geotechnical problems.

GEO 206A. Stratigraphy (4) Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): GEO 118; consent of instructor. Covers rock stratigraphy and time stratigraphy with an emphasis on their principles, history, and methods. Includes reading and analysis of pertinent literature and field trips.

GEO 206B. Stratigraphy (4) Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): GEO 118; consent of instructor. Covers time stratigraphy and biostratigraphy with an emphasis on their principles, history, and methods. Includes reading and analysis of pertinent literature and field trips.

GEO 212. Ecological Systems in Space and Time (4) Lecture, 3 hours; field, 30 hours per quarter. Prerequisite(s): BIOL 117 or BIOL 152/GEO 152 or equivalent or consent of instructor. Focuses on how ecological systems are interpreted and reconciled at the community, landscape, and paleontological scales. Addresses the role of extrinsic factors operating at each of these scales. Also examines the historical development of our understanding of ecological systems at various scales. Cross-listed with BIOL 212 and ENTM 212.

GEO 219. Theory of Systematics (4) Lecture, 2 hours; discussion, 2 hours. Prerequisite(s): BIOL 112/BPSC 112/ENTM 112 or equivalent or consent of instructor. Examines topics developed around a series of classical and recent papers on the principles, philosophy, and methodology of modern systematics and phylogenetic methods. Cross-listed with BIOL 219 and ENTM 219.

GEO 221. Electron Microscopy and Microanalysis (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Introduction to electron microscopy and microanalysis of inorganic solids including minerals and synthetic materials. Students learn the physical principles, strengths, and limitations of the method. Laboratory provides hands-on experience with scanning and transmission electron microscopes and interpretation of images and data.

GEO 223. Seminar in Geobiology (1) Seminar, 2 hours. Prerequisite(s): graduate standing or consent of instructor. Lectures, discussions and demonstrations by students, faculty and invited scholars on current research topics in Geobiology. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

GEO 224. Sierran Studies: The Paleoclimate Record of the Sierra (4) Field, 90 hours per quarter; term paper, 3 hours. Prerequisite(s): graduate standing. A study of climate change in the Sierra Nevada Mountains, extending from Precambrian glacigenic sediments to modern glaciers. Utilizes field evidence to access the controls of climate and determine the resolution and limitations of the physical record. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable as topics change to a maximum of 8 units.

GEO 225A. Geology of Carbonate Rocks (4) Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): GEO 118; consent of instructor. Covers characterization, recognition, and interpretation of carbonate rocks. Laboratory work includes study of polished and thin sections of selected suites of rocks.

GEO 225B. Geology of Detrital Rocks (4) Lecture, 2 hours; laboratory, 6 hours. Prerequisite(s): GEO 118; consent of instructor. Covers characterization, recognition, and interpretation of detrital rocks. Laboratory work includes study of polished and thin sections of selected suites of rocks.

GEO 226. Soil Geomorphology (4) Lecture, 2 hours; laboratory, 6 hours; two saturday field trips per quarter. Prerequisite(s): ENSC 138/GEO 138/SWSC 138, GEO 162, or equivalents. Examines the interaction of pedogenic and geomorphic processes during the Quaternary, with an emphasis on the rate of these processes. Group research includes field data collection and analysis. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Cross-listed with SWSC 226.

GEO 239. Advanced Topics in Resource Geology (4) Seminar, 4 hours. Prerequisite(s): GEO 100; consent of instructor. Covers topics in nonrenewable mineral and energy resources, such as petroleum resources; nuclear energy and waste disposal; toxic metals and groundwater contamination; and coal resources and global warming. Discusses geologic and environmental aspects of these resource issues. Content may vary from year to year. Requires oral and written research reports. Course is repeatable to a maximum of 8 units.

GEO 241. Advanced Field Geophysics (14) Lecture, 10 hours; laboratory, 16 hours; field, 14 hours. Prerequisite(s): GEO 140; proficiency in a word processing, spread sheet, or programming language. Advanced applications of modern geophysical field techniques to the solution of complex geological problems, using seismic refraction and reflection, electrical and electromagnetic, potential field, and well-logging methods.

GEO 243. Earthquake Physics (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): GEO 144, MATH 010A, MATH 010B, MATH 046, PHYS 040A, PHYS 040B, PHYS 040C; basic computer programming experience; or consent of instructor. MATH 146A, MATH 146B, and MATH 146C are recommended. An exploration of the physics of the earthquake process. Students use both numerical models and theoretical and analytical tools to learn about the processes of fault fracture, rupture propagation, and slip, and their relation to ground motion in earthquakes. Requires an independent project in computer earthquake modeling.

GEO 243A. Earthquake Physics (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): GEO 144, MATH 010B, PHYS 40C, basic computer programming experience; or consent of instructor. MATH 046 is recommended. An exploration of the physics of the earthquake process. Focuses on processes controlling fault slip and friction mechanics, as well as modeling the space/time characteristics of earthquake occurrence. Utilizes theoretical/analytical tools and numerical models. Includes an independent project in computer modeling.

GEO 243B. Earthquake Physics (4) Lecture, 3 hours; laboratory, 3 hours. Prerequisite(s): GEO 144, MATH 010B, PHYS 040C, basic computer programming experience; or consent of instructor. MATH 046 is recommended. An exploration of the physics of the earthquake process. Focuses on fault dynamics during the earthquake rupture and slip processes and its relationship to ground motion. Utilizes theoretical/analytical tools and numerical models. Includes an independent project in computer modeling.

GEO 245. Principles and Applications of Geochronology (4) Lecture, 2 hours; laboratory, 3 hours; field, 30 hours per quarter. Prerequisite(s): consent of instructor. Examines methods of dating Quaternary successions, including isotopic, physical, chemical, and stratigraphic techniques. Fieldwork and laboratory emphasize the collection, preparation, and analysis of samples using modern methods.

GEO 247. Electrical Exploration Methods (4) Lecture, 3 hours; laboratory, 4 hours. Prerequisite(s): MATH 009A, MATH 009B, MATH 009C, PHYS 040C; or consent of instructor. Study of electrical properties of Earth's materials. Galvanic resistivity methods in a multilayered medium. Potential distribution and interpretation of empirical data. Electrical well logging. Elements of telluric and magneto-telluric sounding.

GEO 249. Field Methods in Quaternary Geology (4) Discussion, 2 hours; laboratory, 6 hours; three 2-day field trips. Prerequisite(s): GEO 101 or GEO 162 or consent of instructor. Geologic field problems and associated techniques for reconstructing Quaternary geologic, climatologic, and hydrologic events recorded in the landforms, stratigraphy, and weathering profiles of selected regions. Field techniques include relative and calibrated dating analysis, section measurements, morpho- and lithostratigraphic analysis, and map constructions in fluvial, lacustrine, glacial, coastal, and eolian environments.

GEO 250. Graduate Seminar in Geological Sciences (1) Seminar, 1 hour. Prerequisite(s): graduate student status. Oral reports by graduate students, faculty, and visiting scholars on current research topics in geological sciences. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

GEO 251 (E-Z). Advanced Topics in Paleontology (3-5) Seminar, 3 hours; laboratory, 0-6 hours. Prerequisite(s): consent of instructor. Selected advanced topics in paleontology. Content varies from quarter to quarter. After consultation with the instructor, students enroll in only the seminar (3 units) or in both the seminar and laboratory (4-5 units). May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor. Course is repeatable.

GEO 252. Marine Paleoecology (3) Lecture, 1 hour; discussion, 1 hour; two 1-day field trips. Prerequisite(s): graduate standing. Examines fundamental principles of paleoecology and the measurement of biodiversity, abundance, and biomass from the fossil record. Covers the significance of mass extinctions, diversification events, and environments on the Earth's changing marine ecosystem. Includes taphonomy, ichnology, and field studies. Course is repeatable to a maximum of 6 units.

GEO 253. Advanced Topics in Petrology and Geochemistry (3-5) Seminar, 3 hours; laboratory, 0-6 hours. Prerequisite(s): consent of instructor. Selected advanced topics from petrology and geochemistry of igneous, metamorphic, and sedimentary rocks. Course content varies from year to year. Course is repeatable to a maximum of 6 to 10 units.

GEO 255. Advanced Topics in Sedimentary Petrology (4) Seminar, 2 hours; laboratory, 6 hours. Prerequisite(s): GEO 225A, GEO 225B. Selected advanced topics from sedimentary petrology and physical stratigraphy. Course content varies from year to year. Course is repeatable.

GEO 256. Earth's Deep Interior: Frontiers in Mantle Petrology and Mineralogy (4) Lecture, 2 hours; discussion, 2 hours. Prerequisite(s): GEO 001 or GEO 030 or equivalent. Discusses mineral reactions in extreme conditions in the Earth's mantle and at the core-mantle boundary, the possible fate of continental and oceanic plates subducted to Earth's deep interior, and new models of the origin and evolution of mantle convection and plumes. Graded Satisfactory (S) or No Credit (NC). Course is repeatable to a maximum of 8 units.

GEO 257. Current Issues in Seismology (4) Lecture, 3 hours; outside research, 3 hours. Prerequisite(s): graduate standing or consent of instructor. Explores current topics in seismology that are not covered by existing graduate courses. Discussion and research topics may include the history of seismology, source mechanics, seismic wave propagation, site effects, earthquake prediction, and whole-Earth structure. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

GEO 257 (E-Z). Advanced Topics in Geophysics (4) Seminar, 3 hours; outside research, 3 hours. Prerequisite(s): consent of instructor. Selected advanced topics from geophysics. Course content

varies from quarter to quarter. Each segment is repeatable to a maximum of 12 units.

GEO 259. Tectonics of California (4) Lecture, 2 hours; seminar, 2 hours. Prerequisite(s): consent of instructor. Geological, geophysical, and paleontological bases of interpreting tectonic development of California, with special emphasis on southern California. Interdisciplinary approach will be emphasized. Weekly reading assignments, active participation in discussions, and appropriate field and library research will be required. Participants will prepare two papers and give presentations.

GEO 260. Global Climate Change (4) Seminar, 3 hours; term paper, 3 hours. Prerequisite(s): PHYS 002C or PHYS 040C or consent of instructor. Explores global climate change in historic and geologic time scales. Topics include ocean-atmosphere feedbacks, El Niño, Pacific decadal oscillation, anthropogenic CO2, volcanism, cosmic rays, polar ozone depletion, global climate modeling, stable isotopes, "ice house" Pleistocene climates, "greenhouse" climates of the Mesozoic and Tertiary, plate tectonics, and the "snowball" Earth.

GEO 263. Organic and Petroleum Geochemistry (4) Lecture, 3 hours; seminar, 1 hour. Prerequisite(s): graduate standing; BIOL 010/GEO 003; CHEM 001C or equivalent; or consent of instructor. Explores the geologic fate of organic molecules in the sedimentary record, from fossil DNA to lipids. Addresses current analytical techniques used for detecting molecular fossils and for characterizing sedimentary organic matter. Covers topical applications of organic geochemical tools to archaeology, geobiology, paleoclimatic and paleoenvironmental reconstruction, petroleum exploration, and cosmochemistry research. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

GEO 264. Biogeochemical Cycles through Time (3) Lecture, 3 hours; two to three 2-day field trips. Prerequisite(s): BIOL 010/GEO 003; CHEM 001C or equivalent; GEO 001; GEO 002; or consent of instructor. A comprehensive exploration of the major biogeochemical cycles at and near Earth's surface. Emphasis is on microbially mediated cycling of elements and isotopes within diverse sedimentary environments and the cause-and-effect relationships with the ocean and atmosphere. Explores 4 billion years of biospheric evolution in light of these cycles. May be taken Satisfactory (S) or No Credit (NC) with consent of instructor and graduate advisor.

GEO 265. Special Topics in Earth and Environmental Sciences (1-3) Seminar, 1-3 hours. Prerequisite(s): graduate standing. Involves oral presentations and small-group discussions of selected topics in the areas of biogeochemistry, global climate change, geomicrobiology, earth surface processes, and interplanetary life. Graded Satisfactory (S) or No Credit (NC). Course is repeatable as content changes to a maximum of 10 units. Cross-listed with ENSC 265.

GEO 268. Seminar in Biogeography (4) Seminar, 2 hours; research, 6 hours. Prerequisite(s): graduate standing. Topics include Mediterranean ecosystems, fire ecology, naturalization of exotic species, succession and ecosystem steady state theory, and mapping of vegetation. Course is repeatable to a maximum of 8 units.

GEO 290. Directed Studies (1-6) Prerequisite(s): consent of instructor. Research and special studies in the geological sciences. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

GEO 297. Directed Research (1-6) Prerequisite(s): consent of instructor. Research for individual graduate students in geological sciences. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

GEO 299M. Research for Master's Thesis (1-12) research, 3 hours per unit. Prerequisite(s): consent of instructor. Thesis research. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

GEO 299P. Research for Dissertation (1-12) research, 3 hours per unit. Prerequisite(s): consent of instructor. Research for dissertation, arranged in consultation with the staff. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

Professional Courses

GEO 301. Teaching of Geosciences at the College Level (1) Seminar, 1 hour. Prerequisite(s): graduate standing in Geological Sciences. A program of weekly meetings and individual formative evaluation required of new Teaching Assistants for Geosciences courses. Covers instructional methods and classroom/section activities most suitable for teaching Geosciences. Conducted by the Teaching Assistant Development Program. Graded Satisfactory (S) or No Credit (NC). Course is repeatable.

GEO 302. Teaching Practicum (1-4) Seminar, 1-4 hours; practicum, 2-8 hours. Prerequisite(s): restricted to those graduate students appointed as Teaching Assistants. Supervised teaching of upper and lower-division courses in Geosciences. Required of all Teaching Assistants. Graded Satisfactory (S) or No Credit (NC). Course is repeatable for credit, but units not applicable toward degree unit requirements.

Economics

Subject abbreviation: ECON
College of Humanities, Arts, and Social Sciences

Aman Ullah, Ph.D., Chair
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Jang-Ting Guo, Ph.D.
Tae-Hwy Lee, Ph.D.
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**

Cooperating Faculty
Kenneth A. Baerenklau, Ph.D. (Environmental Sciences)
Linda Fernandez, Ph.D. (Environmental Sciences)
Keith C. Knapp, Ph.D. (Environmental Sciences)
Roger L. Ransom, Ph.D. (History)
Kurt A. Schwabe, Ph.D. (Environmental Sciences)
Henry J. Vaux, Jr., Ph.D. (Environmental Sciences)

Majors

Economics studies the production and distribution of goods and services, as well as the way in which productive activity helps shape social existence. Economists are concerned with the factors determining national income, inflation, unemployment, output, growth and inequality (macroeconomics), as well as the behavior of individual decision-making units like households and firms (microeconomics). Economists are also concerned with the role of markets, money and interest rates, the forces affecting international trade, and many other problems of production and distribution.

Economics is the basis for many careers, some of which require only a B.A. degree while others require more advanced work. Possible careers include business, government, education and law.

The B.A. is the most general degree offered in economics. It is appropriate background for a wide variety of purposes, including graduate study and professional schools. However, those planning to attend a graduate program in economics may need more quantitative training than the B.A. requires. Students who are considering attending a graduate program in economics should consult with their undergraduate advisor. The Business Economics B.A. degree provides more specific preparation for careers in business administration or management or for graduate work in business.

University Requirements

See Undergraduate Studies section.

College Requirements

See College of Humanities, Arts, and Social Sciences, Colleges and Programs section.

MATH 009A and MATH 009B may also be used to meet breadth requirements.

Major Requirements

The Economics Department offers B.A. degrees in Economics, Business Economics, Economics/Administrative Studies, and Economics/Law and Society.

Economics Major

The major requirements for the B.A. degree in Economics are as follows:

1. Lower-division requirements (4 courses [at least 16 units])

   a) ECON 002, ECON 003