

# GEOLOGICAL SCIENCES (GEOL)

## Courses

### GEOL 1010 (3) Exploring Earth

Introductory geology for majors and non-majors. Studies Earth, its materials, its characteristics, its dynamic processes, and how it relates to people. Separate lab (GEOL 1030) is recommended. Degree credit not granted for both GEOL 1010 and GEOL 1012.

**Additional Information:** GT Pathways: GT-SC2 -Natural Physical Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### GEOL 1012 (3) Exploring Earth for Scientists

Studies Earth, its materials, its characteristics, its dynamic processes, and how it relates to people. This course is an introductory geology course suitable for geology and other STEM majors. Like GEOL 1010, but taught at a higher intellectual level with a greater amount of quantitative analysis. Separate lab (GEOL 1030) is recommended. Degree credit not granted for both GEOL 1010 and GEOL 1012.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

### GEOL 1020 (3) Dodos, Dinosaurs, and Deinococcus: The History of a Habitable Planet

Examines how the solid, fluid, and living Earth interact, how changes in the oceans, atmosphere and life reflect that interaction over the immensity of geologic time, and how the rock record is analyzed to reconstruct the co-evolution of Earth and life.

**Additional Information:** GT Pathways: GT-SC2 -Natural Physical Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### GEOL 1030 (1) Introduction to Geology Laboratory 1

Features field trips to local points of geologic interest. Studies rocks and topographic and geologic maps. Meets the MAPS requirement for natural science lab, if taken with GEOL 1010 or GEOL 1012.

**Recommended:** Requisite Concurrent registration in any 1000-level geology course is beneficial but not required.

**Additional Information:** GT Pathways: GT-SC1 - Natural Physical Sci:Lec Crse w/ Req Lab

Arts Sci Core Curr: Natural Science Lab

Arts Sci Gen Ed: Distribution-Natural Sci Lab

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science Lab or Lab/Lec

### GEOL 1040 (3) Geology of Colorado

Reviews the geologic evolution and history of Colorado. It first develops the basic concepts needed to interpret the geology and then systematically shows how the state evolved through geologic time. Designed for those who enjoy understanding the beauty and splendor of the state.

**Additional Information:** Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### GEOL 1060 (3) Global Change: An Earth Science Perspective

Focuses on evidence for planetary warming, climate change, glacier and ice-sheet melting and sea level rise both now and in the recent past. Attempts to develop understanding of the interactions within the coupled Earth system that regulate such changes. Utilizes examples from the geological and instrumental records, and evaluates the global warming forecast.

**Additional Information:** Arts Sci Core Curr: Natural Science Sequence

Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### GEOL 1150 (3) Water, Energy and Environment: An Introduction to Earth Resources

Explores how geological processes and human populations together affect the quantity, quality and availability of Earth resources. Includes examination of the water cycle and how humans use and modify water; fossil-fuel and mineral resources, and renewable energy options. Sustainable versus non-sustainable use and population growth is considered.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### GEOL 1160 (3) Environmental Geoscience & Where Science Meets Society

This is an introductory-level course designed primarily for freshmen non-science majors. The course targets four main questions at the intersection of geoscience and society. (1) What is science and how is it useful to me? (2) How do Earth processes, particularly natural disasters, impact people? (3) How does the Earth, particularly its natural resources, allow people to live the way we do? (4) How do people impact the environment? The course is designed to not only support students in learning about how science and society intersect in the realm of environmental geoscience, it is also designed to support students' development of academic-success and career-ready skills including goal setting, time management, communication, collaboration and teamwork, and more.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

### GEOL 1170 (3) Our Deadly Planet

This course investigates those events so dramatic and catastrophic that they have left evidence in the geologic record that suggest they significantly impacted life on the planet. These include, but are not limited to, violent volcanic eruptions, mega-earthquakes and associated tsunamis, landslides and sector collapse on volcanoes, megafloods, rapid climatic change, superstorms, and impacts from asteroids and comets. The intent is to use examples from recent events and processes to frame and interpret evidence for these types of events observed in the rock record.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

### GEOL 1180 (3) Our Microbial Planet

Examines how microorganisms shape the world around us, both throughout the Earth's history and today. Major topics include the origin and evolution of life, the interplay between microbes and the environment, roles of microbes in global change, and applications of microbiology in biotechnology and energy.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

MAPS Course: Natural Science

**GEOL 2001 (4) Planet Earth**

Explores the dynamics of planet Earth with particular emphasis on the factors that make the planet habitable. Includes examination of heat balance, hydrology, geomorphology, biogeochemistry and climate history through both lecture and lab-based activities. Required for the Geology major, introduces students to the major concepts in contemporary Earth system science.

**Requisites:** Requires prerequisite course of GEOL 1010 or GEOL 1012 or GEOL 1020 or GEOL 1040 or GEOL 1060 or GEOL 1150 or GEOL 1170 or GEOL 1180 or GEOL 2100 or ENVS 1000 (minimum grade D-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 2005 (4) Introduction to Earth Materials**

Provides introduction to the classification, composition and properties of the materials that compose the Earth, how these materials are studied, and how they are used to interpret Earth history and processes. Required for the Geology major.

**Requisites:** Requires prerequisite courses of (GEOL 1010 or GEOL 1012 or GEOL 1020 or GEOL 1040 or GEOL 1060 or GEOL 1150 or GEOL 1170 or GEOL 1180 or GEOL 2100) and CHEM 1113 and CHEM 1114 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 2040 (3) The Search for Life in the Universe**

Introduces the scientific basis for the possible existence of life elsewhere in the universe. Includes origin and evolution of life on Earth and the search for evidence of life in our solar system, including Mars and Jupiter's moon Europa. Discusses the conditions necessary for life and whether they might arise on planets around other stars.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 2040

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 2100 (3) Environmental Geology**

Introduces the influences of geologic processes on human lives and the changes human actions cause in geologic systems. Uses examples and case studies from Colorado and the West.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 2700 (2) Introduction to Field Geology**

Introduces basic field techniques necessary to collect geologic data and samples, and necessary to map geologic units.

**Requisites:** Requires prerequisite courses of GEOL 1030 and GEOL 2005 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3005 (3) Mesozoic Monsters & Dinosaurs, Pterosaurs, and Sea Lizards**

Origin and evolution of the reptiles that lived during the Mesozoic Era, including dinosaurs, pterosaurs, mosasaurs, and plesiosaurs. Course will focus on evolution, paleobiology, paleoecology, and extinction of these extraordinary animals, and a history of their discoveries. The course also introduces students to the scientific method and how hypotheses in paleontology are formulated and tested.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3010 (3) Introduction to Mineralogy**

Covers origin, occurrence, identification, classification, and uses of minerals with emphasis on applications of mineralogy to economic geology and petrology. Two lectures and one lab per week.

**Requisites:** Requires prerequisite courses of CHEM 1113 and CHEM 1114 and GEOL 2005 and MATH 1300 or APPM 1350 (all minimum grade C-).

**Recommended:** Prerequisite GEOL 2005.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3020 (4) Petrology**

Studies field relations, petrography, petrology, chemistry, and origins of igneous and metamorphic rocks by means of lectures, reading, and lab and field experience. Labs include instruction in the fundamentals of optical petrography and the study of rocks in thin section.

**Requisites:** Requires prerequisite course of GEOL 2005 or GEOL 3010 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3023 (4) Statistics and Geographic Data**

Learn how to use computational and statistical tools to solve problems in the geographic domain and apply introductory statistical concepts to real world problems through lab exercises. Using spatial data you will be trained in powerful specialized descriptive and predictive analysis technique. You will explore how to manipulate and visualize data and make inference using state-of-the art statistics software, applied to various social and Earth Science problems.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOG 3023

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences  
Arts Sci Gen Ed: Quantitative Reasoning Math

**GEOL 3030 (3) Introduction to Hydrogeology**

Introduces groundwater flow concepts, hydrologic cycle, physical and chemical properties, flow net, hydraulic potential, geologic controls on heterogeneity and anisotropy, aquifers and aquitards in a geologic system, saturated and unsaturated flow, flow to a well, pumping tests, and role of groundwater in geologic processes.

**Requisites:** Requires prerequisite courses of any 1000-level GEOL lecture course (GEOL 1010, 1012, 1020, 1040, 1060, 1150, 1170, or 1180), GEOL 2001, and (MATH 1300 or APPM 1350) (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3040 (3) Global Change: The Recent Geological Record**

Geological records in lakes, oceans, deserts, and around glaciers indicate the significant changes in the global systems that have taken place over the last few hundred or thousand years. Explores the timing and nature of these changes. Department enforced prerequisites: any two-course sequence of natural science core courses.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3050 (2) GIS for Geologists**

Provides an introduction to Geographic Information Systems (GIS) techniques focused on geological applications. Covers GIS analyzing, mapping and GPS use. Basic computer skills are a plus before entering the class.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3070 (3) Introduction to Oceanography**

Explores Earth's dynamic oceans. Discusses the disciplines of oceanography including marine geology, chemistry, biology and physical oceanography with emphasis on global change. Specific topics may include: tectonics, currents, biogeochemical cycles, ecology and global warming.

**Equivalent - Duplicate Degree Credit Not Granted:** ATOC 3070

**Recommended:** Prerequisite any 1000-level ATOC or GEOL course or ATOC major.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3090 (3) Developing Scientific Writing Skills**

Focuses on the development of scientific writing skills. Enhances student ability to write professionally, revise text and review the work of others. Writing assignments integrate the subject matter of different topics in earth science. Department enforced prerequisites: a lower division writing course.

**Requisites:** Two of the following: GEOL 2001 or GEOL 2005 or GEOL 2700 or GEOL 3010 or GEOL 3030 or GEOL 3120 or GEOL 3320 or GEOL 3430 or GEOL 3820 (min grade C-).

**Additional Information:** Arts Sci Core Curr: Written Communication  
Arts Sci Gen Ed: Written Communication-Upper

**GEOL 3120 (4) Structural Geology**

Introduces the basic principles and processes involved in deformation of natural rocks and minerals and the techniques used to analyze a variety of common geological structures (e.g., fractures, folds, fault zones).

**Requisites:** Requires prerequisite courses of GEOL 2001 and GEOL 2005 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3181 (4) Microbial Planet Laboratory**

Provides beginner friendly lab & research experience working on a microbiology project. The course teaches how to conduct original scientific research from hypothesis to experimentation, evaluation and reporting. Students study non-pathogenic microorganisms they isolate themselves from nature as part of the course. Hands-on topics covered in class include how to isolate & culture new microbes; how to observe, describe and classify them; and how to examine their metabolic capabilities such as the production of antibiotics.

**Equivalent - Duplicate Degree Credit Not Granted:** MCDB 3181

**Requisites:** Requires prerequisite courses of CHEM 1113 and CHEM 1114 or CHEM 1400 and CHEM 1401 (all minimum grade C-).

**Recommended:** Prerequisite GEOL 1180 or MCDB 1150 or EBIO 1210.

**GEOL 3300 (3) Extraterrestrial Life**

Discusses the scientific basis for the possible existence of extraterrestrial life. Includes origin and evolution of life on Earth; the possibility of life elsewhere in the solar system, including Mars; and the possibility of life on planets around other stars. Department enforced prerequisite: one-year sequence in a natural science.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 3300

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3320 (3) Introduction to Geochemistry**

Students build upon principles introduced in general chemistry in order to predict and interpret chemical dynamics in Natural environmental systems. We explore the formation and chemical differentiation of the early Earth, how chemical weathering and mineral dissolution and precipitation modifies the Earth's surface, and how redox biogeochemistry shapes aquatic environments.

**Requisites:** Requires prerequisite courses of CHEM 1113, CHEM 1114, GEOL 2001, and (MATH 1300 or APPM 1350). All minimum grade C-.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3330 (3) Principles of Geophysics**

Provides an introduction to fundamental geophysics including seismology, geomagnetism, gravity, and electromagnetic methods with applications to plate tectonics and exploration of the subsurface.

**Requisites:** Requires prerequisite courses of MATH 1300 or APPM 1350 and PHYS 1110 or PHYS 1115 and GEOL 2001 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3410 (3) Paleobiology**

Surveys morphology, ecology and evolution of ancient animal and plant life and their interactions on Earth. Fossils used to solve geological and biological problems. Department enforced prerequisites: GEOL 1010 and GEOL 1020 or GEOL 2005 or EBIO 1030 and EBIO 1040 or EBIO 1210 and EBIO 1220 (all minimum grade of C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3430 (4) Sedimentology and Stratigraphy**

Introduces the study of sedimentary rocks emphasizing their origin, characteristics, and interpretation; and the principles and techniques for establishing the temporal order and spatial distribution of sedimentary layers.

**Requisites:** Requires prerequisite courses of GEOL 2001 and GEOL 2005 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3520 (3) Energy and Climate Change: An Interdisciplinary Approach**

Examines sources of energy and other resources in light of their availability, use, environmental impact, as well as their impact on policy, economics and values. As fossil fuels are the dominant energy source today, particular emphasis is placed on climate impacts and the carbon cycle. All material is assessed through the lenses of the physical sciences, policy, ethics and economics.

**Equivalent - Duplicate Degree Credit Not Granted:** ENVS 3520

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3540 (3) Introduction to Petroleum Geology**

Discusses the origin and distribution of conventional and unconventional petroleum resources, source rocks, types of traps and seals, reservoir rock properties, exploration methods (seismic data analysis and interpretation, formation evaluation, subsurface mapping), reservoir characterization and modeling, reserves calculations.

**Requisites:** Requires prerequisite courses of GEOL 2001 and GEOL 2005 (minimum grade C-).

**Recommended:** Corequisite GEOL 3430.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3600 (3) Introduction to Python Programming for Earth Scientists**

Introduces students to scientific computing and computer programming using the Python language. Emphasis is on scientific applications such as data input and analysis, plotting, and simulation. Examples are drawn from earth and environmental sciences. Course covers variables, operations, data types, conditionals, loops, data structures, array calculations, and libraries for data analysis and plotting. Coursework is primarily based on weekly programming assignments.

**Requisites:** Requires prerequisite course of GEOL 2001 (minimum grade C-).

**Recommended:** Prerequisite Introductory course in GEOL, ENVS, GEOG, ATOC, or EVEN.

**GEOL 3720 (3) Evolution of Life: The Geological Record**

Discusses the evolution of life on Earth, beginning with the earliest origins and surveying the major steps that led to the rise of higher plants and animals. Covers modern ideas on the causes of periodic mass extinctions in both the marine and terrestrial realms. Emphasizes geologic evidence for the pathways of evolution, using examples from the ordinary to the bizarre.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3820 (4) The Fluid Earth**

Examines the myriad forms of fluid behavior found on Earth, from the atmosphere to the inner core. Explores how basic principles of fluid physics may be used to understand a broad range of earth processes, including mantle convection, atmosphere and ocean dynamics, stream flow, lava spreading, and glacier motion, among others. Covers fundamental fluid concepts such as viscosity, pressure, convection, friction, and free-surface flow.

**Requisites:** Department enforced prerequisites: GEOL 2001 and (MATH 1300 or (APPM 1340 and APPM 1345) or APPM 1350) (all minimum grade of C-).

**Recommended:** Prerequisites Any 1000 level GEOL class and PHYS 1110.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 3910 (4) Earth and Planetary Inference**

Introduces modern ways to interpret earth science observations in the context of conceptual models. We will learn how earth and planetary scientists synthesize geological, geochemical, and geophysical measurements and theoretical knowledge to make new discoveries and predictions. The tools that will be introduced in the course range from order-of-magnitude estimation techniques to a gentle intro to inverse thinking.

**GEOL 3950 (3) Natural Catastrophes and Geologic Hazards**

Surveys historic and prehistoric natural disasters, their cause and potential for recurrence. Meteorite impact, earthquakes, volcanic eruptions, tsunamis, landslides, floods, magnetic reversals and major extinction events. Department enforced prerequisite: one year of science.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4001 (1) Geology Majors Research Seminar**

Reading and discussion seminar to enhance students' critical evaluation of research design, assumptions, and presentation of results in the geosciences. Readings will focus on the events involved in the geologic evolution of the American West and its timing. Papers read will employ a variety of geologic and geophysical techniques. Geared towards students completing independent research and interested in pursuing a research-focused career. Development of career/graduate school plan and application materials is covered.

**Repeatable:** Repeatable for up to 4.00 total credit hours.

**Requisites:** Requires Prerequisites of GEOL 2005 or GEOL 2001 (all minimum grade C-). Restricted to Geology majors only.

**Recommended:** Prerequisite or corequisite GEOL 2700.

**GEOL 4021 (4) Petrology: Evolution of Crustal and Mantle Rocks**

Origin, physical, and chemical properties of igneous and metamorphic rocks. This course develops a thermodynamic framework for the interpretation of geologic processes from observed mineral assemblages and rock textures. Laboratory component emphasizes the study of rocks in thin section and hand samples to understand earth processes in the mantle and crust.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5021

**Requisites:** Requires prerequisite courses of CHEM 1113 and CHEM 1114 and GEOL 2005 and (MATH 1300 or APPM 1350) (all minimum grade C-).

**Recommended:** Prerequisites GEOL 2001 and 2700.

**Grading Basis:** Letter Grade

**GEOL 4060 (4) Oceanography**

Examines the ocean as a system influencing the Earth's surficial processes and climate. Composition and properties of seawater, ocean circulation, waves, tides, coastal-, shallow-, and deep-water processes, biogeochemical cycles, deep sea sediments. Laboratory emphasizes the use of oceanographic data. Department enforced prerequisite: one semester chemistry or physics or geology.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5060

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4070 (3) Paleoclimatology**

Covers the primary forcings and feedbacks that determine Earth's energy balance and the resultant climate system on decadal to millennial time scales. Covers ocean/atmosphere circulation, the role of ice sheets in the climate system, monsoons, Holocene climate change and 20th Century warming. Includes coverage of the proxies available to reconstruct climates of the past and the archives that contain these proxies. Department enforced prerequisite: environmental science or geology introduction sequence courses.

**Requisites:** Requires prerequisite course of GEOL 2001 (minimum grade C-).

**Recommended:** Prerequisite natural science majors only.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences



**GEOL 4093 (4) Remote Sensing of the Environment**

Covers acquisition and interpretation of environmental data by remote sensing. Discusses theory and sensors as well as manual and computerized interpretation methods. Stresses infrared and microwave portions of the spectrum.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOG 5093 and GEOG 4093 and GEOL 5093

**Requisites:** Requires prerequisite course of APPM 1340 1345 or APPM 1350 or ECON 1088 or 3818 or MATH 1081 or 1300 or 1310 or 2510 or ANTH 4000 or BCOR 1020 or GEOG 3023 or GEOL 3023 or PSCI 2075 or PSYC 2111 or SOCY 2061 or 4061 or STAT 4000 (minimum grade D-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4120 (3) Advanced Structural Geology and Tectonics**

Provides valuable exposure to theory and applications related to deformation (rheology) of solid Earth materials as well as the structural and geophysical characteristics of the world's major orogenic belts. The processes that will be covered span a wide range of Earth's depths, from compaction in sedimentary rocks and flow of ice/salt near Earth's surface to cataclastic mechanisms in fault rocks to plastic flow of deep crust and mantle rock. The course will involve lectures, some in-class and take home problem sets, some local field exercises and field data analysis, classic and modern paper discussions, and a research term project (written and oral presentation).

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5120

**Requisites:** Requires prerequisite course of GEOL 3120 (minimum grade C-).

**Grading Basis:** Letter Grade

**GEOL 4150 (2) Planetary Field Geology**

Provides an overview of the geology, age and origins of the solid (rocky) planets, dwarf planets and moons of our solar system and the processes that form them from comparative studies from comparative geology. Includes modules on volcanism, rifting, aeolian processes, fluvial erosion, impacts, climate change and paleontology.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5150

**Requisites:** Requires prerequisite course of GEOL 2700 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4160 (3) Introduction to Biogeochemistry**

Covers fundamentals of biogeochemical cycling, emphasizing water, carbon and nutrient dynamics in terrestrial ecosystems; chemical interactions of atmosphere, biosphere, lithosphere and hydrosphere; natural and human-managed environments. Department enforced prerequisites: GEOL 3320 or EBIO 3270 and CHEM 1011.

**Equivalent - Duplicate Degree Credit Not Granted:** EBIO 4160 and ENVS 4160

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4185 (3) Geomicrobiology**

Examines how microbial and chemical processes interact on the Earth's surface today and have shaped the planet throughout its history. Emphasis will be placed on how the life styles and chemical ingenuity of microorganisms drive key biogeochemical processes including weathering and transformations of carbon, oxygen, sulfur, iron and nitrogen. Towards this goal, major geologic and evolutionary events will be examined through the lens of microbial diversity, metabolic energetics, microbe-mineral interactions, and molecular biomarkers.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5185, ENVS 4185, and MCDB 4185

**Requisites:** Requires prerequisite courses of CHEM 1113 and CHEM 1114 or CHEM 1400 and CHEM 1401 (minimum grade C-).

**Recommended:** Prerequisites GEOL 1180 or MCDB 1150 or GEOL 3320 or EBIO 3400 or ENVS 4160 or EVEN 4484.

**Grading Basis:** Letter Grade

**GEOL 4215 (2) Geochronology and Thermochronology**

Constraining the timing of events and rates of processes is fundamental to earth science research. The field of geochronology and thermochronology is rapidly evolving. Cutting-edge aspects of geochronologic methods and emerging techniques will be especially emphasized. Lectures will emphasize the principles and assumptions of each technique. Seminar discussions will focus on recent papers that demonstrate state-of-the-art applications to diverse problems.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5215

**Requisites:** Requires prerequisite courses of GEOL 2001 and GEOL 2005 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4241 (4) Earth Surface Processes**

Earth's surface is constantly reshaped by water, ice, wind, and life. This class investigates the earth's landscapes and the processes that modify them, both gradually by slow weathering and erosion, and abruptly through the action of floods, landslides, and other geologic events. We cover surface processes in hillslope, glacial, riverine, desert, and coastal environments. Upon completion of the course, students will have mastered knowledge about diverse surface processes and landforms and applied core geomorphic principles to a variety of landscapes. Students will also learn that understanding surface processes is important for managing natural hazards (e.g., landslides and floods). This course will draw from many disciplines, including geology, geography, physics, chemistry, and biology. The laboratory portion of the course will include quantitative problem solving and field trips to collect and analyze geomorphic data.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOG 4241

**Requisites:** Requires prerequisite courses of GEOG 1011 or GEOL 2001 and a calculus course (MATH 1300 or APPM 1350 or (APPM 1340 and APPM 1345)), all minimum grade C-.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4270 (3) Marine Chemistry and Geochemistry**

Examines the chemical, biological, geological and physical processes affecting (and affected by) the chemistry of the oceans. Topics include: chemical cycling in seawater; the marine carbon cycle and its long-term control on atmospheric CO<sub>2</sub>; the large-scale interdependence of nutrient distributions and biological productivity, chemical tracers of ocean circulation; the chemistry of marine sediments, including early diagenesis.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5270

**Requisites:** Restricted to students with 57-180 credits (Juniors or Seniors). Requires prerequisite courses of CHEM 1113, CHEM 1114, CHEM 1133, CHEM 1134, and GEOL 2001 (minimum grade C-).

**Recommended:** Prerequisites introductory chemistry, introductory geology, introductory oceanography.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4330 (3) Cosmochemistry**

Investigates chemical and isotopic data to understand the composition of the solar system: emphasis on the physical conditions in various objects, time scales for change, chemical and nuclear processes leading to change, observational constraints, and various models that attempt to describe the chemical state and history of cosmological objects in general and the early solar system in particular.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5330 and ASTR 4330 and ASTR 5330

**Requisites:** Restricted to students with 57-180 credits (Juniors or Seniors). Requires prerequisite courses of (CHEM 1113 or CHEM 1400 or CHEN 1211) and (PHYS 1110 or PHYS 1115); all minimum grade C-.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4341 (3) The Cryosphere: Earth's Icy Environments**

Serves as an advanced introductory course in to the cryosphere for science majors. The course covers the nature of ice and the icy component of the Earth System, and how changing ice affects society. The course will not cover sea ice. Formerly offered as a special topics course.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5341

**Requisites:** Requires prerequisite course of GEOL 2001 or PHYS 1110 or PHYS 1115 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4380 (3) Fundamentals of Stable Isotope Geochemistry**

This course teaches students the fundamental principles of stable isotope fractionation during physical and biological processes, and the application of these behaviors to a wide range of important geologic questions. The course will use classic case studies from the geologic record to illustrate these principles.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5380

**Requisites:** Requires prerequisite courses of (MATH 1300 or APPM 1350) and CHEM 1113 (all minimum grade C-).

**GEOL 4474 (4) Vertebrate Paleontology**

Discusses the history and evolution of the vertebrates, including the phylogenetic relationships and evolutionary patterns of the major groups. Lab focuses on comparative vertebrate osteology and fossil representation of major groups. Department enforced prerequisites: GEOL 1020 and GEOL 3410 (or permission from the instructor).

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5474

**Requisites:** Restricted to students with 57-180 credits (Juniors or Seniors).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4611 (3) Organic Geochemistry**

Explores the  $\delta$ biomarker concept as a tool to elucidate microbial, biogeochemical, and climatic processes in natural systems through three fundamental goals: a) characterization and classification of organic molecules in complex, natural mixtures; b) biosynthesis, transport, transformation, preservation and destruction of organic matter in nature; c) application of lipid biomarkers and their stable isotope composition to study biological, biogeochemical, and climatic processes in modern and ancient systems.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5611

**Requisites:** Requires prerequisite courses of CHEM 1113, CHEM 1114, CHEM 1133, and GEOL 2001 (all minimum grade C-).

**Recommended:** Prerequisite GEOL 3320 or GEOL 4270.

**Grading Basis:** Letter Grade

**GEOL 4660 (3) Sedimentology and Geobiology of Carbonates**

Focuses on how carbonate sediments are formed, deposited, and lithified and what influences the preservation and alteration of textural and geochemical signals. We will cover facies identification, interpreting depositional environment, and carbonate geochemistry, with a particular emphasis on recent advances and unanswered questions at the intersection of carbonates and geobiology, including the role of microbial carbonate precipitation and/or dissolution in the formation and degradation of stromatolites, carbonate mud, ooids, etc.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5660

**Requisites:** Requires prerequisite course of GEOL 3430 (minimum grade C-).

**Recommended:** Prerequisites GEOL 3320, GEOL 4185.

**GEOL 4670 (3) Isotope Geology**

Introduces principles of stable and radiogenic isotope systematics in inorganic and organic geochemistry. Emphasizes application of isotope data to problems in igneous, metamorphic and sedimentary petrology, geobiochemistry, and petroleum genesis.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5670

**Requisites:** Requires prerequisite a course of MATH 1300 or APPM 1350 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4675 (3) Stable Isotopes in Paleoclimate and Paleoecology**

Explores the use of stable isotope geochemistry for research questions in paleoclimatology and paleoecology. Covers physical and biological drivers of isotopic fractionation, systematics and applications of light elements such as carbon, nitrogen, oxygen, hydrogen, sulfur and boron and some less traditional isotopic systems. Applications include marine and terrestrial paleoclimate proxies and some uses for ecology and paleoecology.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5675

**Requisites:** Requires prerequisite course of CHEM 1113 (minimum grade C-).

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4700 (1-4) Special Geological Topics**

Studies in selected geological subjects of special current interest (for undergraduates).

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to students with 57-180 credits (Juniors or Seniors).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4711 (2) Igneous and Metamorphic Field Geology**

Applies field techniques to interpretation of igneous and metamorphic rocks. Field exercises and lectures focus on collecting data required to map igneous and metamorphic rock units.

**Requisites:** Requires prerequisite courses of (GEOL 2001 or GEOL 2700) and GEOL 2005 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4712 (2) Structural Field Geology**

Explores methods of field study of structure of rocks, including observations, data collection and interpretation to understand geometry of deformation and causative processes and kinematics. Field projects are mapped using different scales, air photos, topographic maps and compass and tape.

**Requisites:** Requires prerequisite courses of GEOL 2700 and GEOL 3120 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4714 (2) Field Geophysics**

Applies geophysical field techniques and data interpretation to studying geological and engineering problems. Fieldwork includes seismic, gravity, magnetic, and electrical measurements.

**Requisites:** Requires prerequisite courses of GEOL 2001 or GEOL 2700 and GEOL 3330 and MATH 1300 and PHYS 1110 or PHYS 1115 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4715 (2) Field Techniques in Hydrogeology**

Introduces various field techniques and data analysis methods in hydrogeologic studies for students in geology, environmental studies, geography, and civil engineering. Exercises include mapping ground water levels, conducting slug and pumping tests, measuring stream flows, interpreting aquifer parameters from geophysical measurements, and using field data for water budget analysis.

**Requisites:** Requires prerequisite courses of GEOL 3030 and GEOL 2001 or GEOL 2700 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4716 (2) Environmental Field Geochemistry**

This is a critical thinking course that makes use of field and laboratory environments. Students learn methods and develop hands-on expertise needed to identify, characterize and interpret the reactions that govern the quality of water in natural systems, through activities in local watersheds.

**Requisites:** Requires prerequisite courses of (GEOL 2001 or GEOL 2700) and GEOL 3320 and (CHEM 1011 and CHEM 1031) or (CHEM 1113 and CHEM 1133). All minimum grade C-.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4717 (2) Field Seminar in Geology and Tectonics**

Studies geologic features in and around Colorado to gain an overview of the geologic and tectonic evolution of the western U.S.

**Requisites:** Requires prerequisite courses of GEOL 2001 or GEOL 2700 and GEOL 3120 or GEOL 3320 or GEOL 3430 or GEOL 4241 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4719 (2) Field Analysis and Tectonics of Crystalline Rocks**

Introduces basic and advanced mapping tools and concepts for structural and tectonic analysis of solid-state and magmatic deformation, metamorphism, and fluid flow in igneous and metamorphic rocks. Includes some digital mapping concepts using smartpad and smartphone applications, and computer-based analysis of structure data. Includes multi-day mapping projects in the Front Range, and in western Colorado, southern Wyoming, or northern New Mexico. Also includes introductions to Precambrian tectonic history of western North America and mineral resources of Colorado.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5719

**Requisites:** Requires prerequisite courses of GEOL 2700 and GEOL 3120 (all minimum grade C-).

**Grading Basis:** Letter Grade

**GEOL 4721 (2) Field Methods in Active Tectonics**

Analysis of active geologic structures, including strike slip fault systems, secondary structures in stepovers and related eruptive centers. Includes the use of digital imagery, elevation models, offset geomorphic features and Quaternary deposits to determine local deformation rates and their relation to plate motions.

**Requisites:** Requires prerequisite courses of GEOL 2700 and GEOL 3120 (all minimum grade C-).

**Recommended:** Prerequisite GEOL 4712.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4723 (2) Field Studies in Sedimentology**

Provides students experience in observing and interpreting sedimentary rocks in the field. We will visit outcrops in CO and UT spanning a range of depositional environments, including eolian, lacustrine, fluvial, and marine. Developing observational and notetaking skills will be emphasized; students will be responsible for contributing to a group field guide based on their guided field observations at each site.

**Requisites:** Requires prerequisite courses of GEOL 2700 and GEOL 3430 (all minimum grade C-).

**GEOL 4725 (1-4) Field Based Special Topics in Geoscience**

Explores selected geological subjects of special interest in a field setting.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5725

**Repeatable:** Repeatable for up to 8.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to students with 57-180 credits (Juniors or Seniors).

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**GEOL 4747 (3) Unconventional Resources**

To introduce the concepts, principles, methods, and techniques of unconventional reservoirs. Unconventional reservoirs can be defined informally as those reservoirs that need artificial stimulation to produce. Accumulations in conventional traps are due to buoyancy. Seven common kinds of unconventional reservoirs: tight-gas sandstones, shale gas, shale oil, coal-bed methane, heavy-oil sands, oil shale, gas hydrates. Formerly offered as a special topics course.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5747

**Requisites:** Requires prerequisite courses of GEOL 2001, GEOL 2005, GEOL 2700, and GEOL 3430 (all minimum grade C-).

**GEOL 4755 (2) Field Geobiology**

Provides students technical fieldwork skills in the interdisciplinary field of geobiology, spanning modern environments and to ancient environments in preserved in rock record, and spanning techniques from geochemistry, environmental microbiology, and sedimentology.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5755

**Repeatable:** Repeatable for up to 8.00 total credit hours.

**Requisites:** Requires prerequisite courses of GEOL 2700 and GEOL 3430 (all minimum grade C-).

**GEOL 4833 (3) Teaching and Learning Earth Systems**

Learn and develop pedagogically effective strategies for teaching and understanding Earth Science concepts. Particular emphasis is placed on understanding the importance of geoscience habits of mind (i.e. spatial/temporal reasoning, multiple working hypotheses, geographic context). Focuses upon inquiry and evaluation of evidence, the importance of background knowledge and misconceptions, and developing effective discourse within and outside the classroom.

**Equivalent - Duplicate Degree Credit Not Granted:** EDUC 5833 and EDUC 4833 and GEOL 5833

**Requisites:** Requires prerequisite course of ATOC 1060 or ENVS 1000 or GEOL 1010 or GEOL 1020 or GEOL 1060 (minimum grade C-).

**Grading Basis:** Letter Grade

**GEOL 4840 (1-3) Independent Study in Geology**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4841 (1-3) Independent Study-Economic Geology**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4842 (1-3) Independent Study-Petrology**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4843 (1-3) Independent Study-Sedimentology**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4844 (1-3) Independent Study-Structure/Tectonics**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4845 (1-3) Ind Stdy-Geochemistry**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4846 (1-3) Independent Study-Geophysics**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4847 (1-3) Independent Study-Hydrology**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4849 (1-3) Independent Study-Paleontology**

Time and credit to be arranged. For advanced undergraduates who have high scholastic standing. Open only upon consultation with department advisor. May be repeated for a total of 7 credit hours.

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**GEOL 4851 (1-3) Independent Study in Geoscience Education**

**Repeatable:** Repeatable for up to 3.00 total credit hours.

**GEOL 4862 (1-4) Geology Independent Study**

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 5862

**Repeatable:** Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.

**Recommended:** Prerequisite students may not enroll in this course without completing the Independent Study Contract.

**GEOL 4990 (1-3) Honors Thesis**

Supervised project involving original research in any area of the geological sciences. The thesis is submitted to the Honors Program of the College of Arts and Sciences and is orally defended. Must be accepted by the departmental honors committee. Department enforced prerequisite: minimum cumulative GPA of 3.30.

**Additional Information:** Arts Sciences Honors Course

**GEOL 5001 (3) Physics and Chemistry of the Solid Earth**

Reviews the physical and chemical characteristics of the solid earth, from the core to the crust, and the processes that govern behavior through the earth. Lectures are supplemented with readings from the recent literature. Topics include convection, phase transitions, melt generation, forces of plate tectonics, origin of continents and lithosphere, continental tectonics, and earthquakes.

**Requisites:** Restricted to graduate students only.

**Recommended:** Requisite a course in basic chemistry and a course in physics.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5002 (3) Physics, Chemistry, and Biology of Sedimentary Systems**

Reading and discussion of current issues and themes in the stratigraphic sciences, including stratigraphic and facies analysis, spatial heterogeneity and self-organization, numerical modeling; origin, evolution, mass extinctions, and megatrazjectories of life; and paleoceanographic and paleoclimatic signals in sedimentary rocks. Goal is to diversify students' understanding of the role of physics, chemistry, and biology in attacking research problems in sedimentary systems.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5003 (2) Graduate Writing Seminar**

Aims at improving graduate student writing, editing, and reviewing skills, while meeting student writing goals. Includes discussion of materials about effective writing, and peer-editing of text that students are producing for their graduate research endeavors.



**GEOL 5021 (4) Petrology: Evolution of Crustal and Mantle Rocks**

Origin, physical, and chemical properties of igneous and metamorphic rocks. This course develops a thermodynamic framework for the interpretation of geologic processes from observed mineral assemblages and rock textures. Laboratory component emphasizes the study of rocks in thin section and hand samples to understand earth processes in the mantle and crust.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4021

**Requisites:** Restricted to graduate students only.

**GEOL 5042 (3) Computational Tools in Geosciences**

Scientific research and teaching in geological sciences and related disciplines relies increasingly on computational tools. This class aims to introduce graduate students in the geological, geophysical and biogeochemical sciences to a wide range of commonly used concepts and open source data tools to empower them to find the right tool for their computational needs in research and teaching. Previously offered as a special topics course.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Recommended:** Prerequisite Prior experience with at least one programming language is recommended.

**GEOL 5060 (4) Oceanography**

Examines the ocean as a system influencing the Earth's surficial processes and climate. Composition and properties of seawater, ocean circulation, waves, tides, coastal-, shallow-, and deep-water processes, biogeochemical cycles, deep sea sediments. Laboratory emphasizes the use of oceanographic data.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4060

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5080 (1-3) Advanced Hydrogeology and Modeling Concepts**

Introduces advanced groundwater flow and modeling concepts, equations for steady state and transient flow, saturated and unsaturated flow, finite difference method, application of modeling in geologic processes, radial flow and aquifer parameters, infiltration and groundwater recharge, model calibration, verification and prediction. Department enforced prerequisite: MATH 2300 or Fortran.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5093 (4) Remote Sensing of the Environment**

Covers acquisition and interpretation of environmental data by remote sensing. Discusses theory and sensors as well as manual and computerized interpretation methods. Stresses infrared and microwave portions of the spectrum.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4093 and GEOG 4093 and GEOG 5093

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5101 (1) Introduction to Geological Sciences Faculty I**

Welcomes and introduces all new graduate students to the Department of Geological Sciences. Faculty discuss their research and their academic trajectories. The week's geology colloquium is discussed. Tutorials from staff introduce how the university works, what funding opportunities exist, and how and when to apply for such funding.

**Grading Basis:** Letter Grade

**GEOL 5102 (1) Introduction to Geological Sciences Faculty II**

Continues to introduce all new graduate students to the Department of Geological Sciences. Faculty discuss their research and their academic trajectories. The week's geology colloquium is discussed. In addition, students craft reports on their intended research.

**Grading Basis:** Letter Grade

**GEOL 5110 (3) Geomechanics**

Introduces fundamental physical processes important to the transport of heat and mass in the Earth and on Earth's surface. Provides practice with quantitative treatment of geological problems. Solutions for each problem are derived from first principles, including conservation and flux laws. Emphasizes heat conduction and viscous fluid flow. Department enforced prerequisite: restricted to graduate students only and a course in calculus.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5111 (3) Rheology: Fracture and Flow of Rocks**

Focuses on the elastic and plastic deformation of planetary materials (e.g. rocks and minerals, melts, tectonic plates, etc.). Topic include stress and strain, failure criterion, fracture propagation, creep (dislocation and diffusion), and deformation of multiphase materials. Prior coursework in basic chemistry, physics, mineralogy/petrology, and structure/geology is recommended.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**GEOL 5120 (3) Advanced Structural Geology and Tectonics**

Provides valuable exposure to theory and applications related to deformation (rheology) of solid Earth materials as well as the structural and geophysical characteristics of the world's major orogenic belts. The processes that will be covered span a wide range of Earth's depths, from compaction in sedimentary rocks and flow of ice/salt near Earth's surface to cataclastic mechanisms in fault rocks to plastic flow of deep crust and mantle rock. The course will involve lectures, some in-class and take home problem sets, some local field exercises and field data analysis, classic and modern paper discussions, and a research term project (written and oral presentation).

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4120

**Recommended:** Prerequisite GEOL 3120.

**Grading Basis:** Letter Grade

**GEOL 5123 (3) Teaching and Learning in Post-Secondary Science Education**

Introduces the science of learning and research-based instructional strategies. Open to students in any STEM discipline considering a career that involves college-level teaching. Students apply research on learning and teaching to the development of instructional materials for a target course they envision teaching at the college level in the future.

**Recommended:** Prerequisite at least one semester teaching/TAing undergraduate courses (waived with instructor approval).

**GEOL 5125 (3) Communicating Earth Science with the Public**

Introduces research on science communication and discusses examples drawn from geoscience. Students apply research on science communication to conceptualizing how to communicate about their specific geoscience research to the public in different contexts. Students should be familiar enough with their area of graduate research in geoscience to apply different models of science communication to it.

**Requisites:** Restricted to graduate students only.

**GEOL 5150 (2) Planetary Field Geology**

Provides an overview of the geology, age and origins of the solid (rocky) planets, dwarf planets and moons of our solar system and the processes that form them from comparative studies from comparative geology. Includes modules on volcanism, rifting, aeolian processes, fluvial erosion, impacts, climate change and paleontology.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4150

**Repeatable:** Repeatable for up to 12.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5185 (3) Geomicrobiology**

Examines how microbial and chemical processes interact on the Earth's surface today and have shaped the planet throughout its history. Emphasis will be placed on how the life styles and chemical ingenuity of microorganisms drive key biogeochemical processes including weathering and transformations of carbon, oxygen, sulfur, iron and nitrogen. Towards this goal, major geologic and evolutionary events will be examined through the lens of microbial diversity, metabolic energetics, microbe-mineral interactions, and molecular biomarkers.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4185, ENVS 4185, and MCDB 4185

**Grading Basis:** Letter Grade

**GEOL 5215 (2) Geochronology and Thermochronology**

Constraining the timing of events and rates of processes is fundamental to earth science research. The field of geochronology and thermochronology is rapidly evolving. Cutting-edge aspects of geochronologic methods and emerging techniques will be especially emphasized. Lectures will emphasize the principles and assumptions of each technique. Seminar discussions will focus on recent papers that demonstrate state-of-the-art applications to diverse problems.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4215

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5216 (1) Geochronology Reading and Discussion Seminar**

The goals of this reading and discussion seminar are to: 1) learn key aspects of a selected geochronology topic, 2) read, critically evaluate, and discuss peer-reviewed scientific papers that include geochronology data, methods, and interpretations, and 3) set up a framework and appropriate environment in which participants will discuss the next steps to address the big problems associated with each theme. This course will focus on a different geochronology theme each time that it is offered. A theme will be selected based on conversations among interested participants. At the beginning of the semester, weekly discussion topics and associated papers will be chosen to systematically work through concepts associated with that theme. Previously offered as a special topics course.

**Repeatable:** Repeatable for up to 5.00 total credit hours.

**GEOL 5253 (3) Stable Isotope Fractionation in Biogeochemical Processes**

Investigates the origins of stable isotope fractionation in geochemical systems with special emphasis on the role of biological catalysts as key drivers of isotopic effects during biogeochemical transformations. The class will cover a wide range of topics relevant to isotope fractionation including partition functions, diffusional, enzymatic and equilibrium isotope effects, open and closed system behavior, Rayleigh distillation, reservoir effects, enzymatic catalysis, physiological drivers and signal preservation.

**Recommended:** Prerequisites MATH 1300 or APPM 1350.

**GEOL 5270 (3) Marine Chemistry and Geochemistry**

Examines the chemical, biological, geological and physical processes affecting (and affected by) the chemistry of the oceans. Topics include: chemical separation in seawater; the marine carbon cycle and its long-term control on atmospheric CO<sub>2</sub>; the large-scale interdependence of nutrient distributions and biological productivity, chemical tracers of ocean circulation; the chemistry of marine sediments, including early diagenesis.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4270

**Recommended:** Prerequisites introductory chemistry, introductory geology, introductory oceanography.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5280 (3) Aqueous and Environmental Geochemistry**

Explores the fundamentals of low-temperature geochemistry to investigate element speciation and chemical behavior in waters, soils and sediments. Topics include water-rock interaction and weathering, mineral dissolution and precipitation reactions, aqueous complexation, mineral surface chemistry, kinetics, element cycles, and redox biogeochemistry. Includes exposure to spectroscopic tools, computer simulations and microbial geochemistry. Department enforced prerequisite: GEOL 3320 or 2 year of college chemistry.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5305 (3) Global Biogeochemical Cycles**

Focuses on the cycling of elements at the global scale with a particular emphasis on human modification of biogeochemical cycles. Major biogeochemical cycles, their past dynamics, present changes and potential future scenarios will be addressed. Ecosystem to global-scale model of the earth system will be discussed along with global scale measurements of element fluxes from satellites, aircraft and measurement networks. Department enforced prerequisite: restricted to graduate students only, general chemistry and some organic chemistry.

**Equivalent - Duplicate Degree Credit Not Granted:** ENVS 5840

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5330 (3) Cosmochemistry**

Investigates chemical and isotopic data to understand the composition of the solar system: emphasis on the physical conditions in various objects, time scales for change, chemical and nuclear processes leading to change, observational constraints, and various models that attempt to describe the chemical state and history of cosmological objects in general and the early solar system in particular. Department enforced prerequisite: graduate standing in physical science and graduate chemistry or physics or math courses.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4330 and ASTR 4330 and ASTR 5330

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5341 (3) The Cryosphere: Earth's Icy Environments**

Serves as an advanced introductory course in to the cryosphere. The course covers the nature of ice and the icy component of the Earth System, and how changing ice affects society. The course will not cover sea ice. Formerly offered as a special topics course.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4341

**Requisites:** Restricted to graduate students only.

**GEOL 5380 (3) Fundamentals of Stable Isotope Geochemistry**

This course teaches students the fundamental principles of stable isotope fractionation during physical and biological processes, and the application of these behaviors to a wide range of important geologic questions. The course will use classic case studies from the geologic record to illustrate these principles.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4380

**Requisites:** Restricted to graduate students only.

**GEOL 5420 (3) Quaternary Dating Methods**

Features in-depth survey of standard and experimental dating methods that provide absolute ages for events of the last two million years of Earth history. Includes theory and application of radiocarbon, uranium series, amino acid, thermo-luminescence, fission track, potassium/argon, hydration, light stable isotopes, and other radioactive techniques.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5430 (3) Paleooceanography and Paleoclimatology**

Examines scientific tools, data, and theories related to the dramatically varied past climate of the Earth. Focus will be on marine records of climate change and ocean circulation, but ice cores and other continental archives will also be discussed. Course covers the Cenozoic Era (66 Ma to present), but with particular emphasis on the Quaternary ice age cycles.

**Recommended:** Prerequisites Introductory geology and introductory oceanography or atmospheric science.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5432 (3) Active Tectonics**

Considers the physical processes that drive coseismic and interseismic strain in the upper crust on Earth. It is focused on recognition and interpretation of surface strain produced by active faulting, folding and flexure at a range of timescales. This includes defining how coseismic strain cycles act to build geologic structures while considering methods of analysis with rapidly emerging remotely sensed and geochronologic datasets to quantify strain rates for seismic hazard assessment. Previous coursework in structural geology, geomorphology and remote sensing is recommended.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Grading Basis:** Letter Grade

**GEOL 5474 (4) Vertebrate Paleontology**

Discusses the history and evolution of the vertebrates, including the phylogenetic relationships and evolutionary patterns of the major groups. Lab focuses on comparative vertebrate osteology and fossil representation of major groups.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4474 and MUSM 5474

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5555 (3) Topics in Macroevolution**

Macroevolution extends beyond the limits of microevolution by including processes that encompass many species, in both recent and fossils organisms. Some of the topics include evolutionary novelty and innovation, developmental evolution, disparity and diversity dynamics, and extinction. We will survey case studies, methods, and the current literature.

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**GEOL 5611 (3) Organic Geochemistry**

Explores the ¿biomarker concept¿ as a tool to elucidate microbial, biogeochemical, and climatic processes in natural systems through three fundamental goals: a) characterization and classification of organic molecules in complex, natural mixtures; b) biosynthesis, transport, transformation, preservation and destruction of organic matter in nature; c) application of lipid biomarkers and their stable isotope composition to study biological, biogeochemical, and climatic processes in modern and ancient systems.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4611

**Recommended:** Prerequisites CHEM 1113 or equivalent from undergraduate degree and GEOL 5270 or GEOL 5280 or GEOL 5305 or GEOL 5675.

**GEOL 5612 (3) Techniques in Organic Geochemistry**

Explores the techniques in analytical chemistry and organic geochemistry for the study of lipid biomarkers in the environment, which include the following topics: a) Extraction of environmental samples and separation of lipid classes; b) Analysis of apolar lipids using gas chromatography-mass spectrometry (GC-MS); c) Determine the stable isotope composition of lipids using GC-isotope ratio-MS (GC-IR-MS); d) Analysis of polar lipids using high performance liquid chromatography-MS (HPLC-MS). Requires previous coursework in general chemistry and Organic Geochemistry.

**Recommended:** Prerequisites Introductory or advanced courses in organic chemistry, biochemistry, biogeochemistry, geochemistry, geomicrobiology, paleoclimate, or geology.

**GEOL 5660 (3) Sedimentology & Geobiology of Carbonates**

Carbonate sedimentary rocks are a significant component of the geobiological rock record, capturing a history of organisms and the environments they inhabit. This course will focus on how carbonate sediments are formed, deposited, and lithified and what influences the preservation and alteration of textural and geochemical signals. We will cover facies identification, interpreting depositional environment, and carbonate geochemistry, with a particular emphasis on recent advances and unanswered questions at the intersection of carbonates and geobiology, including the role of microbial carbonate precipitation and/or dissolution in the formation and degradation of stromatolites, carbonate mud, ooids, etc.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4660

**Recommended:** Prerequisite prior coursework in Sedimentology.

**GEOL 5670 (3) Isotope Geology**

Introduces principles of stable and radiogenic isotope systematics in inorganic and organic geochemistry. Emphasizes application of isotope data to problems in igneous, metamorphic and sedimentary petrology, geobiochemistry, and petroleum genesis.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4670

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5675 (3) Stable Isotopes in Paleoclimate and Paleoecology**

Explores the use of stable isotope geochemistry for research questions in paleoclimatology and paleoecology. Covers physical and biological drivers of isotopic fractionation, systematics and applications of light elements such as carbon, nitrogen, oxygen, hydrogen, sulfur and boron and some less traditional isotopic systems. Applications include marine and terrestrial paleoclimate proxies and some uses for ecology and paleoecology.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4675

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5690 (3) Tectonic History of the Western United States**

Provides students with the practical tools needed to make tectonic interpretations through study of the geologic history of the western United States and the geodynamic models used in interpreting that history. Paleomagnetism, geobarometry, geothermometry, geodynamic modeling, and elements of structural geology and stratigraphy are topics considered in this class.

**Requisites:** Requires prerequisite courses of GEOL 3120 and PHYS 1110 (all minimum grade D-).

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5700 (1-4) Geological Topics Seminar**

Offers seminar studies in geological subjects of special current interest. Primarily for graduate students, as departmental staff and facilities permit.

**Repeatable:** Repeatable for up to 15.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5701 (2) Super-Problems in Quaternary Climate**

Investigates major problems in the study and understanding of Quaternary climate variation, in seminar format. Each year one major topic will be addressed, such as: the physics and chemistry of the Ice Age ocean circulation; the theory and mechanics of glacial/interglacial atmospheric CO<sub>2</sub> change; the origins of the 20, 40, and 100 kyr orbital (Milankovitch) climate cycles.

**Recommended:** Prerequisites Introductory geology and climatology, oceanography, paleoclimatology, or paleoceanography.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5702 (1-3) Geomorphology Seminar**

Explores the dynamics and forms of the earth's surface through critical reading and discussion of both classical and modern literature.

**Repeatable:** Repeatable for up to 10.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5703 (1) Seminar in Tectonics**

Focuses on a wide variety of topics related to crust, mantle and whole earth tectonics. Published papers from recent peer-reviewed literature are read and discussed. The format and specific topics will vary each semester (e.g., a relatively focused theme or open format) and will in part be determined by the makeup of enrolled students. Department enforced prerequisite: restricted to graduate students only.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5704 (1) Carbonates Seminar**

Focuses broadly on the topic of carbonates, including sedimentology, geochemistry, and geobiology of carbonates. Each semester will have a distinct theme under these sub-topics. Students will be responsible for leading discussion on individual readings and will be able to provide input on both the theme and the individual reading selections. Upper-level GEOL majors can register with instructor approval.

**Repeatable:** Repeatable for up to 10.00 total credit hours.

**GEOL 5705 (1-3) Seminar in Paleoclimate**

Investigates major problems in the study and understanding of past climate variations as preserved in the geologic record. Course format is a seminar-style critical reading and discussion of journal articles in paleoclimatology and paleoceanography. Topical focus varies from year to year. Prior coursework in geology, climate science, and/or paleoclimate is recommended.

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**GEOL 5711 (1-3) Igneous and Metamorphic Field Geology**

Applies field techniques to interpretation of igneous and metamorphic rocks. Field exercises and lectures focus on collecting data required to map igneous and metamorphic rock units. Department enforced prerequisites: restricted to graduate students only and GEOL 2001 or GEOL 2700 and GEOL 3020.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5712 (1-3) Structural Field Geology**

Methods of field study of structure of rocks, including observations, data collection and interpretation to understand geometry of deformation and causative processes and kinematics. Field projects are mapped using different scales, air photos, topographic maps and compass and tape. Department enforced prerequisites: GEOL 2001 or GEOL 2700 and GEOL 3020.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5714 (2) Field Geophysics**

Applies geophysical field techniques and data interpretation to studying geological and engineering problems. Fieldwork includes seismic, gravity, magnetic and electrical measurements. Department enforced prerequisite: restricted to graduate students only and GEOL 2001 or GEOL 2700 and MATH 1300 and PHYS 1110.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5715 (1-3) Field Techniques in Surficial Geology and Geohydrology**

Introduces various field techniques and data analysis methods in hydrogeologic studies for students in geology, environmental studies, geography and civil engineering. Exercises include mapping ground water levels, conducting slug and pumping tests, measuring steam flows, interpreting aquifer parameters from geophysical measurements and using field data for water budget analysis. Department prerequisite: GEOL 2001 or GEOL 2700.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5716 (1-3) Environmental Field Geochemistry**

Develops basic field skills in the most commonly performed tasks required for the environmental characterization of solid and aqueous wastes. Media of study include soils, stream sediments, surface waters, ground waters and atmospheric particulates. Department enforced prerequisites: GEOL 2001 or GEOL 2700 and CHEM 1011 and CHEM 1031 or CHEM 1113 or CHEM 1133 and GEOL 3320.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5717 (2) Field Seminar in Geology and Tectonics**

Studies geologic features in and around Colorado to gain an overview of the geologic and tectonic evolution of the western U.S. Department enforced prerequisites: restricted to graduate students only and GEOL 2001 or GEOL 2700 and at least one of the following: GEOL 3120 or GEOL 3320 or GEOL 3430.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Graduate Course



**GEOL 5719 (2) Field Analysis and Tectonics of Crystalline Rocks**

Introduces basic and advanced mapping tools and concepts for structural and tectonic analysis of solid-state and magmatic deformation, metamorphism, and fluid flow in igneous and metamorphic rocks. Includes some digital mapping concepts using smartpad and smartphone applications, and computer-based analysis of structure data. Includes multi-day mapping projects in the Front Range, and in western Colorado, southern Wyoming, or northern New Mexico. Also includes introductions to Precambrian tectonic history of western North America and mineral resources of Colorado.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4719

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**GEOL 5721 (2) Classics and Frontiers in Hydrology**

The first part of this course studies classic papers in hydrology that include development of fundamental concepts and governing principles governing water flow in subsurface. It will also include benchmark papers that define critical advances in hydrology. The second part of this course focuses on latest research front that spans from theoretical and modeling studies to measuring and monitoring technologies.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**GEOL 5725 (1-4) Field Based Special Topics in Geoscience**

Explores selected geological subjects of special interest in a field setting.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4725

**Repeatable:** Repeatable for up to 8.00 total credit hours. Allows multiple enrollment in term.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5747 (3) Unconventional Resources**

To introduce the concepts, principles, methods, and techniques of unconventional reservoirs. Unconventional reservoirs can be defined informally as those reservoirs that need artificial stimulation to produce. Accumulations in conventional traps are due to buoyancy. Seven common kinds of unconventional reservoirs: tight-gas sandstones, shale gas, shale oil, coal-bed methane, heavy-oil sands, oil shale, gas hydrates. Formerly offered as a special topics course.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4747

**GEOL 5755 (2) Field Geobiology**

Provides students technical fieldwork skills in the interdisciplinary field of geobiology, spanning modern environments and to ancient environments in preserved in rock record, and spanning techniques from geochemistry, environmental microbiology, and sedimentology. Formerly offered as a special topics course.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4755

**Repeatable:** Repeatable for up to 8.00 total credit hours.

**GEOL 5775 (3) Introduction to Numerical Modeling in Geoscience**

Numerical models play an essential role across the geosciences, with applications that include hypothesis exploration, data interpretation, and prediction. This course provides a hands-on introduction to numerical modeling. Students learn scientific programming and modeling concepts by iterating through a series of model-development assignments in Python and Matlab. Applications span a range of topics in the geosciences, with emphasis on physical processes that involve mass, energy, and/or momentum transport.

**GEOL 5800 (3) Planetary Surfaces and Interiors**

Examines processes operating on the surfaces of solid planets and in their interiors. Emphasizes spacecraft observations, their interpretation, the relationship to similar processes on Earth, the relationship between planetary surfaces and interiors and the integrated geologic histories of the terrestrial planets and satellites.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 5800

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5820 (3) Origin and Evolution of Planetary Systems**

Considers the origin and evolution of planetary systems, including proto-planetary disks, condensation in the solar nebula, composition of meteorites, planetary accretion, comets, asteroids, planetary rings and extrasolar planets. Applies celestial mechanics to the dynamical evolution of solar system bodies.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 5820

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5830 (3) Topics in Planetary Science**

Examines current topics in planetary science, based on recent discoveries, spacecraft observations and other developments. Focuses on a specific topic each time the course is offered, such as Mars, Venus, Galilean satellites, exobiology, comets or extrasolar planets. Department enforced prerequisite: restricted to graduate students in the physical sciences.

**Equivalent - Duplicate Degree Credit Not Granted:** ATOC 5830 and ASTR 5830

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5833 (3) Teaching and Learning Earth Systems**

Learn and develop pedagogically effective strategies for teaching and understanding Earth Science concepts. Particular emphasis is placed on understanding the importance of geoscience habits of mind (i.e. spatial/temporal reasoning, multiple working hypotheses, geographic context). The course focuses upon inquiry and evaluation of evidence, the importance of background knowledge and misconceptions and developing effective discourse within and outside the classroom.

**Equivalent - Duplicate Degree Credit Not Granted:** EDUC 4833 and GEOL 4833 and EDUC 5833

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**GEOL 5835 (1) Seminar in Planetary Science**

Studies current research on a topic in planetary science. Students and faculty give presentations. Subjects may vary each semester. Department enforced prerequisite: senior level undergraduate physics.

**Equivalent - Duplicate Degree Credit Not Granted:** ATOC 5835 and ASTR 5835

**Repeatable:** Repeatable for up to 4.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5840 (1-3) Independent Study-Quaternary Geology**

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5841 (1-3) Independent Study-Economic Geology**

**Repeatable:** Repeatable for up to 7.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 5842 (1-3) Independent Study-Petrology****Repeatable:** Repeatable for up to 7.00 total credit hours.**Requisites:** Restricted to graduate students only.**Additional Information:** Departmental Category: Graduate Course**GEOL 5843 (1-3) Independent Study-Sedimentology****Repeatable:** Repeatable for up to 7.00 total credit hours.**Requisites:** Restricted to graduate students only.**Additional Information:** Departmental Category: Graduate Course**GEOL 5844 (1-3) Independent Study-Structure/Tectonics****Repeatable:** Repeatable for up to 7.00 total credit hours.**Requisites:** Restricted to graduate students only.**Additional Information:** Departmental Category: Graduate Course**GEOL 5845 (1-3) Independent Study-Geochemistry****Repeatable:** Repeatable for up to 7.00 total credit hours.**Requisites:** Restricted to graduate students only.**Additional Information:** Departmental Category: Graduate Course**GEOL 5846 (1-3) Independent Study-Geophysics****Repeatable:** Repeatable for up to 7.00 total credit hours.**Requisites:** Restricted to graduate students only.**Additional Information:** Departmental Category: Graduate Course**GEOL 5847 (1-3) Independent Study-Hydrology****Repeatable:** Repeatable for up to 7.00 total credit hours.**Requisites:** Restricted to graduate students only.**Additional Information:** Departmental Category: Graduate Course**GEOL 5849 (1-3) Independent Study-Paleontology****Repeatable:** Repeatable for up to 7.00 total credit hours.**Additional Information:** Departmental Category: Graduate Course**GEOL 5851 (1-3) Independent Study-Sediment Petrology****Repeatable:** Repeatable for up to 7.00 total credit hours.**Additional Information:** Departmental Category: Graduate Course**GEOL 5852 (1-3) Independent Study--GIS Applications in Quaternary Geosciences**

Leads students through quantitative spatial analysis of environmental and paleoclimatic problems. Each student will develop a project from start to finish, with emphasis on raster GIS for building large empirical databases that bear on process and variability.

**Additional Information:** Departmental Category: Graduate Course**GEOL 5862 (1-4) Geology Independent Study**

Students may not enroll in this course without completing the Independent Study Contract.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 4862**Repeatable:** Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.**GEOL 5910 (3) Geothermodynamics**

Provides a solid foundation in chemical thermodynamic concepts and calculations as applied to geochemistry and geobiology.

**GEOL 6050 (3) Space Instrumentation**

Provides an overview of the relevant space environment and process, the types of instruments flown on recent mission and the science background of the measurement principles.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 6050 and ASEN 6050**Grading Basis:** Letter Grade**Additional Information:** Departmental Category: Graduate Course**GEOL 6060 (4) Petroleum Geology of Turbidite Systems**

Covers the exploration and production aspects of petroleum submarine fans and turbidite systems.

**Requisites:** Requires prerequisite course of GEOL 6330 (minimum grade B).**Additional Information:** Departmental Category: Graduate Course**GEOL 6310 (3) Sedimentary Petrology**

Covers interpretation of depositional and diagenetic history of sedimentary rocks as determined from thin-section studies. Department enforced prerequisites: GEOL 3010 and GEOL 3020 and GEOL 3430 or equivalents.

**Additional Information:** Departmental Category: Graduate Course**GEOL 6330 (4) Applied Sequence Stratigraphy and Basin Analysis**

Develops skills in the stratigraphic interpretation of seismic reflection data, recognition of sequence stratigraphy in well logs and outcrop and their applications to basin analysis in petroleum exploration.

Department enforced prerequisite: restricted to graduate students only and introductory undergraduate physics and sedimentology/stratigraphy.

**Additional Information:** Departmental Category: Graduate Course**GEOL 6610 (3) Earth and Planetary Physics 1**

Examines mechanics of deformable materials, with applications to earthquake processes. Introduces seismic wave theory. Other topics include inversion of seismic data for the structure, composition and state of the interior of the Earth.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 6610 and PHYS 6610**Additional Information:** Departmental Category: Graduate Course**GEOL 6620 (3) Earth and Planetary Physics 2**

Covers space and surface geodetic techniques as well as potential theory. Other topics are the definition and geophysical interpretation of the geoid and of surface gravity anomalies; isostasy; post-glacial rebound; and tides and the rotation of the Earth.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 6620 and PHYS 6620**Requisites:** Restricted to graduate students only.**Additional Information:** Departmental Category: Graduate Course**GEOL 6630 (3) Earth and Planetary Physics 3**

Examines the solar system, emphasizing theories of its origin and meteorites. Highlights distribution of radioactive materials, age dating, heat flow through continents and the ocean floor, internal temperature distribution in the Earth, and mantle convection. Also covers the origin of the oceans and atmosphere.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 6630 and PHYS 6630**Additional Information:** Departmental Category: Graduate Course**GEOL 6650 (1-3) Seminar in Geophysics**

Advanced seminar studies in geophysical subjects for graduate students.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 6650 and PHYS 6650**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.**Additional Information:** Departmental Category: Graduate Course**GEOL 6655 (3) InSAR Processing and Interpretation**

Understand the concepts and applications of interferometric synthetic aperture radar (InSAR) and differential InSAR, to include an introduction to physical geodesy and satellite techniques.

**Equivalent - Duplicate Degree Credit Not Granted:** PHYS 6655**Grading Basis:** Letter Grade

**GEOL 6670 (2) Geophysical Inverse Theory**

Principles of geophysical inverse theory as applied to problems in the Earth sciences, including topography, Earth structure and earthquake locations. Department enforced prerequisites: a course in calculus and a course in computer programming (any language).

**Equivalent - Duplicate Degree Credit Not Granted:** PHYS 6670

**Additional Information:** Departmental Category: Graduate Course

**GEOL 6940 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 6950 (1-6) Master's Thesis**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 6960 (1-3) Plan II Master's Research**

The Plan II program requires at least 3 credit hours of GEOL 6960 (Plan II Master's Research) under the supervision of the advisory committee.

**Additional Information:** Departmental Category: Graduate Course

**GEOL 8990 (1-10) Doctoral Dissertation**

All doctoral students must register for not fewer than 30 hours of dissertation credit as part of the requirements for the degree. For a detailed discussion of doctoral dissertation credit, refer to the Graduate School section.

**Repeatable:** Repeatable for up to 30.00 total credit hours.

**Additional Information:** Departmental Category: Graduate Course