THE UNIVERSITY OF CHICAGO
DEPARTMENT OF GEOPHYSICAL SCIENCES
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2021-2021 Proposed Course Offerings:

The following are the course options proposed by the Department of Geophysical Sciences for the 2021-2022 Academic Year. Classes with separate lab sessions are denoted [Lab]. This list is current as of 4/19/21. Course listings subject to change.

Autumn 2021

GEOS 13100. Physical Geology. [Lab]
100 Units. Instructor(s): D. Rowley.
This course introduces plate tectonics; the geologic cycle; and the internal and surface processes that make minerals and rocks, as well as that shape the scenery. Topics include: planetary geophysics; evidence leading to the theory of plate tectonics; natural hazards including earthquakes and volcanoes; economic geology including energy resources, ores, and mineral resources; crustal deformation and mountain building; and surface processes (erosion, groundwater). Laboratory exercises introduce identifying features of rocks and minerals and interpreting geological maps. Biweekly writing assignments explore topics in geology that are supplemental to the lecture material.

GEOS 13410/PHSC13410. Global Warming: Understanding the Forecast. (Flipped Class)
100 Units. Instructor(s): D. Abbot
This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; predictions and reliability of climate model forecasts of the greenhouse world. This course is part of the College Course Cluster program, Climate Change, Culture, and Society. This course covers the same material as PHSC 13400, but is organized using a flipped classroom approach in order to increase student engagement and learning.
Prerequisite(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): ENSC 13410, ENST 13410

GEOS 21000/31000. Mineralogy. [Lab]
100 Units. Instructor(s): A. Campbell
This course covers structure, chemical composition, stability, and occurrence of major rock-forming minerals. Labs concentrate on mineral identification with the optical microscope.
Prerequisite(s): CHEM 11100-11200-11300 or equivalent

GEOS 21900. Introduction to Structural Geology. [Lab]
100 Units. Instructor(s): D. Rowley
This course explores the deformation of the Earth materials primarily as observed in the crust. We emphasize stress and strain and their relationship to incremental and finite deformation in crustal rocks, as well as techniques for inferring paleostress and strain in deformed crustal rocks. We also look at mesoscale to macroscale structures and basic techniques of field geology in deformed regions.
Prerequisite(s): GEOS 13100.

GEOS 22200/32200. Geochronology. [Lab]
100 Units. Instructor(s): N. Dauphas
This course covers the duration of planetary differentiation and the age of the Earth (i.e., extinct and extant chronometers); timescales for building a habitable planet (i.e., the late heavy bombardment, the origin of the atmosphere, the emergence of life, and continent extraction); dating mountains (i.e., absolute ages, exposure ages, and thermochronology); the climate record (i.e., dating layers in sediments and ice cores); and dating recent artifacts (e.g., the Shroud of Turin).
Prerequisite(s): Background in college-level geology, physics, and mathematics.

GEOS 22600/32600. Topics in Earth Science: The Accretion of Extraterrestrial Matter Throughout Earth's History.
100 Units. Instructor(s): P. Heck
This course will provide a discussion of the nature and variability of extraterrestrial (ET) matter accreted throughout Earth's history that is preserved in the geological record. This record is a rich archive of ET matter whose study not only provides unique insight into the origin and evolution of different Solar System objects but also enables a better understanding of delivery mechanisms. The course will highlight periods of dramatically increased accretion rates and important impact events. This includes events such as the recent Chelyabinsk and Tunguska air blasts, the "global killer" Chicxulub impact 66 Ma ago, the Ordovician meteorite showers, all the way to cataclysmic events that occurred on early Earth. The course will also provide an introduction to related key techniques such as classification with material from the meteorite collection, the identification of impact craters, and the use of tracers of ET material in the geological record.
Prerequisite(s):

GEOS 23900/33900. Environmental Chemistry.
100 Units. Instructor(s): D. Archer
The focus of this course is the fundamental science underlying issues of local and regional scale pollution. In particular, the lifetimes of important pollutants in the air, water, and soils are examined by considering the roles played by photochemistry, surface chemistry, biological processes, and dispersal into the surrounding environment. Specific topics include urban air quality, water quality, long-lived organic toxins, heavy metals, and indoor air pollution. Control measures are also considered. This course is part of the College Course Cluster program: Climate Change, Culture, and Society.
Prerequisite(s): CHEM 11101-11201 or equivalent, and prior calculus course
Equivalent Course(s): ENST 23900, ENSC 23900

GEOS 24220/34220. Climate Foundations. [Lab]
100 Units. Instructor(s): E. Moyer
This course introduces the basic physics governing the climate of planets, the Earth in particular but with some consideration of other planets. Topics include atmospheric thermodynamics of wet and dry atmospheres, the hydrological cycle, blackbody radiation, molecular absorption in the atmosphere, the basic principles of radiation balance, and diurnal and seasonal cycles. Students solve problems of increasing complexity, moving from pencil-and-paper problems to programming exercises, to determine surface and atmospheric temperatures and how they evolve. An introduction to scientific programming is

provided, but the fluid dynamics of planetary flows is not covered. This course is part of the College Course Cluster program: Climate Change, Culture and Society.
Prerequisite(s): Prior physics course (preferably PHYS 13300 and 14300) and knowledge of calculus required; prior geophysical sciences course not required.
Note(s): Prior programming experience helpful but not required.

GEOS 24230/34230. Geophysical Fluid Dynamics: Foundations.
100 Units. Instructor(s): D. MacAyeal
This course is for incoming graduate students in physical sciences intending to take further courses in geophysical fluid dynamics, fluid dynamics, condensed matter physics, and other areas requiring this fundamental skill set. It sets the stage for follow-on courses that present the detail of the behavior of fluids and continuums in geophysical, physical, chemical, and other settings. The material may be a student's first contact with continuum mechanics or a remedial or review for students who have previously taken similar courses. Topics include description of material properties in a continuum, including displacement, velocity, and strain rate; scalar, vector, and tensor properties of continuums, strain, strain rate, and stress; derivations and understanding of mass, momentum, and energy conservation principles in a continuum; applications of conservation principles to simple rheological idealizations, including ideal fluids and potential flow, viscous fluids and Navier-Stokes flow, elasticity and deformation; introductory asymptotic analysis, Reynolds number; heat transfer by conduction and convection, convective instability, Rayleigh number; fluids in gravitational fields, stratification, buoyancy; elliptic, parabolic, and hyperbolic partial differential equations, typical properties of each.
Prerequisite(s): Vector calculus, linear algebra, advanced classical mechanics, basic knowledge of computing. Undergrads who take this course should intend to complete a second fluid-dynamics course in Geophysical Sciences.

GEOS 26300/36300. Invertebrate Paleobiology and Evolution. [Lab]
100 Units. Instructor(s): M. Webster
This course provides a detailed overview of the morphology, paleobiology, evolutionary history, and practical uses of the invertebrate and microfossil groups commonly found in the fossil record. Emphasis is placed on understanding key anatomical and ecological innovations within each group and interactions among groups responsible for producing the observed changes in diversity, dominance, and ecological community structure through evolutionary time. Labs supplement lecture material with specimen-based and practical application sections. An optional field trip offers experience in the collection of specimens and raw paleontological data. Several "Hot Topics" lectures introduce important, exciting, and often controversial aspects of current paleontological research linked to particular invertebrate groups.
Prerequisite(s): GEOS 13100 and 13200, or equivalent. Students majoring in Biological Sciences only: completion of the general education requirement in the Biological Sciences, or consent of instructor.
Equivalent course(s): BIOS 23261, EVOL 32400

GEOS 26650/36650. Environmental Microbiology.
100 Units. Instructor(s): M. Coleman
The objective of this course is to understand how microorganisms alter the geochemistry of their environment. The course will cover fundamental principles of microbial growth, metabolism, genetics, diversity, and ecology, as well as methods used to study microbial communities and activities. It will emphasize microbial roles in elemental cycling, bioremediation, climate, and ecosystem health in a variety of environments including aquatic, soil, sediment, and engineered systems.
Prerequisite(s): CHEM 11100-11200 and BIOS 20186 or BIOS 20197 or BIOS 20198.
Equivalent course(s): ENSC 24500

GEOS 28300/38300. Principles of Stratigraphy.
100 Units. Instructor(s): S. Kidwell
This course introduces principles and methods of stratigraphy. Topics include facies analysis, physical and biostratigraphic correlation, and development and calibration of the geologic time scale. We also discuss controversies concerning the completeness of the stratigraphic record; origin of sedimentary cycles; and interactions between global sea level, tectonics, and sediment supply.
Prerequisite(s): GEOS 13100-13200 or equivalent required; GEOS 23500 and/or 28200 recommended

GEOS 30200. Introduction to Research in the Geophysical Sciences.
100 Units. Instructor(s): C. Blättler
This course is mandatory for all incoming graduate students in the department. Its purpose is to introduce the faculty's current research themes/areas and to familiarize incoming graduate students with research areas they might contemplate for further specialization. Lectures are presented by individual faculty on either 1) a general survey of a research area, or 2) a specialized topic of interest. Student activity varies from year to year and is based on a combination of oral and written presentations.

GEOS 32300. Cosmochemistry.
100 Units. Instructor(s): A. Davis
Chemical, mineralogical, and petrographic classifications of meteorites. Topics include: abundances of the elements, origin of the elements and stellar evolution, the interstellar medium and formation of the solar nebula, condensation of the solar system, chemical fractionations in meteorites and planets, age of the solar system, extinct radionuclides in meteorites, isotope anomalies.

GEOS 33825. Topics in Microbial Biogeochemistry.
100 Units. Instructor(s): M. Coleman
In this seminar we explore the role of microorganisms in biogeochemical cycles. Topics include microbial metabolism, physiology, ecology and evolution in natural habitats, responses to short- and long-term climate change, and coevolution of life and its environment over Earth history. Can be taken multiple times for credit since the specific topic will change each quarter.

GEOS 33850. Low Temperature Geochemistry.
100 Units. Instructor(s): C. Blättler
This course covers topics related to the geochemistry of Earth's surface, including all its fluid and solid components. Specific emphasis will be placed on stable isotopic tools for understanding modern Earth system processes and the ancient geological record. Seminar format will allow students to choose topics of interest to them and shape the reading and discussion content of the course.
Equivalent course(s): ENSC 33850.

GEOS 34530. Turbulence and Transport Processes in the Atmosphere and Oceans.
100 Units. Instructor(s): M. Jansen
The atmosphere and oceans exhibit non-linear turbulent motions on a wide range of scales. Yet introductory classes in atmosphere and ocean dynamics focus almost exclusively on linear theories. While there is undoubtedly much to learn from linear theory, statistical descriptions of turbulent flows provide a valuable perspective from a different angle. In this advanced graduate course we will discuss the theory of 3-dimensional, 2-dimensional and quasi-geostrophic turbulence, as well as the role of turbulent motions for the transport of properties in the atmosphere and ocean. We will also discuss the wave-turbulence crossover, and eddy-mean-flow interactions, thus connecting back to linear theories. The format of the course will be a mixture of lectures and student-led paper discussions.
Prerequisite(s): GEOS 24230 and GEOS 24240 or equivalent; Knowledge of mechanics (PHYS 13100 or equivalent), vector calculus and linear algebra (MATH 20000-20100-20200 or equivalent). Knowledge of the basics of statistics/stochastics is also expected.

GEOS 36050. Models of Morphological Evolution.
100 Units. Instructor(s): G. Slater
Over the past 30 years the study of morphological evolution, from inference of evolutionary process to understanding correlated trait changes, has increasingly relied on phylogenetic approaches. This is due to the realization that species may exhibit similar traits due to shared evolutionary history as much as due to similar adaptive responses to other factors. The field of phylogenetic comparative methods is rapidly expanding. This graduate course will cover basic and advanced models of morphological character evolution that underlie comparative methods, as well as the statistical models themselves. Topics covered in this class will span: Brownian motion as a model of quantitative trait evolution; Independent contrasts and evolutionary regressions; Measuring phylogenetic signal; Alternative models of quantitative trait evolution - early bursts, Ornstein-Uhlenbeck processes, and multivariate data; Discrete traits, Markov processes and the threshold model; Phylogenetic analogues of traditional comparative methods (e.g., ANOVA, PCA). Lectures will cover theory behind concepts but students will also be expected to bring laptops to class so as to write code to simulate data and fit statistical models. All coding will be done in the R statistical language.

GEOS 36900. Topics in Paleobiology.
100 Units. Instructor(s): D. Jablonski, S. Kidwell
In this seminar we investigate paleobiological or multidisciplinary topics of current interest to students and faculty. Previous subjects include the origin of phyla, historical and macro-ecology, the stratigraphic record and evolutionary patterns, and climate and evolution.
Equivalent Course(s): EVOL 31900, ECEV 36900

PHSC 10800: Earth as a Planet: Exploring Our Place in the Universe. [Lab]
100 Units. Instructor(s): F. Ciesla
This course explores the diversity of bodies in our Solar System, and the physical and chemical processes that have shaped them over their histories. We will also discuss how these studies have carried us away from an Earth-centered view of the universe to one where Earth is just one of billions of planets that exist in our galaxy. Topics to be covered include: early observations of the Solar System and the laws of planetary motion, the formation and evolution of the Moon, the structure and geophysical evolution of the planets, and the search for habitable environments outside of Earth.

Winter 2022

GEOS 13200. Earth History. [Lab]
100 Units. Instructor(s): M. Foote.
This courses covers principles of historical inference in Earth science; the physical, chemical, and biological data that are used to reconstruct Earth history; and the geographic, biotic, and environmental development of Earth. Weekly labs focus on observation and interpretation of sedimentary rocks and fossil assemblages in hand samples. A required one-day field trip introduces students to observation and interpretation of sedimentary rocks at the outcrop scale.
Prerequisite(s): GEOS 13100.

GEOS 13900. Biological Evolution.
100 Units. Instructor(s): D. Jablonski.
This course is an introduction to evolutionary processes and patterns in present-day organisms and in the fossil record and how they are shaped by biological and physical forces. Topics emphasize evolutionary

principles. They include DNA and the genetic code, the genetics of populations, the origins of species, and evolution above the species level. We also discuss major events in the history of life, such as the origin of complex cells, invasion of land, and mass extinction. Due to significant overlap of course content, students may register for only one of PHSC 11000, BIOS 12117, or GEOS 13900/BIOS 13123. Students using this course for credit in the GEOS or ENSC major register for GEOS 27300; additional work, including a term paper, will be required. This course is part of the College Course Cluster program: Climate Change, Culture and Society.
Prerequisite(s): BIOS 10130; no Biological Sciences majors except by petition to BSCD Senior Advisers.
Equivalent Course(s): BIOS 13123

GEOS 21205/31205. Introduction to Seismology, Earthquakes, and Near-Surface Earth Seismicity.
100 Units. Instructor(s): D. Heinz
This course introduces the mechanics and phenomenology of elastic waves in the Earth and in the fluids near the Earth's surface (e.g., S and P waves in the solid earth, acoustic waves in the ocean and atmosphere). Topics include stress and strain, constitutive equations, elasticity, seismic waves, acoustic waves, theory of refraction/reflection, surface waves, dispersion, and normal modes of the Earth. Phenomenology addressed includes exploration geophysics (refraction/reflection seismology), earthquakes and earthquake source characterization, seismograms as signals, seismometers and seismological networks, and digital seismogram analysis.

GEOS 22060/32060. What Makes a Planet Habitable?
100 Units. Instructor(s): E. Kite.
This course explores the factors that determine how habitable planets form and evolve. We will discuss a range of topics, from the accretion and loss of atmospheres and oceans, to the long-term carbon cycle, climate dynamics, and the conditions that sustain liquid water on a planet's surface over timescales relevant to the origin and evolution of life. Students will be responsible for reading and discussing papers in peer-reviewed journals each meeting, periodically preparing presentations and leading the discussion. This course is part of the College Course Cluster program: Climate Change, Culture and Society.
Equivalent Course(s): ASTR 45900

GEOS 23205/32305. Introductory Glaciology.
100 Units. Instructor(s): D. MacAyeal
The fundamentals of glacier and ice-sheet dynamics and phenomenology will be covered in this introductory course (snow and sea ice will be excluded from this course, however may be taken up in the future). Emphasis will be placed on developing the foundation of continuum mechanics and viscous fluid flow as a means of developing the basic equations of glacier deformation, ice-sheet and -shelf flow, basal processes, glacier hydrology, and unstable modes of flow. This course is intended for advanced undergraduate students in physics, math, geophysical sciences, and related fields as well as graduate students considering research in glaciology and climate dynamics. This course is part of the College Course Cluster program: Climate Change, Culture, and Society.
Prerequisite(s): Knowledge of vector calculus, linear algebra, and computer programming.

GEOS 24240/34240. Geophysical Fluid Dynamics: Rotation and Stratification.
100 Units. Instructor(s): T. Shaw
This course is an introduction to geophysical fluid dynamics for upper-level undergraduates and starting graduate students. The topics covered will be the equations of motion, the effects of rotation and stratification, shallow water systems and isentropic coordinates, vorticity and potential vorticity, and simplified equations for the ocean and atmosphere.
Prerequisite(s): PQ: GEOS 24230 or equivalent; Knowledge of mechanics (PHYS 13100 or equivalent), thermodynamics (PHYS 19700 or equivalent), vector calculus and linear algebra (MATH 20000-20100-

20200 or equivalent)

GEOS 24300/34300. Paleoclimatology.
100 Units. Instructor(s): D. Archer
This class will cover the theory and reconstruction of the evolution of Earth's climate through geologic time. After reviewing fundamental principles that control Earth's climate, the class will consider aspects of the climate reconstructions that need to be explained theoretically, such as the faint young sun paradox, snowball Earth episodes, Pleistocene glacial / interglacial cycles, and long-term Cenozoic cooling. Then we will switch to a temporal point of view, the history of Earth's climate as driven by plate tectonics and biological evolution, and punctuated by mass extinctions. This will allow us to place the theoretical ideas from the first part of the class into the context of time and biological progressive evolution.
Prerequisite(s): one quarter of chemistry

GEOS 25400/35400. Introduction to Numerical Techniques for Geophyiscal Sciences.
100 Units. Instructor(s): F. Ciesla
This course provides an introduction to different types of numerical techniques used in developing models used in geophysical science research. Topics will include how to interpolate and extrapolate functions, develop functional fits to data, integrate a function, or solve partial differential equations. Students are expected to have some familiarity with computers and programming—programming methods will not be discussed in detail. While techniques will be the focus of the course, we will also discuss the planning needed in developing a model as well as the limitations inherent in such models.

GEOS 27300. Biological Evolution - Advanced.
100 Units. Instructor(s): D. Jablonski
This course is an introduction to evolutionary processes and patterns in present-day organisms and in the fossil record and how they are shaped by biological and physical forces. Topics emphasize evolutionary principles. They include DNA and the genetic code, the genetics of populations, the origins of species, and evolution above the species level. We also discuss major events in the history of life, such as the origin of complex cells, invasion of land, and mass extinction. Aimed at Geophysical Sciences and Environmental Science majors, this course differs from GEOS 13900 in requiring a term paper, topic chosen from a list provided by the instructor.
Prerequisite(s): BIOS 10130. No Biological Science majors except by petition to the BSCD Senior Advisers.

GEOS 36000. Morphometrics. [Lab]
100 Units. Instructor(s): M. Webster
This graduate-level course serves as an introduction to the field of morphometrics (the analysis of organismal shape). Quantitative exploratory and confirmatory techniques involving both traditional (length-based) and geometric (landmark-based) summaries of organismal shape are introduced in a series of lectures and practical exercises. Emphasis is placed on the application of morphometric methods to issues such as (but not restricted to) quantification of intraspecific variability, interspecific differences, disparity, ontogenetic growth patterns (allometry), and phylogenetic changes in morphology. Relevant statistical and algebraic operations are explained assuming no prior background. Students are required to bring personal laptop computers, and are expected to acquire and analyze their own data sets during the course.
Equivalent course(s): EVOL 36700

GEOS 36900. Topics in Paleobiology.
100 Units. Instructor(s): G. Slater

In this seminar we investigate paleobiological or multidisciplinary topics of current interest to students and faculty. Previous subjects include the origin of phyla, historical and macro-ecology, the stratigraphic record and evolutionary patterns, and climate and evolution.
Equivalent Course(s): EVOL 31900, ECEV 36900

PHSC 10100. Origin and Evolution of the Solar System and the Earth. [Lab]

100 Units. Instructor(s): A. Davis
This course examines the physical and chemical origins of planetary systems, the role of meteorite studies in this context, and a comparison of the Earth with neighboring planets. It then turns to chemical and physical processes that lead to internal differentiation of the Earth. Further topics include the thermal balance at the Earth's surface (glaciation and the greenhouse effect), and the role of liquid water in controlling crustal geology and evolution.
Class Notes & Prerequisites: *Registration priority for first- and second-year students and first-year transfers. This course includes a lab section. Day/time of lab sections TBA.*
Under no circumstances may a student receive credit for both PHSC 10100 and PHSC 10800.

PHSC 13600. Natural Hazards. [Lab]
100 Units. Instructor(s): N. Nakamura
This course presents the current understanding of high-impact weather and geologic events and an introduction to risk assessment and mitigation. Topics include an overview of geography, statistics, and societal impacts of the world's natural hazards; physics and forecasts of hurricanes, extratropical cyclones, tornadoes, earthquakes, tsunamis, volcanic eruptions, droughts, floods, wildfires, and landslides; climate change and weather events; quantifying risks; and successful examples of community- and national-level disaster prevention programs.

Spring 2022

GEOS 13300. The Atmosphere.
100 Units. Instructor(s): T. Shaw
This course introduces the physics, chemistry, and phenomenology of the Earth's atmosphere, with an emphasis on the fundamental science that underlies atmospheric behavior and climate. Topics include (1) atmospheric composition, evolution, and structure; (2) solar and terrestrial radiation in the atmospheric energy balance; (3) the role of water in determining atmospheric structure; and (4) wind systems, including the global circulation, and weather systems.
Prerequisite(s): MATH 13100-MATH 13200.
Equivalent Course(s): ENST 13300, ENSC 13300

GEOS 13410/PHSC 13410. Global Warming: Understanding the Forecast (Flipped Class).
100 Units. Instructor(s): D. Abbot
This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; an overview of the carbon cycle in its role as a global thermostat; predictions and reliability of climate model forecasts of the greenhouse world. This course is part of the College Course Cluster program Climate Change, Culture, and Society. This course covers the same material as PHSC 13400, but is organized

using a flipped classroom approach in order to increase student engagement and learning.
Prerequisite(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): ENSC 13410, ENST 1230, PHSC 13400

GEOS 21100. Introduction to Petrology. [Lab]
100 Units. Instructor(s): N. Dauphas
Students in this course learn how to interpret observable geological associations, structures, textures, and mineralogical and chemical compositions of rocks so as to develop concepts of how they form and evolve. Our theme is the origin of granitic continental crust on the only planet known to have oceans and life. Igneous, sedimentary, and metamorphic rocks; ores; and waste disposal sites are reviewed.
Prerequisite(s): GEOS 21000 is strongly recommended. This course includes a lab, time to be determined.

GEOS 21200/31200. Physics of the Earth.
100 Units. Instructor(s): D. Heinz
This course considers geophysical evidence bearing on the internal makeup and dynamical behavior of the Earth, including seismology (i.e., properties of elastic waves and their interpretation, and internal structure of the Earth); mechanics of rock deformation (i.e., elastic properties, creep and flow of rocks, faulting, earthquakes); gravity (i.e., geoid, isostasy); geomagnetism (i.e., magnetic properties of rocks and history, origin of the magnetic field); heat flow (i.e., temperature within the Earth, sources of heat, thermal history of the Earth); and plate tectonics and the maintenance of plate motions.
Prerequisite(s): Prior calculus and college-level physics courses, or consent of instructor.

GEOS 23800/33800. Global Biogeochemical Cycles.
100 Units. Instructor(s): J. Waldbauer
This survey course covers the geochemistry of the surface of the Earth, focusing on biological and geological processes that shape the distributions of chemical species ,in the atmosphere, oceans and terrestrial habitats. Budgets and cycles of carbon, nitrogen, oxygen, phosphorous, and sulfur are discussed, as well as chemical fundamentals of metabolism, weathering, acid-base and dissolution equilibria, and isotopic fractionation. The course examines the central role that life plays in maintaining the chemical disequilibira that characterize Earth's surface environments. The course also explores biogeochemical cycles change (or resist change) over time, as well as the relationships between geochemistry, biological (including human) activity, and Earth's climate.
Prerequisite(s): CHEM 11100-11200 or consent of instructor
Equivalent course(s): ENSC 23800

GEOS 24250. Geophysical Fluid Dynamics: Understanding the Motions of the Atmosphere and Oceans.
100 Units. Instructor(s): N. Nakamura
This course is part of the atmospheres and oceans sequence (GEOS 24220, 24230, 24240, 24250) and is expected to follow Geophysical Fluid Dynamics: Rotation and Stratification (GEOS 24240). The course demonstrates how the fundamental principles of geophysical fluid dynamics are manifested in the large-scale circulation of the atmosphere and oceans and their laboratory analogs. Topics include: balance of forces and the observed structure of the atmospheric and oceanic circulations, statistical description of the spatially and temporally varying circulation, theory of Hadley circulation, waves in the atmosphere and oceans, baroclinic instability, wind-driven ocean circulation.
Prerequisite(s): GEOS 24230 and 24240, or consent of the instructor. Knowledge of vector calculus, linear algebra, and ordinary differential equations is assumed.
Equivalent Course(s): GEOS 34250

GEOS 24550/34550. Ocean Circulation.
100 Units. Instructor(s): M. Jansen
In this course we discuss the dynamics of the global-scale ocean circulation, which plays an important role in the climate system via the transport and storage of heat and carbon. Topics include the wind-driven ocean gyres, the ocean's thermocline, the turbulent Antarctic Circumpolar Current as a critical connector of the major ocean basins, as well as the meridional overturning circulation. The course aims to promote a fundamental understanding of ocean dynamics, rather than a purely empirical treatment, and hence builds on the fluid dynamical equations that govern the oceanic motions. The structure of the course includes a combination of lectures, in-class exercises, and discussion of material read by the students at home. The course is suitable for graduate students and upper-level undergraduates.
Prerequisite(s): GEOS 24230/34230 and GEOS 24240/34240, or consent of instructor. Knowledge of vector calculus, linear algebra, and ordinary differential equations is assumed.

GEOS 28600. Earth and Planetary Surface Processes.
100 Units. Instructor(s): E. Kite
The focus of this course is geomorphology, both of the Earth and other planets. Moving from the controls on planetary-scale topography down to the scale of individual streams and hillslopes, the course will emphasize fluvial and aeolian sediment transport, and landscape evolution.

GEOS 35100. Data Analysis for the Geophysical Sciences.
100 Units. Instructor(s): M. Foote
A graduate-level introduction to probability, modeling, and data analysis. Though some emphasis is given to paleontological problems, the goal is to keep approaches sufficiently general that they should be relevant to students across the geophysical sciences as well as evolutionary biology. Required work includes coding exercises and a term project based on original research.

GEOS 36800. Macroevolution.
100 Units. Instructor(s): D. Jablonski
Patterns and processes of evolution above the species level, in both recent and fossil organism. A survey of the current literature, along with case studies.
Equivalent Course(s): EVOL 31700

GEOS 38400. Topics in Stratigraphy and Biosedimentology.
100 Units. Instructor(s): S. Kidwell
Seminar course using the primary literature and/or a field problem. Topic selected from the rapidly evolving fields of sequence stratigraphy, basin analysis, and animal sediment relationships.
Equivalent course(s): EVOL 41500

PHSC 11000. Environmental History of the Earth. [Lab]
100 Units. Instructor(s): M. Webster
This course considers how physical and biological processes determine environmental conditions at the surface of the Earth, and how environments have changed over the 4.5 billion-year history of Earth. Topics include the methods of historical inference in geology; major transitions in the history of life, including the origin of life, the evolution of oxygen-producing photosynthesis, the origin of animals, and the series of massive extinctions that have repeatedly re-set ecosystems both on land and in the sea; and ecosystem evolution, including the environmental effects of human evolution. Labs involve hands-on study of rock and fossil specimens, and analysis and interpretation of datasets drawn from the scientific literature and/or faculty research programs.
Prerequisite(s): Due to significant overlap in course content, students may register for only one of PHSC 11000, BIOS 12117 or GEOS13900/BIOS 13123

Field Courses and Independent Study

GEOS 29001/39001. Field Course in Geology.
100 Units. Instructor(s): S. Kidwell
Students visit classic locations to examine a wide variety of geological environments and processes and to learn basic field skills; themes include tectonics and sedimentation, basin-scale paleogeography, and geomorphology. Course meets weekly in Winter Quarter prior to a Spring Break field trip; interested students should contact an instructor in advance.
Prerequisite(s): GEOS 13100-13200 and consent of instructor
Equivalent course(s): ENSC 29001

GEOS 29700. Reading and Research in the Geophysical Sciences.
100 Units. Instructor(s): Staff. Terms Offered: Autumn, Spring, Summer, Winter
Independent study; regular meetings with Geophysical Sciences faculty member required. Topics available include, but are not limited to: Mineralogy, Petrology, Geophysics, High Pressure Geophysics, Geodynamics, Volcanology, Cosmochemistry, Geochemistry, Atmospheric Dynamics, Paleoclimatology, Physical Oceanography, Chemical Oceanography, Paleoceanography, Atmospheric Chemistry, Fluid Dynamics, Glaciology, Climatology, Radiative Transfer, Cloud Physics, Morphometrics, Phylogeny, Analytical Paleontology, Evolution, Taphonomy, Macroevolution, Paleobiology, Paleobotany, Biomechanics, Paleoecology, Tectonics, Stratigraphy.
Prerequisite(s): Consent of instructor and departmental counselor
Note(s): Students are required to submit the College Reading and Research Course Form. Available to nonmajors for P/F grading. Must be taken for a quality grade when used to meet a requirement in the major.