THE UNIVERSITY OF CHICAGO
DEPARTMENT OF THE GEOPHYSICAL SCIENCES
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2016-2017 Proposed Course Offerings*

*This list is current as of 9/20/2016. Course listings subject to change.

Autumn 2016

GEOS 13100. Physical Geology. 100 Units.
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. (L)

GEOS 13400. Global Warming: Understanding the Forecast. 100 Units.
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. (L)

Prerequisite(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): PHSC 13400,ENST 12300,ENSC 13400

GEOS 20500. Topics in the Geophysical Sciences. 100 Units.

Autumn 2016: The Accretion of Extraterrestrial Matter Throughout Earth's History

GEOS 22200. Geochronology. 100 Units.
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 23900. Environmental Chemistry. 100 Units.
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. (L)

Prerequisite(s): CHEM 11101-11201 or equivalent, and prior calculus course
Equivalent Course(s): GEOS 23900,ENST 23900,ENSC 23900

GEOS 24220. Climate Foundations. 100 Units.
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. (L)

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. Geophysical Fluid Dynamics: Foundations. 100 Units.
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 26100. Phylogenetics and the Fossil Record. 100 Units.
Phylogenies are branching diagrams that reflect evolutionary relationships. In addition to providing information on the history of life, phylogenies are fundamental to modern methods for studying macroevolutionary and macroecological pattern and process. In the biological sciences, phylogenies are most often inferred from genetic data. In paleobiology, phylogenies can only be inferred from the fossilized remains of morphological structures, and collecting and analyzing morphological data present a different set of challenges. In this course, students will study both traditional and state-of-the-art approaches to inferring phylogenies in the fossil record, from data collection to interpretation. Lectures will explore the statistical underpinnings of phylogenetic methods, as well as their practical implementation in commonly used software. Topics will include: identifying and coding morphological characters, models of morphological evolution, parsimony, maximum likelihood, and bayesian methods, supertree approaches, and integrating time into phylogenetic inference. Fifty percent of the final assessment will come from a research paper due at the end of the quarter.

Prerequisite(s): BIOS 20197 or equivalent.
Equivalent Course(s): GEOS 26100

GEOS 28300. Principles of Stratigraphy. 100 Units.
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. (L)

Prerequisite(s): GEOS 13100-13200 or equivalent required; GEOS 23500 and/or 28200 recommended
Note(s): This course is offered in alternate years.
Equivalent Course(s): GEOS 28300

GEOS 29700. Reading and Research in the Geophysical Sciences. 100 Units.

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.

Terms Offered: Summer, Autumn, Winter, Spring
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.

GEOS 30200. Introduction to Research in the Geophysical Sciences. 100 Units.
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 30500. Topics in the Geophysical Sciences. 100 Units.

Autumn 2016: The Accretion of Extraterrestrial Matter Throughout Earth's History

GEOS 32200. Geochronology. 100 Units.
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.
Equivalent Course(s): GEOS 22200

GEOS 33900. Environmental Chemistry. 100 Units.
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. (L)

Prerequisite(s): CHEM 11101-11201 or equivalent, and prior calculus course
Equivalent Course(s): GEOS 23900,ENST 23900,ENSC 23900

GEOS 34220. Climate Foundations. 100 Units.
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. (L)

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.
Equivalent Course(s): GEOS 24220

GEOS 34230. Geophysical Fluid Dynamics: Foundations. 100 Units.
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.
Equivalent Course(s): GEOS 24230

GEOS 34530. Turbulence and transport processes in the atmosphere and oceans. 100 Units.

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.

Prerequisites: 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 36100. Phylogenetics and the Fossil Record. 100 Units.
Phylogenies are branching diagrams that reflect evolutionary relationships. In addition to providing information on the history of life, phylogenies are fundamental to modern methods for studying macroevolutionary and macroecological pattern and process. In the biological sciences, phylogenies are most often inferred from genetic data. In paleobiology, phylogenies can only be inferred from the fossilized remains of morphological structures, and collecting and analyzing morphological data present a different set of challenges. In this course, students will study both traditional and state-of-the-art approaches to inferring phylogenies in the fossil record, from data collection to interpretation. Lectures will explore the statistical underpinnings of phylogenetic methods, as well as their practical implementation in commonly used software. Topics will include: identifying and coding morphological characters, models of morphological evolution, parsimony, maximum likelihood, and bayesian methods, supertree approaches, and integrating time into phylogenetic inference. Fifty percent of the final assessment will come from a research paper due at the end of the quarter.

Prerequisite(s): BIOS 20197 or equivalent.
Equivalent Course(s): GEOS 26100

GEOS 36900. Topics in Paleobiology. 100 Units.
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

GEOS 38300. Principles of Stratigraphy. 100 Units.
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. (L)

Prerequisite(s): GEOS 13100-13200 or equivalent required; GEOS 23500 and/or 28200 recommended
Note(s): This course is offered in alternate years.
Equivalent Course(s): GEOS 28300

GEOS 49700-49799. Advanced Reading and Research in the Geophysical Sciences. Variable Units (100, 200, or 300 units).

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.

Winter 2017

GEOS 13200. Earth History. 100 Units.
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. (L)

Prerequisite(s): GEOS 13100

GEOS 13900. Biological Evolution. 100 Units.
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.

Prerequisite(s): Students using this course as part of the general education requirement register for GEOS 13900 or BIOS 13123; prerequisite BIOS 10130. No Biological Sciences majors except by petition to the BSCD Senior Advisers. Due to significant overlap of course content, students may register for only one of PHSC 11000, BIOS 12117, or GEOS 13900 (=NTSC 10300, =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.

GEOS 21000. Mineralogy. 100 Units.
This course covers structure, chemical composition, stability, and occurrence of major rock-forming minerals. Labs concentrate on mineral identification with the optical microscope. (L)

Prerequisite(s): CHEM 11100-11200-11300 or equivalent
Equivalent course: GEOS 31000

GEOS 22000. Origin and Evolution of the Solar System. 100 Units.
This course will explore the formation and evolution of the Solar System, from the collapse of the natal molecular cloud core to the orbital restructuring of the planets. Topics to be covered include: structure and evolution of the solar nebula, dust dynamics in the solar nebula and the formation of planetesimals, accretion of the terrestrial planets, giant planet formation and migration, and meteorites and the historical record of the Solar System they preserve. (L)

Prerequisite(s): At least one year of physics or chemistry and an understanding of multivariate calculus.
Note(s): This course is offered in alternate years.
Equivalent Course(s): ASTR 21300

GEOS 23800. Global Biogeochemical Cycles. 100 Units.
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 disequilibria 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 24240. Geophysical Fluid Dynamics: Rotation and Stratification. 100 Units.
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 26905. Topics in Conservation Paleobiology. 100 Units.
Paleobiological data from very young sedimentary records, including skeletal 'death assemblages' actively accumulating on modern land surfaces and seabeds, provide unique information on the status of present-day populations, communities, and biomes and their responses to natural and anthropogenic stress over the last few decades to millennia. This course on the emerging discipline of ‘conservation paleobiology’ uses weekly seminars and individual research projects to introduce how paleontologic methods, applied to modern samples, can address critical issues in the conservation and restoration of biodiversity and natural environments, including such basic questions as ‘has a system changed, and if so how and when relative to suspected stressors?’. The course will include hands-on experience, either in the field or with already-collected marine benthic samples, to assess societally relevant ecological change in modern systems over time-frames beyond the reach of direct observation. Enrollment limited.

Prerequisite(s): Prerequisities for undergraduates: completion of GEOS 13100-13200-13300 or equivalent or completion of a 20000-level course in paleontology.
Equivalent Course(s): EVOL 36905,GEOS 36905

GEOS 27300. Biological Evolution. 100 Units.
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.

Prerequisite(s): Students using this course as part of the general education requirement register for GEOS 13900 or BIOS 13123; prerequisite BIOS 10130. No Biological Sciences majors except by petition to the BSCD Senior Advisers. Due to significant overlap of course content, students may register for only one of PHSC 11000, BIOS 12117, or GEOS 13900 (=NTSC 10300, =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.

GEOS 28100. Global Tectonics. 100 Units.
This course reviews the spatial and temporal development of tectonic and plate tectonic activity of the globe. We focus on the style of activity at compressive, extensional, and shear margins, as well as on the types of basin evolution associated with each. (L)

Prerequisite(s): GEOS 13100 or consent of instructor
Note(s): This course is offered in alternate years.
Equivalent Course(s): GEOS 28100

GEOS 28600. Earth and Planetary Surface Processes. 100 Units.
The focus of this course is to examine surface and lithospheric processes on planets and dwarf planets. Emphasis is placed on constraints that can be obtained from reconnaissance spacecraft (orbiter or flyby). The course will cover impact cratering, strength of the lithosphere, volcanism, fluvial and aeolian sediment transport, and landscape evolution.

Equivalent Course(s): GEOS 28600

GEOS 29700. Reading and Research in the Geophysical Sciences. 100 Units.

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.

Terms Offered: Summer, Autumn, Winter, Spring
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.

GEOS 31000. Mineralogy. 100 Units.
This course covers structure, chemical composition, stability, and occurrence of major rock-forming minerals. Labs concentrate on mineral identification with the optical microscope. (L)

Prerequisite(s): CHEM 11100-11200-11300 or equivalent
Equivalent course: GEOS 31000

GEOS 32000. Origin and Evolution of the Solar System. 100 Units.
This course will explore the formation and evolution of the Solar System, from the collapse of the natal molecular cloud core to the orbital restructuring of the planets. Topics to be covered include: structure and evolution of the solar nebula, dust dynamics in the solar nebula and the formation of planetesimals, accretion of the terrestrial planets, giant planet formation and migration, and meteorites and the historical record of the Solar System they preserve. (L)

Prerequisite(s): At least one year of physics or chemistry and an understanding of multivariate calculus.
Note(s): This course is offered in alternate years.
Equivalent Course(s): ASTR 21300

GEOS 33300. Advanced Topics in Climate Dynamics. 100 Units.
The course will go beyond radiative-convective equilibrium and explore spatial and temporal aspects of Earth's climate with a focus on the atmosphere. The goal is to gain a physical understanding of Earth's climate and its past and future changes. We will discuss a range of topics from the surface and atmospheric energy balance, hydrological cycle, atmospheric general circulation and energy transport, climate variability, paleoclimate, natural & anthropogenic climate change. The course will combine lectures of the theory and observations underlying our understanding of Earth's climate with student presentations of peer-reviewed papers. The evaluation will be based on a data-analysis project.

Prerequisite(s): GEOS 24220 or equivalent

GEOS 33800. Global Biogeochemical Cycles. 100 Units.
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 disequilibria 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 23800

GEOS 34240. Geophysical Fluid Dynamics: Rotation and Stratification. 100 Units.
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)
Equivalent Course(s): GEOS 24240

GEOS 36050. Models of Morphological Evolution. 100 Units.
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.

Course status: *Number not finalized and may be subject to change. Quarter of offer not finalized and may be subject to change: Winter or Spring.*

GEOS 36200. Evolution and the Fossil Record. 100 Units.
This course serves as an introduction to the practical and theoretical issues involved in obtaining primary systematic data from the fossil record, and demonstrates the criticality of such data to the rigorous documentation and interpretation of evolutionary patterns. Precise topics of the seminar discussions will vary from year to year depending on relevance to student research projects and interest, but are likely to focus on issues such as (but not restricted to) practical techniques in specimen-based paleontology (including fossil preparation and photography), species delimitation (including species concepts, variability, and ecophenotypy), stratigraphic/geographic range determination (including biostratigraphic correlation), phylogeny reconstruction (including the relevance of stratigraphic data), and the importance of these topics to broader macroevolutionary issues such as diversity/disparity dynamics and the determination of evolutionary trends, rates and processes.

Equivalent Course(s): EVOL 46200

GEOS 36905. Topics in Conservation Paleobiology. 100 Units.
Paleobiological data from very young sedimentary records, including skeletal 'death assemblages' actively accumulating on modern land surfaces and seabeds, provide unique information on the status of present-day populations, communities, and biomes and their responses to natural and anthropogenic stress over the last few decades to millennia. This course on the emerging discipline of ‘conservation paleobiology’ uses weekly seminars and individual research projects to introduce how paleontologic methods, applied to modern samples, can address critical issues in the conservation and restoration of biodiversity and natural environments, including such basic questions as ‘has a system changed, and if so how and when relative to suspected stressors?’. The course will include hands-on experience, either in the field or with already-collected marine benthic samples, to assess societally relevant ecological change in modern systems over time-frames beyond the reach of direct observation. Enrollment limited.

Prerequisite(s): Prerequisities for undergraduates: completion of GEOS 13100-13200-13300 or equivalent or completion of a 20000-level course in paleontology.
Equivalent Course(s): EVOL 36905

GEOS 38100. Global Tectonics. 100 Units.
This course reviews the spatial and temporal development of tectonic and plate tectonic activity of the globe. We focus on the style of activity at compressive, extensional, and shear margins, as well as on the types of basin evolution associated with each. (L)

Prerequisite(s): GEOS 13100 or consent of instructor
Note(s): This course is offered in alternate years.
Equivalent Course(s): GEOS 28100

GEOS 38600. Earth and Planetary Surface Processes. 100 Units.
The focus of this course is to examine surface and lithospheric processes on planets and dwarf planets. Emphasis is placed on constraints that can be obtained from reconnaissance spacecraft (orbiter or flyby). The course will cover impact cratering, strength of the lithosphere, volcanism, fluvial and aeolian sediment transport, and landscape evolution.

Equivalent Course(s): GEOS 28600

GEOS 49700-49799. Advanced Reading and Research in the Geophysical Sciences. Variable Units (100, 200, or 300 units).

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.

Spring 2017

GEOS 13300. The Atmosphere. 100 Units.
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 13400. Global Warming: Understanding the Forecast. 100 Units.
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. (L)

Prerequisite(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): PHSC 13400,ENST 12300,ENSC 13400

GEOS 21100. Introduction to Petrology. 100 Units.
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. (L)

Prerequisite(s): GEOS 21000

GEOS 21200. Physics of the Earth. 100 Units.
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. (L)

Prerequisite(s): Prior calculus and college-level physics courses, or consent of instructor.

GEOS 23205. Introductory Glaciology. 100 Units.
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. (L)

Prerequisite(s): Knowledge of vector calculus, linear algebra, and computer programming.
Equivalent Course(s): GEOS 23205

GEOS 23400. Global Warming: Understanding the Forecast. 100 Units.
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. Lectures are shared with PHSC 13400, but students enrolled in GEOS 23400 are required to write an individual research term paper and do some elementary climate modeling exercises in Python (no previous coding experience required). (L)

Prerequisite(s): Consent of instructor required.
Note(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): ENSC 25200

GEOS 24250. Geophysical Fluid Dynamics: Understanding the Motions of the Atmosphere and Oceans. 100 Units.
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 24250

GEOS 24705. Energy: Science, Technology, and Human Usage. 100 Units.
This course covers the technologies by which humans appropriate energy for industrial and societal use, from steam turbines to internal combustion engines to photovoltaics. We also discuss the physics and economics of the resulting human energy system: fuel sources and relationship to energy flows in the Earth system; and modeling and simulation of energy production and use. Our goal is to provide a technical foundation for students interested in careers in the energy industry or in energy policy. Field trips required to major energy converters (e.g., coal-fired and nuclear power plants, oil refinery, biogas digester) and users (e.g., steel, fertilizer production).

Prerequisite(s): Knowledge of physics or consent of instructor
Equivalent Course(s): GEOS 24705,ENST 24705,ENSC 21100

GEOS 26600. Geobiology. 100 Units.
Geobiology seeks to elucidate the interactions between life and its environments that have shaped the coevolution of the Earth and the biosphere. The course will explore the ways in which biological processes affect the environment and how the evolutionary trajectories of organisms have in turn been influenced by environmental change. In order to reconstruct the history of these processes, we will examine the imprints they leave on both the rock record and on the genomic makeup of living organisms. The metabolism and evolution of microorganisms, and the biogeochemistry they drive, will be a major emphasis.

Prerequisite(s): GEOS 13100-13200-13300 or college-level cell & molecular biology
Equivalent Course(s): ENSC 24000,GEOS 26600

GEOS 29700. Reading and Research in the Geophysical Sciences. 100 Units.

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.

Terms Offered: Summer, Autumn, Winter, Spring
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.

GEOS 31200. Physics of the Earth. 100 Units.
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. (L)

Prerequisite(s): Prior calculus and college-level physics courses, or consent of instructor.
Equivalent Course(s): GEOS 21200

GEOS 33205. Introductory Glaciology. 100 Units.
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. (L)

Prerequisite(s): Knowledge of vector calculus, linear algebra, and computer programming.
Equivalent Course(s): GEOS 23205

GEOS 34250. Geophysical Fluid Dynamics: Understanding the Motions of the Atmosphere and Oceans. 100 Units.
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 24250

GEOS 34500. Large-Scale Ocean Dynamics. 100 Units.
In this course we will discuss the dynamics of the large-scale ocean circulation, which plays an important role in the global climate system. Topics will include the wind-driven ocean gyres, the turbulent Antarctic Circumpolar Current, thermocline theory, as well as the meridional overturning circulation. Depending on interest and progress, we will also cover equatorial wave dynamics and El Nino. The course will mostly be centered around the discussion of classical papers, supplemented by some more recent developments.

Prerequisite(s): GEOS 24230 and GEOS 24240 or equivalent.

GEOS 34705. Energy: Science, Technology, and Human Usage. 100 Units.
This course covers the technologies by which humans appropriate energy for industrial and societal use, from steam turbines to internal combustion engines to photovoltaics. We also discuss the physics and economics of the resulting human energy system: fuel sources and relationship to energy flows in the Earth system; and modeling and simulation of energy production and use. Our goal is to provide a technical foundation for students interested in careers in the energy industry or in energy policy. Field trips required to major energy converters (e.g., coal-fired and nuclear power plants, oil refinery, biogas digester) and users (e.g., steel, fertilizer production).

Prerequisite(s): Knowledge of physics or consent of instructor
Equivalent Course(s): GEOS 24705,ENST 24705,ENSC 21100

GEOS 35100. Data Analysis for the Geophysical Sciences. 100 Units.
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 36600. Geobiology. 100 Units.
Geobiology seeks to elucidate the interactions between life and its environments that have shaped the coevolution of the Earth and the biosphere. The course will explore the ways in which biological processes affect the environment and how the evolutionary trajectories of organisms have in turn been influenced by environmental change. In order to reconstruct the history of these processes, we will examine the imprints they leave on both the rock record and on the genomic makeup of living organisms. The metabolism and evolution of microorganisms, and the biogeochemistry they drive, will be a major emphasis.

Prerequisite(s): GEOS 13100-13200-13300 or college-level cell & molecular biology
Equivalent Course(s): ENSC 24000,GEOS 26600

GEOS 36800. Macroevolution. 100 Units.
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 49700-49799. Advanced Reading and Research in the Geophysical Sciences. Variable Units (100, 200, or 300 units).

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.