

EARTH SCIENCES

Earth sciences are vital to understanding our dynamic Earth, ocean, and atmosphere; our changing climate; and how to create a sustainable future. The Department of Earth Sciences offers three majors: the B.S. Earth Sciences, with tracks in Geology, Geophysics, Climate, and Oceanography, the B.S. Environmental Sciences, with options in Hydrology and Geosystems, and the B.A. Earth Sciences. All of our degree programs provide a strong concentration in geoscience that is built upon a solid foundation in mathematics and the physical sciences.

Our Earth and environmental science degrees are especially well-suited for students who wish to work in the environmental and geosciences industries, energy sector and climate technologies, teaching at the secondary level, state and federal environmental agencies, or to pursue graduate studies in the Earth, environmental, and climate sciences, oceanography, and related fields of study. Students are encouraged to participate in research, field, lab, or internship opportunities to round out their experiences in the degree program.

In addition to the B.S. and B.A. degrees, the Department of Earth Sciences also offers three minors: Earth Sciences, Climate Science, and Oceanography.

Descriptions and requirements for the majors and minors are arranged alphabetically.

<https://ceps.unh.edu/earth-sciences>

Programs

- [Climate Science Minor](#)
- [Earth Sciences Major \(B.A.\)](#)
- [Earth Sciences Major \(B.S.\)](#)
- [Earth Sciences Minor](#)
- [Environmental Sciences Major: Geosystems Option \(B.S.\)](#)
- [Environmental Sciences Major: Hydrology Option \(B.S.\)](#)
- [Oceanography Minor](#)

Courses

Earth Sciences (ESCI)

ESCI 400 - Freshman Field Seminar

Credits: 1

A field introduction for new or prospective majors to New Hampshire's mountains, rivers, estuaries, and beaches. Field excursions (approximately five) are scheduled on Friday afternoons.

Grade Mode: Credit/Fail Grading

Special Fee: Yes

ESCI 401 - Dynamic Earth

Credits: 4

In this course we study the minerals, rocks and fluids which make up the Earth; the landforms on the surface of the Earth such as mountains, flood plains and stratovolcanoes; and processes such as volcanism, earthquakes, erosion and glaciation that create and alter them. The rock cycle and plate tectonics are used to integrate activity at the surface of the Earth with processes in the Earth's interior. Campus field exercises. Lab.

Attributes: Discovery Lab Course; Physical Science(Discovery)

Mutual Exclusion: No credit for students who have taken ESCI 409.

Grade Mode: Letter Grading

Special Fee: Yes

ESCI 402 - Earth History

Credits: 4

Course provides knowledge and skills necessary to interpret, understand, and appreciate the Earth's 4.6 billion-year history. The first third of the course introduces basic principles, including geological materials, plate tectonics, geological time, fossil preservation, and biological evolution.

The remainder of the course tells the story of Earth history through case studies that illustrate scientific methods used to reconstruct critical events in our planet's evolution through time. Topics include the origin of the Earth, the Cambrian explosion of life, building of the Appalachians, assembly of Pangaea, the rise and fall of dinosaurs, the formation of the Rocky Mountains, mammalian evolution, human origins, and Pleistocene glaciation. Students gain experience in making geological observations through laboratory exercises and during one afternoon field trip. Lab.

Attributes: Discovery Lab Course; Physical Science(Discovery)

Grade Mode: Letter Grading

Special Fee: Yes

ESCI 405 - Global Environmental Change

Credits: 4

Human activity rivals nature as an agent of change in the global environment. Explores evidence of environmental degradation in Earth's crust, hydrosphere, and atmosphere; considers prospects for future sustainable human health, diversity, and economic development. Problem solving through critical analysis of environmental variables.

Attributes: Physical Science(Discovery)

Grade Mode: Letter Grading

Special Fee: Yes

ESCI 409 - Geology and the Environment

Credits: 4

Environmental impact of geologic processes; natural hazards, landslides, earthquakes, volcanoes, flooding, erosion, and sedimentation; land exploitation and site investigations; environmental considerations of water-supply problems; the recovery of energy and mineral resources. Lab.

Attributes: Discovery Lab Course; Physical Science(Discovery)

Mutual Exclusion: No credit for students who have taken ESCI 401.

Grade Mode: Letter Grading

Special Fee: Yes

ESCI 410 - Earth Hazards**Credits:** 4

Introductory-level physical science course concerning Earth processes that impact humanity, with natural disasters as the focus. Topics include the causes and effects of earthquakes, tsunamis, volcanic eruptions, floods, and landslides. The course covers basic concepts of physical geology using hands-on-activities, small-group discussions, and in-class demonstrations and is intended for students with little or no previous experience in Earth sciences.

Attributes: Discovery Lab Course; Physical Science(Discovery)**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 420 - Our Solar System****Credits:** 4

Course focuses on the nature and formation of our solar system and the planets associated bodies it contains, with emphasis on the physical and chemical processes significant in the system's origin and evolutionary history. Our approach provides the basis for understanding key differences between the Earth-like terrestrial planets and those farther out in the solar system (the gas giants). We also explore recent discoveries on Mars and moons of the gas giant planets and their implications for the search for life elsewhere in our solar system.

Attributes: Discovery Lab Course; Physical Science(Discovery)**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 444A - Philosophy of Earth Science****Credits:** 4

Course provides an introduction to the discipline of Philosophy of Science, but from an Earth Science perspective. Considers various philosophical perspectives on the nature of science and scientific progress, drawing from works by thinkers such as Aristotle, Popper, Kuhn and Lakatos. Particular attention is given to the following questions: What is scientific knowledge? Is the acquisition of scientific knowledge a rational process? And, what makes some scientific discoveries "revolutionary"? These questions are considered using examples from the history of scientific progress in the Earth Sciences, focusing on groundbreaking discoveries such as the age of the earth, the evolution of organisms as observed in the fossil record, sea-floor spreading, and modern-day global warming.

Attributes: Environment,TechSociety(Disc); Inquiry (Discovery)**Grade Mode:** Letter Grading**ESCI 451 - Earth in Film****Credits:** 4

Introductory-level focusing on interactions between Earth system and its inhabitants, with special emphasis on understanding societal implications of Earth system processes. Topics include Earth's interior processes, volcanism, earthquakes, climate change, storms, tornadoes, and biological change. Students are expected to learn about Earth system processes and critique cinematic portrayal of such processes. Taken together this approach affords building a foundation in the natural sciences and provides insights into societal portrayal of scientific ideas.

Attributes: Physical Science(Discovery)**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 501 - Introduction to Oceanography****Credits:** 4

Introduces students to the four oceanographic disciplines: the geology of the ocean basins, including the creation of oceans and continents. The physics of the seas, including the origin of the ocean currents and their effect on the Earth's climate. The chemistry of the ocean waters, including how the distribution of elements reflects circulation and biology. The life in the ocean, including animals, plants and microbes, and humanity's influence on them. Lab.

Attributes: Discovery Lab Course; Physical Science(Discovery); Inquiry (Discovery)**Mutual Exclusion:** No credit for students who have taken SCI 480.**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 502 - Beaches and Coasts****Credits:** 4

Introductory-level physical science course on ocean, air, and landform dynamics affecting beaches and coasts, with considerations of natural processes associated with waves and currents, wind and rain, sediments and rocks, and ecology. Emphasis is placed on impacts on ecosystem and human health, the economics of coastal industry, and consequences of pollution and engineering practices. Topics are approached via real world examples, small-group discussions, and field trips to local sites. Recitation.

Attributes: Physical Science(Discovery)**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 512 - Principles of Mineralogy****Credits:** 4

Minerals record variations in chemistry, pressure, temperature, and time in the Earth. This course emphasizes minerals and mineral assemblages in rocks, sediments and soils; their identification, symmetry, chemistry, equilibria, and physical properties. Introduction to x-ray diffraction and optical techniques. Special fee for field trips. Lab.

Prerequisite(s): CHEM 403 with a minimum grade of D- or CHEM 405 with a minimum grade of D-.**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 514 - Introduction to Climate****Credits:** 3

The climate as a system controlled by the fluid, chemical, geological, and biological dynamics of the earth. Investigation of natural and man-made climate change over the period of 100 to 100 million years, including the greenhouse effects, tectonic climate forcing, astronomic (Milankovitch) cycles, deep ocean circulation, and biological feedback. How past climate is measured.

Prerequisite(s): ESCI 401 with a minimum grade of D- or ESCI 409 with a minimum grade of D- or ESCI 402 with a minimum grade of D- or ESCI 501 with a minimum grade of D-.**Grade Mode:** Letter Grading

ESCI 530 - Geological Field Methods**Credits:** 4

An introduction to basic geologic field mapping of bedrock and surficial materials using pace and compass, surveying and GPS techniques. Observational data plotted on topographic maps and/or aerial photographs, accompanied with stratigraphic measurements and sampling sites where appropriate, provide the basis for interpretative maps, cross sections and written reports and a field context for more advanced Earth sciences course work and independent research. One weekend field trip to western or northern New England.

Attributes: Writing Intensive Course**Prerequisite(s):** (ESCI 401 with a minimum grade of D- or ESCI 409 with a minimum grade of D-) and ESCI 402 with a minimum grade of D-.**Equivalent(s):** ESCI 534**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 534 - Techniques in Environmental Sciences****Credits:** 3

Elementary mapping and monitoring methods. Map interpretation, preparation of maps; survey techniques including pace and compass, leveling, and global positioning systems; environmental monitoring. Field lab. Cannot receive credit if taken after receiving credit for ESCI 530 or NR 542.

Attributes: Writing Intensive Course**Equivalent(s):** ESCI 530, NR 542**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 561 - Landscape Evolution****Credits:** 4

Course focuses on the processes that shape the Earth's surface. Lectures discuss the development of landscapes in a wide variety of climatic and geologic settings, with an emphasis on understanding the process mechanics that create landforms and surficial deposits. Labs involve topographic map interpretation, geomorphic data analysis, and short field exercises. Course incorporates one weekend field trip that explores the landscapes of Cape Cod. Students also gain practical experience in geomorphic research by teaming up and completing a required lab- or field-based project. Lab.

Prerequisite(s): ESCI 401 with a minimum grade of D- or ESCI 409 with a minimum grade of D-.**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 614 - Introduction to Petrology****Credits:** 0 or 4

Description, classification and formation of igneous, sedimentary, and metamorphic rocks in the field, hand specimen, and thin section. Lab and field trips.

Prerequisite(s): (ESCI 401 with a minimum grade of D- or ESCI 409 with a minimum grade of D- or ESCI 402 with a minimum grade of D- or ESCI 501 with a minimum grade of D-) and ESCI 512 with a minimum grade of D-.**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 631 - Structural Geology****Credits:** 4

Structural units of the Earth's crust and mechanics of their formation. Lab and fieldwork.

Prerequisite(s): ESCI 530 with a minimum grade of D-.**Grade Mode:** Letter Grading**Special Fee:** Yes**ESCI 642 - Biogeosciences in the Earth System****Credits:** 3

This interdisciplinary course applies concepts from chemistry, physics, biology and geology to understand biogeochemical cycles in the Earth system. Course topics includes terrestrial, ocean and freshwater environments; water and energy cycles; carbon, nitrogen, phosphorous and sulfur cycles; biogeochemical cycles through Earth history and a synthesis of how humans have impacted the Earth system. Students will use quantitative methods to explore relationships between causes and effects, positive and negative feedbacks, and thresholds in the Earth systems.

Prerequisite(s): (MATH 426 with a minimum grade of D- or MATH 424B with a minimum grade of D-) and (CHEM 404 with a minimum grade of D- or CHEM 405 with a minimum grade of D- or NR 561 with a minimum grade of D-).**Grade Mode:** Letter Grading**ESCI 654 - Fate and Transport in the Environment****Credits:** 4

An introduction to the basic processes controlling the migration and transformation of chemicals in surface water, groundwater, and the atmosphere, including advection, diffusion, dispersion, retardation, and chemical reaction. Extensive practice with quantitative problem solving in the environmental sciences, including constructing and using box models.

Prerequisite(s): (CHEM 404 with a minimum grade of D- or CHEM 405 with a minimum grade of D- or NR 561 with a minimum grade of D-) and (MATH 425 with a minimum grade of D- or MATH 424B with a minimum grade of D-).**Grade Mode:** Letter Grading**ESCI 690 - Capstone & Professional Development****Credits:** 1

Students in ESCI 690 will develop (via participation, assignments and question-asking) insights into potential capstone and post-graduate career and academic opportunities in the Earth Sciences. The course is designed to help students gain experience in learning different ways of communicating scientific research and material to a variety of audiences. Finally, students also expected to develop, collaboratively with a capstone mentor, a capstone plan.

Grade Mode: Credit/Fail Grading**ESCI 701 - Quantitative Methods in Earth Sciences****Credits:** 4

Introduces quantitative tools necessary for upper level Earth Science courses. Includes basic statistical descriptions of spatially and temporally varying data, curve fitting, and time-series analysis with emphasis on atmospheric, oceanic and terrestrial data sets. Students learn to construct simple numerical models of Earth Systems. Instruction in data analysis and modeling in Python.

Prerequisite(s): MATH 426 with a minimum grade of D- and (ESCI 401 with a minimum grade of D- or ESCI 402 with a minimum grade of D- or ESCI 409 with a minimum grade of D- or ESCI 501 with a minimum grade of D- or ESCI 514 with a minimum grade of D- or OE 490 with a minimum grade of D-).**Grade Mode:** Letter Grading

ESCI 705 - Principles of Hydrology**Credits:** 4

Basic physical principles important in the land phase of the hydrologic cycle, including precipitation, snowmelt, infiltration and soil physics, evapotranspiration, and surface and subsurface flow to streams. Problems of measurement and aspects of statistical treatment of hydrologic data. Field trips. Lab.

Attributes: Writing Intensive Course

Prerequisite(s): ESCI 654 with a minimum grade of D- or ((MATH 425 with a minimum grade of D- or MATH 424B with a minimum grade of D-) and (PHYS 401 with a minimum grade of D- or PHYS 407 with a minimum grade of D- or PHYS 407S with a minimum grade of D- or PHYS 407H with a minimum grade of D-)).

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 710 - Groundwater Hydrology****Credits:** 4

Principles for fluid flow in porous media with emphasis on occurrence, location, and development of groundwater but with consideration of groundwater as a transporting medium. Major topics include well hydraulics, regional groundwater flow, exploration techniques, and groundwater modeling. Laboratory exercises involve use of fluid, electrical, and digital computer models to illustrate key concepts. Lab.

Prerequisite(s): ESCI 654 with a minimum grade of D- or CEE 650 with a minimum grade of D- or NR 504 with a minimum grade of D-.

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 720 - Ocean Measurements Lab****Credits:** 4

Measurements of fundamental ocean processes and parameters. Emphasizes understanding typical coastal and estuarine measurements their applications, and the use of acquired data in terms of the effects on structures and processes in the ocean.

Equivalent(s): OE 710**Grade Mode:** Letter Grading**ESCI 726 - Igneous and Metamorphic Petrology****Credits:** 4

This course focuses on the origin and evolution of igneous and metamorphic rocks from field, petrographic mineral chemistry, experimental, and theoretical studies. Igneous systems include volcanic and plutonic suites, with emphasis on mineralogic records of magma chamber systematics. Metamorphic systems include pelitic, mafic, and calc sillcate rocks, with special emphasis on closed- and open-system reactions, mutl-systems, reaction space, and pressure-temperature-time paths. Field trips. Lab.

Attributes: Writing Intensive Course

Prerequisite(s): ESCI 614 with a minimum grade of D-.

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 734 - Global Geophysics****Credits:** 4

This course focuses on the structure of the Earth and dynamic processes within it. Topics include: plate tectonics, earthquakes and seismic waves, mantle convection, rheology and ice age dynamics, Earth's gravity field and geodesy, and the geodynamo. Lab.

Prerequisite(s): MATH 426 with a minimum grade of D- and PHYS 408 with a minimum grade of D-.

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 741 - Geochemistry****Credits:** 4

Course focuses on the application of chemical principles to solve problems in the Earth sciences. Students learn the chemical tools of thermodynamics and kinetics, element partitioning, conservation of mass, and isotope geochemistry. Explore geochemical properties/ processes in the deep Earth and the Earth surface, atmosphere and marine systems, and cosmo-chemistry and investigate the interactions between these components of the Earth system. Lab.

Attributes: Writing Intensive Course

Prerequisite(s): (MATH 424A with a minimum grade of D- or MATH 424B with a minimum grade of D- or MATH 425 with a minimum grade of D- or MATH 425H with a minimum grade of D-) and (CHEM 404 with a minimum grade of D- or CHEM 405 with a minimum grade of D-).

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 745 - Isotope Geochemistry****Credits:** 4

Course focuses on the application of radiogenic, radioactive and stable isotopes to improve students' knowledge about the processes and timescales relevant to the formation of the planet and solar system, the evolution of the Earth system and interactions in the hydrosphere and biosphere. Topics include geochronology, tracer applications, Earth surface applications, as well as applications in the hydrosphere and biosphere. Systems discussed include the classic radiogenic systems (K-Ar, Rb-Sr, Sm-Nd, Lu-Hf and U-Th-Pb), traditional (H, C, N, O) as well as nontraditional (e.g., Mg, Ca, Fe) stable isotope systems, and radioactive isotopes (e.g., radiocarbon). Course consists of lecture, where students are exposed to these applications, and a lab section to work through any questions on the homework assignments, discuss relevant papers from the literature, and carry out a project. Lab.

Prerequisite(s): (MATH 424A with a minimum grade of D- or MATH 424B with a minimum grade of D- or MATH 425 with a minimum grade of D- or MATH 425H with a minimum grade of D-) and (CHEM 404 with a minimum grade of D- or CHEM 405 with a minimum grade of D-).

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 747 - Aqueous Geochemistry****Credits:** 4

The chemical processes that determine the composition of aquatic systems such as rivers, lakes, groundwater and the ocean. The goal is to quantitatively understand the behavior of inorganic species such as carbon dioxide, nutrients, trace metals and inorganic pollutants in natural waters. Topics include, acid-based equilibria, carbonate chemistry, reduction-oxidation reactions, organic complexation and mineral precipitation and dissolution. Lab. Prereq: one year college chemistry or geochemistry or permission.

Prerequisite(s): (MATH 424A with a minimum grade of D- or MATH 424B with a minimum grade of D- or MATH 425 with a minimum grade of D- or MATH 425H with a minimum grade of D-) and (CHEM 404 with a minimum grade of D- or CHEM 405 with a minimum grade of D-).

Grade Mode: Letter Grading**Special Fee:** Yes

ESCI 749W - Ocean Biogeochemistry**Credits:** 3

This course focuses on the elemental cycles of the major bioactive elements carbon, nitrogen, phosphorus, oxygen, and iron in the ocean. Topics include the biological and microbial carbon pumps, nitrogen fixation, iron fertilization, the carbon-climate system, ocean acidification, and deoxygenation. This course will provide insight and corresponding critical review of the current outstanding scientific questions being pursued by ocean biogeochemists. Students will become familiar with data analysis and visualization using open-source software.

Attributes: Writing Intensive Course**Prerequisite(s):** ESCI 501 with a minimum grade of D-.**Grade Mode:** Letter Grading**ESCI 752 - Chemical Oceanography****Credits:** 3

This course investigates the physical and biogeochemical processes that determine the composition of seawater. Topics include biological effects on chemistry, ocean nutrient cycles, air-sea gas exchange, radiogenic and stable isotopes as tracers of ocean processes, sediment and trace-metal chemistry.

Prerequisite(s): (MATH 424A with a minimum grade of D- or MATH 424B with a minimum grade of D- or MATH 425 with a minimum grade of D- or MATH 425H with a minimum grade of D-) and (CHEM 404 with a minimum grade of D- or CHEM 405 with a minimum grade of D-).

Grade Mode: Letter Grading**ESCI 754 - Sedimentology****Credits:** 4

This course focuses on modern sedimentary processes and ancient sedimentary records through the examination, identification, and interpretation of sediments and sedimentary rocks. Topics such as sediment transport mechanisms, depositional environments, and time in sedimentary records will provide a strong framework for any student studying Earth processes and sedimentary systems. Lab and field trips.

Prerequisite(s): (ESCI 401 with a minimum grade of D- or ESCI 402 with a minimum grade of D- or ESCI 409 with a minimum grade of D- or ESCI 501 with a minimum grade of D-) and ESCI 512 with a minimum grade of D-.

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 756 - Geotectonics****Credits:** 3

The geological record of plate tectonics past and present. The first part of the course focuses on modern tectonic settings with an emphasis on plate geometries, geodynamical processes, and sedimentary products. The second part of the course focuses on reconstructing ancient tectonic settings with an emphasis on methodology (paleomagnetism, basin analysis, provenance) and case studies (e.g. India-Asia collision). Field trip.

Attributes: Writing Intensive Course

Prerequisite(s): ESCI 614 with a minimum grade of D- or ESCI 631 with a minimum grade of D-.

Grade Mode: Letter Grading**Special Fee:** Yes**ESCI 758 - Introductory Physical Oceanography****Credits:** 3

Descriptive treatment of atmosphere-ocean interaction; general wind-driven and thermo-haline ocean circulation; waves and tides; continental shelf and near-shore processes; instrumentation and methods used in ocean research. Simplified conceptual models demonstrate the important principles.

Prerequisite(s): (PHYS 407 with a minimum grade of D- or PHYS 407S with a minimum grade of D- or PHYS 407H with a minimum grade of D-) and ESCI 501 with a minimum grade of D-.

Grade Mode: Letter Grading**ESCI 759 - Geological Oceanography****Credits:** 4

Major geological features and processes of the ocean floor; geological and geophysical methods; composition of the earth, sedimentary processes, plate tectonics and paleoceanography.

Attributes: Writing Intensive Course**Prerequisite(s):** ESCI 501 with a minimum grade of D-.**Grade Mode:** Letter Grading**ESCI 760 - Paleoceanography****Credits:** 3

This course introduces the basic principles of paleoceanography, such as the preservation of ocean history in sediment archives and the analysis/interpretation of paleoceanographic data. The course focuses on the capabilities and limitations of paleoceanographic techniques, and empowers students to critically assess the strengths and weaknesses of results presented in scientific journals. Topics include Milankovitch cycles, faunal assemblages, temperature and circulation proxies, linear and non-linear responses to climate forcings, abrupt climate events, atmospheric teleconnections and monsoons.

Prerequisite(s): ESCI 514 with a minimum grade of D- and (CHEM 404 with a minimum grade of D- or CHEM 405 with a minimum grade of D-).

Grade Mode: Letter Grading**ESCI 762 - Glacial Geology****Credits:** 4

This course covers almost everything you always wanted to know about glaciers. More specifically, the course provides a survey of glacier dynamics and processes, with an emphasis on understanding the origin and significance of glacial deposits and landforms. The first half of the course examines the physics of glaciers, and the second half focuses on glacial geologic processes. Lectures discuss glaciers and ice sheets as key agents of geomorphic change and their central role in the Earth's climate system. Labs involve analysis of glaciological data, glacial-geomorphic map interpretation, and short field exercises. A required term project involves a written report and class presentation on a topic of active research in glacial geology.

Attributes: Writing Intensive Course**Prerequisite(s):** ESCI 561 with a minimum grade of D-.**Grade Mode:** Letter Grading**Special Fee:** Yes

ESCI 764 - Spectral Analysis of Geophysical Time Series Data**Credits:** 4

This course considers basic exploratory techniques and in-depth spectral analysis for estimation with geophysical time series data, including calculations of confidence intervals and significance testing. This course prepares students for interpreting time series data with science and engineering applications. Topics include sampling theory, filtering, statistics, probability, spectral analysis, and empirical orthogonal functions. Students gain experience in code-writing for the analysis of time series data.

Prerequisite(s): MATH 426 with a minimum grade of D-.**Equivalent(s):** OE 764**Grade Mode:** Letter Grading**ESCI 765 - Paleoclimatology****Credits:** 3

Course reviews the study of past changes in the Earth's climate system. Main discussion topics include astronomical theories of ice ages, Quaternary dating methods, Antarctic and Greenland ice core records, greenhouse gases, marine-based climate proxies, glacial mega-floods, and linkages between ocean circulation and abrupt climate change. Emphasis on climate variability during the Quaternary period (the last approximately 2.6 million years), a time interval dominated by cycles of global glaciation. Lectures include discussion of recent and emerging scientific papers in order to keep pace with the latest findings in paleoclimatic research.

Attributes: Writing Intensive Course**Grade Mode:** Letter Grading**ESCI 770 - Geodesy for Ocean Mapping****Credits:** 3

Ocean mapping requires precise positioning and navigation. For this we need to precisely know Earth's shape, gravity field, and orientation in space. Data used for this purpose include satellite-based positioning, gravity measurements, and ground surveys. Reference frames can then be created allowing the integration of geometric observations for the creation of mapping products.

Prerequisite(s): (MATH 426 with a minimum grade of D- or MATH 426H with a minimum grade of D-) and (PHYS 407 with a minimum grade of D- or PHYS 407S with a minimum grade of D- or PHYS 407H with a minimum grade of D- or PHYS 401 with a minimum grade of D-).**Grade Mode:** Letter Grading**ESCI 771 - Positioning for Ocean Mapping****Credits:** 4

Ocean mapping necessitates accurate positioning and navigation, which, in turn, rely on a comprehensive grasp of measurement methodologies. This course will comprehensively examine various positioning techniques, including spirit leveling, total stations, Global Navigation Satellite Systems (GNSS), inertial navigation systems (INS), and underwater acoustic positioning systems. Emphasis will be placed on the observational methodologies associated with each technology, along with the propagation of observation uncertainty.

Prerequisite(s): (MATH 426 with a minimum grade of D- or MATH 426H with a minimum grade of D-) and (PHYS 407 with a minimum grade of D- or PHYS 407S with a minimum grade of D- or PHYS 407H with a minimum grade of D- or PHYS 401 with a minimum grade of D-).**Equivalent(s):** OE 771**Grade Mode:** Letter Grading**ESCI 777 - GIS for Earth & Environmental Sciences****Credits:** 4

Geospatial technologies provide insight into spatial and temporal aspects of environmental and earth systems. Students will master basic skills of a geographical information system. Weekly laboratory exercises will build upon a foundation of conceptual knowledge and data processing skills. Focus on applied research questions and projects will be addressed.

The course will use the opensource program QGIS. Additional work will develop programming skills using the python language. Programming background is not a requirement but beneficial.

Grade Mode: Letter Grading**ESCI 778 - Remote Sensing Earth & Environmental Sciences****Credits:** 4

Remote sensing provides insight into spatial and temporal aspects of environmental and Earth systems. Students will examine digital image processing techniques, different sensor and platform technologies, and new trends and frontiers in remote sensing science. Weekly laboratory exercises build upon conceptual knowledge, data processing skills, and development of programming skills. Applied research questions and projects will use Google Earth Engine. Hyperspectral, lidar, and unmanned aerial systems will be presented.

Grade Mode: Letter Grading**ESCI 795 - Topics****Credits:** 1-4

Geologic, hydrologic, and oceanographic problems and independent studies by means of conferences, assigned readings, and field or laboratory work fitted by ESCI faculty to individual student needs; or new or specialized courses. Topics include geochemistry; geomorphology; geophysics; glaciology; groundwater; structural and regional geology; crystallography; mineralogy; petrology; thermodynamics; ore deposits; earth resource policy; paleontology; sedimentation; stratigraphy; water resources management; chemical, physical, and geological oceanography; earth systems. Also, senior synthesis and earth science teaching methods.

Repeat Rule: May be repeated for a maximum of 4 credits. May be repeated up to 3 times.

Grade Mode: Letter Grading**ESCI 796 - Topics****Credits:** 1-4

Geologic, hydrologic, and oceanographic problems and independent studies by means of conferences, assigned readings, and field or laboratory work fitted by ESCI faculty to individual student needs; or new or specialized courses. Topics include geochemistry; geomorphology; geophysics; glaciology; groundwater; structural and regional geology; crystallography; mineralogy; petrology; thermodynamics; ore deposits; earth resource policy; paleontology; sedimentation; stratigraphy; water resources management; chemical, physical, and geological oceanography; earth systems. Also, senior synthesis and earth science teaching methods. Special fee on some topics.

Repeat Rule: May be repeated for a maximum of 4 credits. May be repeated up to 3 times.

Grade Mode: Credit/Fail Grading**Special Fee:** Yes

ESCI 799 - Senior Thesis**Credits:** 1-4

Students work under the direction of a faculty sponsor to plan and carry out independent research resulting in an oral presentation and a written thesis. Research projects should include the development of a research question; collection analysis, and synthesis of data; and interpretation and presentation of results. A copy of the written thesis must be submitted to the Chair of the Department of Earth Sciences prior to graduation. A total of 4 credits is required and may be completed over multiple semesters.

Attributes: Writing Intensive Course**Repeat Rule:** May be repeated for a maximum of 4 credits.**Grade Mode:** Letter Grading

Faculty

[Earth Sciences Department Faculty](#)