

# EARTH SCIENCES (ESCI)

# Course numbers with the # symbol included (e.g. #400) have not been taught in the last 3 years.

## 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. Special fee. Cr/F.

## ESCI 401 - Dynamic Earth

**Credits:** 0 or 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 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. Special fee. Lab.

**Attributes:** Discovery Lab Course; Physical Science(Discovery)

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

## 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. Special fee. Lab.

**Attributes:** Discovery Lab Course; Physical Science(Discovery)

## 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. Special fee.

**Attributes:** Physical Science(Discovery)

**Equivalent(s):** EOS 405

## 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. Special fee. Lab.

**Attributes:** Discovery Lab Course; Physical Science(Discovery)

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

## 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. No prerequisites. Special fee.

**Attributes:** Discovery Lab Course; Physical Science(Discovery)

## 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. Special fee.

**Attributes:** Discovery Lab Course; Physical Science(Discovery)

## ESCI #444 - Water - How Much is Enough?

**Credits:** 4

The natural distribution of water is not adequate to sustain modern civilization. As water mining and redistribution projects continue to grow in number and size, so do the concomitant stresses on the environment. Through a detailed look at the unique properties of water and the processes that drive the earth's hydrologic cycle; this course will explore the concepts of water stress, water scarcity, and safe yield.

**Attributes:** Physical Science(Discovery); Inquiry (Discovery)

## 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)

## 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)

**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. Special fee. Lab.

**Attributes:** Discovery Lab Course; Physical Science(Discovery); Inquiry (Discovery)

**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. No prerequisites. Recitation. Special fee.

**Attributes:** Physical Science(Discovery)

**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. Prereq: CHEM 403 or CHEM 405. Special fee for field trips. Lab.

**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. Prereq: one introductory course in Earth Sciences or permission.

**Equivalent(s):** ESCI 504

**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. Prereq: ESCI 401 or ESCI 409, ESCI 402. Special fee. Writing intensive.

**Attributes:** Writing Intensive Course

**Equivalent(s):** ESCI 534

**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. Special fee.

**Attributes:** Writing Intensive Course

**Equivalent(s):** ESCI 530, NR 542

**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. Prereq: ESCI 401, ESCI 402, or permission. Lab. Special fee.

**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. Prereq: ESCI 401, ESCI 409, or ESCI 501; and ESCI 512. Special fee. Lab and field trips.

**ESCI 631 - Structural Geology****Credits:** 4

Structural units of the Earth's crust and mechanics of their formation. Prereq: ESCI 530. Special fee. Lab and fieldwork.

**Equivalent(s):** ESCI 531

**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. Prereq: calculus, two semesters of chemistry or permission.

**ESCI #652 - Paleontology****Credits:** 4

Use of the fossil record to address current problems in Earth history, paleoecology, and evolutionary biology. Examples are drawn from both vertebrates and invertebrates. Lab combines analytical paleontological methods with a systematic survey of important fossil groups. Prereq: ESCI 402 or permission. Special fee. Lab.

**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. Prereq: CHEM 404 or CHEM 405 or NR 561, MATH 425 or MATH 424B.

**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 and analysis and modeling in Matlab. Prereq: MATH 426, and ESCI 401, ESCI 402 or ESCI 501; or permission.

**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. Prereq: ESCI 654. Special fee. Lab. Writing intensive.

**Attributes:** Writing Intensive Course

**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. Prereq: ESCI 654. Special fee. Lab.

**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

**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. Prereq: ESCI 614; adequate calculus, chemistry, and physics. Field trips. Special fee. Lab.

**Attributes:** Writing Intensive Course

**Equivalent(s):** ESCI 725

**ESCI #734 - Geophysics****Credits: 0 or 4**

The structure of the solid Earth, including the continental and oceanic lithosphere and the deep interior as revealed by investigations of seismic waves, the Earth's gravitational and magnetic fields, heat flow, and earthquakes. Prereq: ESCI 401; one year of calculus; one year of college physics; ESCI 658; or permission. Special fee. Lab.

**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. Prereq: MATH 426; CHEM 404 or permission. Lab. Writing intensive.

**Attributes:** Writing Intensive Course

**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. Prereq: MATH 426, CHEM 404. Special fee. Lab.

**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. Prereq: CHEM 404 and MATH 426.

**ESCI #750 - Biological Oceanography****Credits: 4**

Biological processes of the oceans, including primary and secondary production, trophodynamics, plankton diversity, zooplankton ecology, ecosystems and global ocean dynamics. Field trips on R/V Gulf Challenger and to the Jackson Estuarine Laboratory. Prereq: one year of biology or permission of the instructor. (Also offered as ZOOL 750.) Special fee. Lab. (Not offered every year.)

**Equivalent(s):** EOS 750, ZOOL 750

**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. Prereq: MATH 426 and CHEM 404.

**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. Prereq: ESCI 401 or ESCI 402 or ESCI 501, and ESCI 512; or permission. Special fee. Lab and field trips.

**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. Prereq: ESCI 614 or ESCI 631 or permission. Special fee. Writing intensive.

**Attributes:** Writing Intensive Course

**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. Prereq: PHYS 407; ESCI 501;/or permission.

**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. Prereq: Senior standing in Earth Science major or permission. Writing intensive.

**Attributes:** Writing Intensive Course

**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. Prereq: Introductory Chemistry, Introductory Geology.

**ESCI 762 - Glacial Geology****Credits: 4**

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 large-scale geomorphic change, as well as their central role in the Earth's past and present climate system. Labs involve analysis of glaciological data, glacial-geologic map interpretation, and short field exercises. Course incorporates one mandatory weekend field trip that explores the glacial landscapes of New England. Prereq: ESCI 561 or permission. Special fee. Lab. Writing intensive.

**Attributes:** Writing Intensive Course

**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. Prereq: MATH 426.

**Equivalent(s):** OE 764

**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. Writing intensive.

**Attributes:** Writing Intensive Course

**Equivalent(s):** EOS 765

**ESCI 766 - Volcanology****Credits: 4**

Provides a comprehensive overview of volcanic processes and their influences on planetary evolution and modern-day Earth systems. Lectures discuss the generation and properties of magma, tectonic setting of volcanism, eruption styles, volcanic landforms and products, monitoring of active volcanoes, volcanic hazards, and volcanism on other planets. Laboratory topics include modeling volcanic processes, hand-sample observation, topographic map interpretation, volcanographical data analysis, and two afternoon field trips. As volcanology is a rapidly developing field of active research, the course incorporates discussions of recent and emerging scientific papers from the literature and student-led updates of ongoing volcanic activity. Prereq: one year of calculus and one ESCI course or permission. Special fee. Lab.

**Attributes:** Writing Intensive Course

**ESCI 771 - Geodesy and Positioning for Ocean Mapping****Credits:** 4

The science and technology of acquiring, managing, and displaying geographically-referenced information; the size and shape of the earth, datums and projections; determination of precise positioning of points on the earth and the sea, including classical terrestrial-based methods and satellite-based methods; shoreline mapping, nautical charting and electronic charts. Prereq: MATH 426, PHYS 408. (Also listed as OE 771.)

**Equivalent(s):** OE 771**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. Prereq: Undergraduate Science Course.

**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. Prereq: Undergraduate Science Course.

**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.

**Equivalent(s):** EOS 795**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.

**ESCI 797 - Colloquium****Credits:** 0

Presentation of recent research in the earth sciences by guest speakers and department faculty. Cr/F.

**Repeat Rule:** May be repeated up to 3 times.

**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. Writing intensive.

**Attributes:** Writing Intensive Course

**Repeat Rule:** May be repeated for a maximum of 4 credits.