**EARTH SCIENCES (ESCI)**

**Degree Offered: M.S.**

*This program is offered in Durham.*

The Department of Earth Sciences offers the master of science degree in Earth Sciences with options in geology and ocean mapping, and a specialization in geochemical systems. The department also offers the master of science degree in hydrology, and a master of science and a Ph.D. in Oceanography. A Ph.D. in Earth and Environmental Sciences is offered through the Natural Resources and Earth System Science Program. Students may also pursue a graduate certificate in Ocean Mapping, offered in partnership with the Center for Coastal and Ocean Mapping. Graduate students in the department may conduct research with faculty members in the Department of Earth Sciences; the Institute for the Study of Earth, Oceans, and Space; the Center for Coastal and Ocean Mapping; and the School of Marine Science and Ocean Engineering. Durham, where the University is located, is situated where the Oyster River enters Great Bay, one of the most important estuaries of the Gulf of Maine. Only ten miles away are the Atlantic beaches and Portsmouth, a deep water harbor.

**The M.S. Geology option** is intended for students with interests in petrology, mineralogy, structural geology, tectonics, geophysics, sedimentology, glacial geology, paleoclimate, glaciology, hydrogeology, stratigraphy, paleontology, low- or high-temperature geochemistry, and isotopic geochemistry.

**The M.S. Ocean Mapping option** is intended for students with interests in hydrography and hydrographic survey technology.

**The M.S. Geochemical Systems Specialization** is intended for students with interests in all aspects of geochemistry: bedrock, sediment, water, ice, and air with particular emphasis on interpreting and modeling the interaction of these media (e.g., biogeochemistry, air quality, and climate change).

**The M.S. in Hydrology** is intended for students with interests in fluvial processes, global-scale hydrology, groundwater hydrology, hydroclimatology, surface-water hydrology, water quality, and quantitative and statistical hydrology, and water resource management.

**Degree Requirements**

Students in the M.S. programs are required to complete the core curriculum for their respective areas and complete either the thesis or non-thesis option.

Students in the thesis option must satisfactorily complete at least 30 credits, which include the credits accumulated in the core curriculum. Students in this option must complete a master’s thesis (6 credits) and give an oral presentation of the results.

Students in the non-thesis option must satisfactorily complete at least 34 credits, which includes the core curriculum, a 2-credit directed research project (ESCI 898 Directed Research), and a written and oral presentation of that research.

[https://ceps.unh.edu/earth-sciences](https://ceps.unh.edu/earth-sciences)
ESCI 826 - 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 magmatic records of magma chamber systematics. Metamorphic systems include pelitic, mafic, and calc silicate rocks, with special emphasis on closed- and open-system reactions, multi-systems, reaction space, and pressure-temperature-time paths. Prereq: ESCI 614; adequate calculus, chemistry, and physics. Field trips. Special fee. Lab.  
Grade Mode: Letter Grading  
ESCI #834 - 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; or permission. Special fee. Lab.  
Grade Mode: Letter Grading  
ESCI 841 - 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 processes/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. Prereq: one year each chemistry, calculus.  
Grade Mode: Letter Grading  
ESCI 845 - 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. Special fee. Lab. Prereq: one year each chemistry and calculus.  
Grade Mode: Letter Grading  
ESCI 847 - 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: 1 year of college calculus and chemistry or geochemistry.  
Grade Mode: Letter Grading  
ESCI 852 - 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: one year of college chemistry and calculus or permission.  
Grade Mode: Letter Grading  
ESCI 854 - 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. Special fee.  
Grade Mode: Letter Grading  
ESCI 856 - 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.  
Grade Mode: Letter Grading  
ESCI 858 - Introduction to 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: calculus based physics, introduction to oceanography; or permission.  
Grade Mode: Letter Grading  
ESCI 859 - 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.  
Grade Mode: Letter Grading  
ESCI 860 - 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.  
Grade Mode: Letter Grading
ESCI 862 - 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. Special fee. Lab.
Grade Mode: Letter Grading

ESCI 864 - 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: Calculus.
Equivalent(s): OE 864
Grade Mode: Letter Grading

ESCI 865 - 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 1.8 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.
Equivalent(s): EOS 865
Grade Mode: Letter Grading

ESCI 866 - 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, volcanological 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: on year of calculus and one Earth Science course or permission. Special fee. Lab.
Grade Mode: Letter Grading

ESCI 868 - Applied Physical Oceanography for Hydrographic Surveyors
Credits: 2
This course provides a context-specific examination of physical oceanographic phenomena that impact the quality of hydrographic surveys. This includes a review of global scale ocean circulation followed by a particular focus on processes controlling the variability of coastal and continental shelf oceanography. The instruments used, and the available ocean climatological databases are emphasized. The course is designed to meet the oceanography requirement for the Category A FIG/IHO/ICA Standards of Competence for Hydrographic Surveyors.
Grade Mode: Letter Grading

ESCI 869 - Marine Geology and Geophysics for Hydrographic Surveyors
Credits: 2
This course provides an overview of the geology, physiography, and sediments of the ocean basins, continental margins, shelves and coastal zone, formation and distribution of sediments, major substrate types, and gravity and magnetic fields. It introduces the main marine geophysical techniques (seisms, gravity, magnetics) and describes their methodology and derived information content. The course is designed to meet the marine geology and geophysics requirement for the Category A FIG/IHO/ICA Standards of Competence for Hydrographic Surveyors.
Grade Mode: Letter Grading

ESCI 871 - 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: one year of calculus and one year of college physics. (Also offered as OE 871.)
Equivalent(s): OE 871
Grade Mode: Letter Grading

ESCI 872 - Applied Tools for Ocean Mapping
Credits: 2
A review course on research tools commonly used in ocean mapping. The course focuses on teaching problem solving skills, note merely the application of tools. The course consists of modules addressing the use of: IHS Fledermass; GeoMappApp, GIS, Google Earth, Matlab as well as the effective library research and use of Wikis. Prereq: two terms of single variable calculus. Cr/F.
Equivalent(s): OE 872
Grade Mode: Graduate Credit/Fail grading

ESCI 874 - Integrated Seabed Mapping Systems
Credits: 4
Overview of typical applications that involve mapping the sediment-water interface in the ocean and adjacent waters. Emphasis on defining the task-specific resolution and accuracy requirements. Fundamentals of acoustics relevant to seabed mapping. Progressions through typical configurations involving single beam, sidescan, phase differing and multibeam systems. Integration of asynchronous 3D position, orientation and sound speed measurements with sonar-relative acoustic travel times and angles. Analysis of impact of offsets, mis-alignments and latency in all integrated sensors. Prereq: two terms each of college calculus and physics. Pre- or Co-req: MATH 831 or equivalent material.
Equivalent(s): OE 874
Grade Mode: Letter Grading
ESCI 875 - Advanced Topics in Ocean Mapping
Credits: 4
The second of two courses covering the principles and practices of hydrography and ocean mapping. In this course the following topics are covered: Verification and Field QA/QC, Water Levels (Tides); Mapping Standards; Survey Planning, Execution and Reporting; Terrain Analysis; Optical Remote Sensing; Data Presentation; Seafloor Characterization; Electronic Navigational Charts; Hydrography for Nautical Charting. Product Liability and contracts; and the United Nations Common Law of the Sea (UNCLOS). Prereq: ESCI 872, ESCI 874/OE 874, two terms each of college calculus and physics. Pre- or Co-req: MATH 831 or equivalent material.
Equivalent(s): OE 875
Grade Mode: Letter Grading

ESCI 877 - 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 open source program QGIS. Additional work will develop programming skills using the python language. Programming background is not required but beneficial. Prereq: Undergraduate Science Course.
Equivalent(s): GSS 807, GSS 809, NR 860
Grade Mode: Letter Grading

ESCI 878 - Remote Sensing Earth & Environmental Sciences
Credits: 4
Remote sensing provides insight to 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.
Equivalent(s): GSS #817
Grade Mode: Letter Grading

ESCI 895 - Topics
Credits: 1-4
Study on an individual or group basis in geologic, hydrologic, or oceanographic problems, under members of the graduate staff. 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; earth science teaching methods. Prereq: permission of staff concerned. May be repeated.
Grade Mode: Letter Grading

ESCI 896 - Topics
Credits: 1-4
Study on an individual or group basis in geologic, hydrologic, or oceanographic problems, under members of the graduate staff. 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; earth science teaching methods. Prereq: permission of staff concerned. May be repeated. Special fee on some topics.
Grade Mode: Graduate Credit/Fail grading

ESCI 898 - Directed Research
Credits: 2
Research project on a specified topic in the Earth Sciences, guided by a faculty member. Cr/F.
Grade Mode: Graduate Credit/Fail grading

ESCI 899 - Master's Thesis
Credits: 1-6
May be repeated up to a maximum of 6 credits. Cr/F.
Repeat Rule: May be repeated for a maximum of 6 credits.
Grade Mode: Graduate Credit/Fail grading

ESCI 972 - Hydrographic Field Course
Credits: 4
A lecture, lab, and field course on the methods and procedures for the acquisition and processing of hydrographic and ocean mapping data. Practical experience in planning and conducting hydrographic surveys. Includes significant time underway (day trips and possible multi-day cruises) aboard survey vessel(s). Prereq: Introduction to Ocean Mapping; Geodesy and Positioning for Ocean Mapping; or permission. (Also listed as OE 972.)
Equivalent(s): OE 972
Grade Mode: Letter Grading

ESCI 973 - Seafloor Characterization
Credits: 3
Remote characterization of seafloor properties using acoustic (echo sounders, sub-bottom profilers, side-scan, multi-beam and interferometric sonars) and optical (video and laser linescanner) methods. Models of sound interaction with the seafloor will be explored as well as a range of possible geologic, geotechnical, morphologic, acoustic, and biologic descriptors. Prereq: permission. (Also listed as OE 973.)
Equivalent(s): OE 973
Grade Mode: Letter Grading

ESCI 993 - Advanced Seminar
Credits: 1
Focused seminar in a discipline of earth sciences: earth, ocean, atmosphere, or hydrology. Can not be concurrently enrolled in ESCI 997.
Repeat Rule: May be repeated for a maximum of 4 credits.
Grade Mode: Graduate Credit/Fail grading

ESCI 995 - Advanced Topics
Credits: 1-4
Advanced work on an individual or group basis. Prereq: permission. May be repeated.
Grade Mode: Letter Grading
ESCI 996 - Advanced Topics  
**Credits:** 1-4  
Advanced work on an individual or group basis. Prereq: permission. May be repeated.  
**Equivalent(s):** EOS 996  
**Grade Mode:** Letter Grading

ESCI 997 - Seminar in Earth Sciences  
**Credits:** 1  
Readings, discussion, and presentation of recent investigations in the earth sciences. Required of all M.S. students in Earth Sciences. Cr/F. Can not be concurrently enrolled in ESCI 993.  
**Grade Mode:** Graduate Credit/Fail grading

ESCI 998 - Proposal Development  
**Credits:** 1  
Introduction to research in the earth sciences and development of thesis and directed research proposals. Required of all M.S. students in Earth Sciences. Can not be concurrently enrolled in ESCI 994.  
**Grade Mode:** Letter Grading

ESCI 999 - Doctoral Research  
**Credits:** 0  
Cr/F.  
**Grade Mode:** Graduate Credit/Fail grading

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**Faculty**

See [https://nextcatalog.unh.edu/graduate/programs-study/earth-sciences/](https://nextcatalog.unh.edu/graduate/programs-study/earth-sciences/) for faculty.