MAJOR

The Geosciences major offers an understanding of the evolution of our planet and its interacting global systems. In this era of global change, geoscience provides the tools that can help us learn to live sustainably with our environment, and appreciate our place within the vastness of Earth history. Forces within the Earth create mountain ranges and ocean basins and drive the movements of continents. Wind, water and ice shape the surface of the Earth, making and changing the landscapes around us. Sedimentary rocks and the fossils within them teach us how life and climate have evolved over the vastness of time.

Geosciences graduates have a wide range of career options, both with and without graduate training. The many choices include environmental consulting, hazard assessment, hydrology, gemology, the energy and mining industries, outdoor education, and research and teaching in universities, colleges, and secondary schools. Many students choose to double-major in fields as diverse as Art, Economics, History, Physics, Mathematics, English, and Philosophy, and often find jobs where they can apply the synergies of their Geosciences double major. No matter what field they enter, all our Geosciences graduates pursue their lives and careers with a deeper appreciation for the natural world around them.

The major is designed to provide a solid grounding in the geosciences while being adaptable enough to accommodate diverse paths driven by student interests. There are no required courses, but students work through the menu below, which allows a lot of scheduling flexibility.

The Geosciences major includes at least one and at most two 100-level courses:

- GEOS 100 Introduction to Weather and Climate
- GEOS 101 The Co-Evolution of Earth and Life
- GEOS 102 An Unfinished Planet
- GEOS 103 Global Warming and the Reshaping of Landscapes
- GEOS 104 Oceanography

At least two 200-level courses selected from this group:

- GEOS 201 Geomorphology
- GEOS 202 Mineralogy
- GEOS 205 Earth Resources
- GEOS 210/MAST 211 Oceanographic Processes
- GEOS 212/BIOL 211 Paleobiology
- GEOS 214 Mastering GIS
- GEOS 215 Climate Changes

At least two 300-level courses selected from this group:

- GEOS 301 Structural Geology
- GEOS 302 Sedimentology
- GEOS 303 Igneous and Metamorphic Petrology

At least one of the following 400-level courses:

- GEOS 401 Global Tectonics and the Rise of Mountains
Finally, students must take enough electives to bring the total to a minimum of nine courses.

**PREPARATION FOR GRADUATE SCHOOL**

Although many of our majors take geoscience jobs after graduation, many choose to go to graduate school, and most graduate programs will expect students to have a background in mathematics as well as a year or so of study in related sciences, in addition to the requirements of the Geosciences major. Students considering graduate work in geosciences should therefore consult with faculty to ensure that they plan wisely. The selection of outside courses will depend on the field in which a student wants to specialize. Graduate programs in solid-earth geosciences commonly expect entering students to have taken courses in chemistry. For those going into environmental geosciences, courses in chemistry, computer science and/or statistics are recommended. For those considering geobiology programs, biology courses are important. For students entering planetary geology, physics is recommended.

**THE DEGREE WITH HONORS IN GEO SCIENCES**

The degree with honors in Geosciences provides students with an opportunity to undertake an independent research project under the supervision of a faculty member, culminating in a thesis that demonstrates outstanding achievement of an original and innovative nature. In addition to the major requirements listed above, those who are candidates for the degree with honors take the following sequence in the Fall, Winter Study, and Spring of their senior year:

- **GEOS 493-031-494 Senior Research and Thesis**

The principal considerations in admitting a student to a program of independent research are interest and motivation, mastery of fundamental material and skills, and ability to pursue independent study successfully. Interested students should talk to members of the department about project options at any time, but generally no later than January of the Junior year.

**STUDY AWAY**

Students planning to study off-campus should meet as early as possible with the Department Chair to plan and to discuss how potential courses might be used in the major. Although most study-away programs do not offer geoscience courses, there are some that dovetail well with Geosciences. Examples include the Williams-Mystic program, the Frontiers Abroad program at Canterbury University in New Zealand, and the program at the University of Otago in New Zealand. Courses offered at Norwegian Technical Universities and at several universities in the United Kingdom have also been accepted. Up to two geoscience courses taken away from Williams can be counted toward the nine-course major. Be sure to meet with a Geosciences faculty advisor or Department Chair to discuss your plans and ideas for off-campus work.

**FAQ**

Students MUST contact departments/programs BEFORE assuming study away credit will be granted toward the major or concentration.

**Can your department or program typically pre-approve courses for major/concentration credit?**

Generally not until after a student returns and can provide course material for review (e.g. Syllabus and/or completed work such as exams, portfolios, lab reports and the like).

**What criteria will typically be used/required to determine whether a student may receive major/concentration credit for a course taken while on study away?**

Complete syllabus and course description, including readings, assignments, evaluation criteria.

**Does your department/program place restrictions on the number of major/concentration credits that a student might earn through study away?**

Yes. A maximum of two courses can be credited toward major requirements.

**Does your department/program place restrictions on the types of courses that can be awarded credit towards your major?**

No.

**Are there specific major requirements that cannot be fulfilled while on study away?**

No.

**Are there specific major requirements in your department/program that students should be particularly aware of when weighing study away options? (Some examples might include a required course that is always taught in one semester, laboratory requirements.)**

Students should consult with the chair or other department faculty members to plan ahead and make sure that requirements can be met.

Give examples in which students thought or assumed that courses taken away would count toward the major or concentration and then...
GEOS 11 (W) River Restoration in Practice

River restoration is a growing billion-dollar international industry. Since the environmental movement began in the 1960s and 1970s, renewed interest in the beauty and benefits of healthy streams has resulted in increased research, funding, and applied restoration of rivers, streams, wetlands, and riparian corridors. The restoration of rivers and streams comes in many different forms including dam removal and in-channel habitat restoration. In this course, we'll learn about the history of restoration and the basics of fluvial geomorphology and hydrology. We will gain applied knowledge and experience with the practice of restoration through a combination of lectures, classroom exercises, conversations with restoration advocates and practitioners, field trips and field data collection. A final practicum will involve the design of a restoration project. The course will generally be structured around three sections: Science: Week 1 will primarily involve lectures and classroom exercises and discussion of the literature, learning about the history and evolution of river restoration as well as the basics of the science that drives restoration. Data Collection and Analysis: Week 2 will focus on data collection and analysis typically required for river restoration projects. This will include topographic surveying, geomorphic and habitat mapping, pebble counts, stream discharge measurements, GIS mapping, and hydraulic modeling. Intensive Practicum: Small groups of students will be given a real restoration project example to research, analyze, and design. This practicum will include data collection, GIS analysis, flow modeling, and design plan sheets describing the restoration plan. The class will meet on average 8 hours per week and will include up to 3 day-long field trips. Students should expect to be outside for portions of the day collecting field data in/near rivers in winter conditions.

Adjunct Instructor Bio: Nick Nelson is a fluvial geomorphologist and regional director for Inter-Fluve, a river and wetland restoration company. He has assessed hundreds of miles of river and designed/managed the removal of more than a dozen dams in New England. He has lectured at the University of MN, Tufts University, University of TN, and currently teaches courses at Northeastern University and the Harvard Graduate School of Design.

Class Format: afternoons
Requirements/Evaluation: students will be evaluated based on their final group design submittal
Prerequisites: none, though some background in GIS and a scientific field (geology, biology, ecology, etc.) will be useful
Enrollment Limit: 15
Enrollment Preferences: background in scientific fields of study
Materials/Lab Fee: $16
Attributes: EXPE Experiential Education Courses

Winter 2019
LEC Section: 01 Cancelled

GEOS 12 (W) Geology of the National Parks

Crosslistings: ENVI12 / GEOS12
Primary Crosslisting

A vicarious trip through a variety of national parks of the U.S. and Canada to appreciate the geological basis of their spectacular scenery. Areas will be selected to portray a wide range of geological processes (volcanism, desert and coastal erosion, mountain building, glaciation, etc.). We will meet most mornings during the first two weeks for highly illustrated classes supplemented by the interpretation of topographic and geologic maps and by out-of-class study of rock samples. Reading will be from a paperbound text (PARKS AND PLATES) and from short publications by the U.S. Geological Survey and by natural history associations linked to the parks. The second part of the month will involve independent meetings with the instructor to prepare an oral report about the geology of a park of the student’s choice. These reports during the last week will be comprehensive and well-illustrated, using PowerPoint and pertinent maps and samples. A detailed outline and bibliography will be distributed by the presenter at the time of the report.

Class Format: mornings
Requirements/Evaluation: final project
Prerequisites: none
Enrollment Limit: 10
Enrollment Preferences: preference to first-year students

Materials/Lab Fee: approximately $125 for books

Winter 2019
LEC Section: 01    M-F 10:00 am - 11:50 am PORG 10:00 am - 11:50 am    Bud Wobus

GEOS 22 (W) Geosciences Research
Students will spend part of Winter Study doing fieldwork collecting data. Back at Williams, they will analyze the data. Each student will have responsibility for a subset of the data, and the individual sub-projects will contribute to the overall research.
Class Format: to be arranged with instructor
Requirements/Evaluation: final project
Prerequisites: two Geosciences courses; permission of the instructor required before registering for the course
Enrollment Limit: 3
Expected Class Size: 3
Materials/Lab Fee: $0
Not offered current academic year

GEOS 31 (W) Senior Thesis: Geosciences
To be taken by students registered for Geosciences 493-494.
Class Format: thesis
Distributions: (D3)

Winter 2019
HON Section: 01    TBA    Mea S. Cook

GEOS 99 (W) Independent Study: Geosciences
Open to upperclass students. Students interested in doing an independent project (99) during Winter Study must make prior arrangements with a faculty sponsor. The student and professor then complete the independent study proposal form available online. The deadline is typically in late September. Proposals are reviewed by the pertinent department and the Winter Study Committee. Students will be notified if their proposal is approved prior to the Winter Study registration period.
Class Format: independent study
Distributions: (D3)

Winter 2019
IND Section: 01    TBA    Mea S. Cook

GEOS 100 (S) Introduction to Weather and Climate
Crosslistings: GEOS100 / ENVI100
Primary Crosslisting
How is it that we have such a hard time predicting if it’s going to rain next week, but we can be confident in projections of future climate change decades from now? This course will explore the atmosphere and how air moves and changes, understanding the wind, clouds, precipitation, and extreme events (including thunderstorms, hurricanes, and tornados) that form our weather. Building off of our understanding of the atmosphere, we'll look at longer time scales to develop a basic understanding of earth’s climate, global heat and moisture transport, climate change, and the ways that oceans and glaciers interact with the climate. We will look at weather and climate models to learn how to scientists and meteorologists predict future conditions. Labs will include local field trips, bench top experiments, and learning how to run a climate model on a computer.
Class Format: lecture
Requirements/Evaluation: class participation, labs, one midterm and a final exam
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: none
Enrollment Limit: 40
Enrollment Preferences: first-years and sophomores
Expected Class Size: 40
Distributions: (D3)
Attributes: EXPE Experiential Education Courses

Spring 2019
LEC Section: 01 MWF 11:00 am - 11:50 am Alice C. Bradley
LAB Section: 02 M 1:00 pm - 3:00 pm Alice C. Bradley
LAB Section: 03 T 1:00 pm - 3:00 pm Alice C. Bradley

GEOS 101 (F) The Co-Evolution of Earth and Life
Crosslistings: GEOS101 / ENVI105
Primary Crosslisting
Our planet is about 4.6 billion years old and has supported life for at least the last 3.5 billion of those years. This course will consider the inter-related nature of Earth and the life that inhabits it, starting with the first living organisms and progressing to the interaction of our own species with the Earth today. Students will investigate the dynamic nature of the Earth-life system, examine many of its feedbacks, and learn about the dramatic changes that have occurred throughout the history of the Earth. We will ask questions such as: How did the Earth facilitate biologic evolution, and what effects did those biologic events have on the physical Earth? When did photosynthesis evolve, how can we detect that in the rock record, and how did this biological event lead to profound changes in the environment? How and why did animals evolve and what role did environmental change play in the radiation of animal life? How did the rise and radiation of land plants affect world climate? How do plate tectonics, glaciation, and volcanism influence biodiversity and evolutionary innovation? What caused mass extinctions in the past and what can that teach us about our current extinction crisis? Labs will involve hands-on analysis of rocks, fossils, and real-world data as well as conceptual and analytical exercises; field trips will contextualize major events in Earth history and will help students learn to read the rock record. Through these investigations, the class will provide a comprehensive overview of Earth history, with special attention paid to the geological and paleontological history of the northeastern United States.
Class Format: lecture; one laboratory per week plus one all-day field trip
Requirements/Evaluation: evaluation will be based on lab work, short quizzes, midterms, an independent project, and a final exam
Prerequisites: none
Enrollment Limit: 30
Enrollment Preferences: underclassmen
Expected Class Size: 30
Distributions: (D3)
Attributes: ENVI Natural World Electives; EXPE Experiential Education Courses

Fall 2018
LEC Section: 01 MWF 10:00 am - 10:50 am Phoebe A. Cohen
LAB Section: 02 M 1:00 pm - 3:00 pm Phoebe A. Cohen
LAB Section: 03 T 1:00 pm - 3:00 pm Phoebe A. Cohen

GEOS 102 (S) An Unfinished Planet
The Earth is a work-in-progress, an evolving planet whose vital signs--as expressed by earthquakes, volcanic eruptions, and shifting plates--are still strong. In a geological time frame, nothing on Earth is permanent: ocean basins open and close, mountains rise and fall, continental masses accrete and separate. There is a message here for all of us who live, for an infinitesimally brief time, on the moving surface of the globe. This course uses the
plate tectonics model--one of the fundamental scientific accomplishments of the past century--to interpret the processes and products of a changing Earth. The emphasis will be on mountain systems (on land and beneath the oceans) as expressions of plate interactions. Specific topics include the rocks and structures of modern and ancient mountain belts, the patterns of global seismicity and volcanism, the nature of the Earth's interior, the changing configurations of continents and ocean basins through time, and, in some detail, the formation of the Appalachian Mountain system and the geological assembly of New England. Readings will be from a physical geology textbook, a primary source supplement, selected writings of John McPhee, and references about the geology of the Northeast.

**Class Format:** lecture, three hours per week; lab (several involving field work), two hours per week; one required all-day field trip on the last Monday of the semester to the Connecticut Valley and the highlands of western Massachusetts

**Requirements/Evaluation:** evaluation will be based on two hour-tests, weekly lab work, and a scheduled final exam

**Prerequisites:** none

**Enrollment Limit:** 40

**Enrollment Preferences:** first-year and sophomore students

**Expected Class Size:** 40

**Distributions:** (D3)

**Attributes:** ENVI Natural World Electives; EXPE Experiential Education Courses

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**Spring 2019**

LEC Section: 01  MWF 10:00 am - 10:50 am  Bud Wobus
LAB Section: 02  W 1:00 pm - 3:00 pm  Bud Wobus
LAB Section: 03  R 1:00 pm - 3:00 pm  Bud Wobus

**GEOS 103 (F) Global Warming and Environmental Change**

Crosslistings: ENVI103 / GEOS103

**Primary Crosslisting**

Earth is the warmest it has been for at least five centuries, and the surface of our planet is responding. From extreme floods and drought to landslides and soil erosion, the natural processes that shape the Earth's surface are tied to temperature and precipitation, and as those change, the landscape reacts. People are beginning to feel the impacts, but in different ways depending on where we call home. Our ability to cope with the changes also depends are where we are, with low-income nations the least able to implement costly adaptive strategies. In this course, we will take a tour of the planet, investigating how climate change is altering landscapes and the natural processes that support them. Ultimately, we will develop an understanding of the consequences of climate change that connects physical processes with the geography of place. Specific topics include foundations of the Earth system, plate tectonics and the construction of landscapes, Earth materials, rivers and flooding, hillslope processes, coastal processes, and climate impacts on natural resources such as freshwater and soil. Labs will use local field sites and analytical exercises to evaluate recent cases that reflect an interaction of the landscape and climate.

**Class Format:** lecture/discussion, three hours per week; laboratory, two hours per week in alternate weeks/occasional field trips

**Requirements/Evaluation:** evaluation based on written reports from laboratories, class participation, weekly quizzes, a midterm and final exam

**Prerequisites:** none

**Enrollment Limit:** 48

**Enrollment Preferences:** first-year and sophomore students

**Expected Class Size:** 48

**Distributions:** (D3)

**Attributes:** ENVI Natural World Electives; EXPE Experiential Education Courses; SCST Related Courses

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**Fall 2018**

LEC Section: 01  MWF 11:00 am - 11:50 am  José A. Constantine
LAB Section: 02  M 1:00 pm - 3:00 pm  José A. Constantine
LAB Section: 03  W 1:00 pm - 3:00 pm  José A. Constantine
GEOS 104 (S)  Oceanography  
Crosslistings: MAST104 / ENVI104 / GEOS104

Primary Crosslisting

The oceans cover about 72% of Earth's surface, yet we know the surface of Venus better than our own ocean floors. Why is that? This integrated introduction to the oceans covers formation and history of the ocean basins; the composition and origin of seawater; currents, tides, and waves; ocean-atmosphere interactions; oceans and climate; deep-marine environments; coastal processes; productivity in the oceans; and human impacts. Coastal oceanography will be investigated on an all-day field trip, hosted by the Williams-Mystic program in Connecticut.

Class Format: lecture/discussion, three hours per week; laboratory, two hours per week in alternate weeks/one all-day field trip

Requirements/Evaluation: evaluation will be based on two hour exams, lab work, participation in the field trip, and a final exam

Extra Info: not available for the fifth course option

Prerequisites: none

Enrollment Limit: 48

Enrollment Preferences: first-year and sophomore students

Expected Class Size: 48

Distributions: (D3)

Attributes: ENVI Natural World Electives; EXPE Experiential Education Courses

Not offered current academic year

GEOS 201 (F)  Geomorphology  
Crosslistings: GEOS201 / ENVI205

Primary Crosslisting

Geomorphology is the study of landforms, the processes that shape them and the rates at which surface processes change the landscape in which we live. The course is designed for Geosciences majors and for environmental studies students interested in surficial geologic processes and their importance in shaping the physical environment. We emphasize the influence of climatic, tectonic, and volcanic forces on landform evolution over relatively short periods of geologic time, generally thousands to a few millions of years. At this time scale, the influence of human activity and climate change on geomorphic processes is strong, perhaps dominant, in many geologic environments. Many of our examples analyze human interaction - planned or unplanned-- with geomorphic processes. Labs focus on field measurements of channels and landscapes in the Williamstown area as well as on the analysis of topographic maps and imagery.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week/student projects; weekend field trip to the White Mountains

Requirements/Evaluation: evaluation will be based on two hour exams, a project, lab work and class participation

Prerequisites: any 100-level GEOS course or permission of instructor

Enrollment Limit: 18

Expected Class Size: 15

Distributions: (D3)

Attributes: AMST Space and Place Electives; ENVI Natural World Electives; EVST Environmental Science; EXPE Experiential Education Courses

Fall 2018

LEC Section: 01  TR 11:20 am - 12:35 pm  José A. Constantine

LAB Section: 02  R 1:00 pm - 4:00 pm  José A. Constantine

GEOS 202 (S)  Mineralogy

This course could be subtitled "An Introduction to Earth Materials and Analytical Techniques." As the basis for all subsequent solid-earth courses in the major, it provides a systematic framework for the study of minerals--Earth's building blocks: their physical and chemical properties at all scales and the common analytical methods used to identify and interpret them. The course progresses from hand-specimen morphology and crystallography through element distribution and crystal chemistry to the phase relations, compositional variation, and mineral associations within major rock-forming mineral systems. Laboratory work includes the determination of crystal symmetry; mineral separation; the principles and applications of optical
emission spectroscopy; wavelength- and energy-dispersive x-ray spectrochemical analysis; x-ray diffraction; the use of the petrographic microscope; and the identification of important minerals in hand specimen and thin section.

Class Format: lecture, three hours per week; laboratory, three hours per week; independent study of minerals in hand specimen; one afternoon field trip

Requirements/Evaluation: evaluation will be based on one hour test, lab work, and a final exam

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: one 100-level GEOS course or permission of instructor

Enrollment Limit: 14

Enrollment Preferences: sophomores and juniors planning to take GEOS 301, 302 and/or 303 in the subsequent year

Expected Class Size: 12

Distributions: (D3)

Attributes: EXPE Experiential Education Courses; MTSC Courses

Spring 2019

LEC Section: 01    TR 8:30 am - 9:45 am     Bud  Wobus
LAB Section: 02    T 1:00 pm - 4:00 pm     Bud  Wobus

GEOS 205 (F)  Earth Resources

Crosslistings: ENVI207 / GEOS205

Primary Crosslisting

The metal in your soda can, the plastic in your Nalgene, the components of your computer, the glass in your window, the hydrocarbons being burned to keep you warm in the winter or to transport you in cars or aircraft, the cars and aircraft themselves: all are made of materials mined from the Earth. Right now there are more people building more houses, paving more roads, making more vehicles, more electronics, and more plastic packaging— all with geologic materials. As demand soars in both established and growing economies, and as we realize the environmental damage that can result from resource extraction and processing, the importance of understanding Earth's resources increases. Finding new deposits and managing those we have requires insight into the geology that underlies the location and origin of strategic Earth materials. This class introduces the geologic processes that control formation, distribution, and extent of materials reserves: dimension stone and gravel, base and precious metal ores, gemstones, petroleum, nuclear energy sources, and specialty materials for medical, technological, and military uses.

Class Format: lecture

Requirements/Evaluation: one hour exam, a final exam, lab exercises, and class participation

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: one 100-level GEOS course or permission of instructor

Enrollment Limit: 18

Enrollment Preferences: sophomores and Geosciences majors

Expected Class Size: 18

Distributions: (D3)

Attributes: ENVI Natural World Electives

Not offered current academic year

GEOS 210 (F)  Oceanographic Processes

Crosslistings: GEOS210 / MAST211

Secondary Crosslisting

This course examines ocean and coastal environmental science issues including carbon dioxide and the ocean's role in climate, El Niño and other ocean-atmosphere oscillations that influence our weather, coastal erosion and other hazards, coastal pollution, and fisheries. The focus is on controlling processes with regional comparisons. Blue water oceanography is conducted in the Atlantic and comparative coastal oceanography includes trips to southern New England shores, and the West and Gulf coasts of the US as part of the Williams-Mystic program.
**GEOS 212 (S)  Paleobiology**

Crosslistings: BIOL211 / GEOS212

The fossil record is a direct window into the history of life on Earth and contains a wealth of information on evolution, biodiversity, and climate change. This course investigates the record of ancient life forms, from single-celled algae to snails to dinosaurs. In addition to the intellectual discovery of fossils as organic relics and the ways in which fossils have been used to support conflicting views on nature, geologic time, and evolution, we will cover a range of topics central to modern paleobiology. These include: how the fossil record informs our understanding of evolutionary processes including speciation; the causes and consequences of mass extinctions; how fossils help us tell time and reconstruct the Earth’s climactic and tectonic history; statistical analysis of the fossil record to reconstruct biodiversity through time; analysis of fossil morphology to recreate the biomechanics of extinct organisms; and using fossil communities to reconstruct past ecosystems. Laboratory exercises will take advantage of Williams’ superb fossil collections as well as published datasets to provide a broad understanding of fossils and the methods we use to study the history of life on Earth. We will also view a diversity of fossils in their geologic and paleo-environmental context on our field trip to Eastern New York.

**Class Format:** lecture/laboratory; field trip to the Paleozoic of New York State

**Requirements/Evaluation:** evaluation will be based on lab assignments, short quizzes and writing assignments, and a final exam

**Prerequisites:** any 100-level GEOS course or BIOL 102, 203 or 205

**Enrollment Limit:** 15

**Enrollment Preferences:** sophomores and juniors

**Expected Class Size:** 12

**Department Notes:** does not satisfy the distribution requirement in the Biology major

**Distributions:** (D3)

**Attributes:** EXPE Experiential Education Courses; MAST Interdepartmental Electives

Spring 2019

LEC Section: 01  TR 9:55 am - 11:10 am  Phoebe A. Cohen
LAB Section: 02  W 1:00 pm - 4:00 pm  Phoebe A. Cohen

**GEOS 214 (S)  Mastering GIS**

Crosslistings: GEOS214 / ENVI214

The development of Geographic Information Systems (GIS) has allowed us to investigate incredibly large and spatially complex data sets like never before. From assessing the effects of climate change on alpine glaciers, to identifying ideal habitat ranges for critically endangered species, to determining the vulnerability of coastal communities to storms, GIS tools have opened the door for important, large-scale environmental analyses. And as these technologies improve, our ability to understand the world grows ever greater. This course will teach you how to use GIS tools to investigate environmental problems. We will review fundamental principles in geography, the construction and visualization of geospatial datasets, and tools for analyzing geospatial data. Special attention will also be given to analysis of remotely sensed (satellite) imagery and to collection of field
data. By the end of the course, you will be able to conduct independent GIS-based research and produce maps and other geospatial imagery of professional quality.

**Class Format:** lecture, three hours per week; laboratory, three hours per week

**Requirements/Evaluation:** based on weekly lab exercises, weekly quizzes, a research project, and a midterm and final exam

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** at least one introductory course in BIOL, ENVI, or GEOS

**Enrollment Limit:** 20

**Enrollment Preferences:** Geosciences and Biology majors and Environmental Studies majors and concentrators

**Expected Class Size:** 20

**Distributions:** (D3)

**Attributes:** ENVI Natural World Electives; EVST Methods Courses; EXPE Experiential Education Courses

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**Spring 2019**

**LEC Section:** 01  MW 11:00 am - 12:15 pm  José A. Constantine

**LAB Section:** 02  M 1:00 pm - 4:00 pm  José A. Constantine

**LAB Section:** 03  W 1:00 pm - 4:00 pm  José A. Constantine

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**GEOS 215 (F)  Climate Changes**

Crosslistings: GEOS215 / ENVI215

**Primary Crosslisting**

In recent years, there has been a growing public and scientific interest in the Earth's climate and its variability. This interest reflects both concern over future climate changes resulting from anthropogenic increases in atmospheric greenhouse gases and growing recognition of the economic impact of "natural" climate variability (for example, El Niño events), especially in the developing world. Efforts to understand the Earth's climate system and predict future climate changes require both study of parameters controlling present day climate and detailed studies of climate changes in the past. In this course, we will review the processes that control the Earth's climate, like solar radiation, the greenhouse effect, ocean circulation, configuration of continents, and positive and negative feedbacks. At the same time, we will review the geological record of climate changes in the past, examining their causes. Laboratories and problem sets will emphasize developing problem solving skills as well as sampling and interpreting geological archives of climate change.

**Class Format:** lecture, three hours per week; one three-hour lab per week

**Requirements/Evaluation:** evaluation will be based on lab exercises and problem sets (25%), three hour exams (50%), and a final project (25%) where students will collect, analyze, and interpret data

**Prerequisites:** 100-level course in GEOS, CHEM, or PHYS or permission of instructor

**Enrollment Limit:** 14

**Enrollment Preferences:** Geosciences majors

**Expected Class Size:** 14

**Distributions:** (D3)

**Attributes:** ENVI Natural World Electives; EVST Environmental Science; EXPE Experiential Education Courses; MAST Interdepartmental Electives; SCST Related Courses

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**Fall 2018**

**LEC Section:** 01  MWF 9:00 am - 9:50 am  Mea S. Cook

**LAB Section:** 02  W 1:00 pm - 4:00 pm  Mea S. Cook

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**GEOS 220 (S)  Evolution of and on Volcanic Islands**  (WI)

Crosslistings: ENVI219 / GEOS220

**Primary Crosslisting**
Plate tectonic theory accounts for the vast majority of volcanic islands in ocean basins. They form above mantle plume hot spots (Hawaiian and Galapagos Islands), subduction zones (Aleutian and Indonesian arcs), and mid-ocean ridges (Azores and Ascension Island). Iceland is unusual because it is located above a hot spot and the mid-Atlantic ridge. Each plate tectonic setting produces chemically distinctive magmas, and the lifespan of volcanic islands varies widely. Islands above hot spots may be geographically remote and emergent for only several million years, but be part of a long-lived sequence of islands that persists for over a hundred million years. In contrast, island arc volcanoes belong to long geographically continuous chains of volcanoes, commonly in close proximity to continents. This tutorial explores the geologic evolution and lifespan of volcanic islands from formation to submergence, and searches for correlations between these characteristics and plate tectonic setting. We will also consider how geographic isolation, areal extent, lifespan, and climate affect biological evolution on volcanic islands. There will be weekly tutorial meetings with pairs of students, and students will alternate writing papers on assigned topics.

**Class Format:** tutorial

**Requirements/Evaluation:** evaluation based on five written papers.

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** 100-level GEOS course or permission of instructor

**Enrollment Limit:** 10

**Enrollment Preferences:** geosciences majors and students with a demonstrated interest in geosciences

**Expected Class Size:** 10

**Distributions:** (D3) (WI)

**Attributes:** ENVI Natural World Electives;

Not offered current academic year

**GEOS 221 (F) Examining Inconvenient Truths: Climate Science meets U.S. Senate Politics (WI)**

Crosslistings: GEOS221 / ENVI222

**Primary Crosslisting**

Former President Barack Obama once said: "There's one issue that will define the contours of this century more dramatically than any other, and that is the urgent threat of a changing climate." While consensus regarding the causes and impacts of climate change has been growing steadily among scientists and researchers (and to some extent, the general public) over the past two decades, the U.S. has yet to confront this issue in a manner consistent with its urgency. This lack of action in the U.S. is at least partly due to the fact that science provides necessary but insufficient information towards crafting effective climate change legislation and the unfortunate fact that climate change has become a highly partisan issue. The primary objective of this tutorial will be to help students develop a greater understanding of the difficulties associated with crafting climate change legislation, with an emphasis on the role of science and politics within the legislative process. To this end, the tutorial will address how the underlying scientific complexities embedded in most climate policies (e.g., offsets, carbon capture and sequestration, uncertainty and complexity of the climate system, leakage) must be balanced by and blended with the different operational value systems (e.g., economic, social, cultural, religious) that underlie U.S. politics. Over the course of this tutorial, students will develop a nuanced sense of how and when science can support the development of comprehensive national climate change legislation within the current partisan climate. This course will take a practical approach, where students will craft weekly policy oriented documents (e.g., policy memos, action memos, research briefs) targeted to selected members of the current U.S. Senate Environment and Public Works Committee, the committee that has historically held jurisdiction over a majority of the major climate change bills that have moved through the legislative process.

**Class Format:** tutorial

**Requirements/Evaluation:** weekly papers and a final oral presentation

**Extra Info:** may not be taken on a pass/fail basis; not available for the fifth course option

**Prerequisites:** none

**Enrollment Limit:** 10

**Enrollment Preferences:** second-year students, Geosciences and Environmental Studies third- and fourth-year students

**Expected Class Size:** 10

**Distributions:** (D3) (WI)

**Distribution Notes:** WI: This course will involve significant writing in terms of weekly assignments.

**Attributes:** EXPE Experiential Education Courses;
GEOS 234 (S) Introduction to Materials Science  (QFR)
Crosslistings: GEOS234 / PHYS234

Secondary Crosslisting
Materials Science is the study of how the microscopic structure of materials—whether steel, carbon fiber, glass, wood, plastic, or mayonnaise—determines their macroscopic mechanical, thermal, electric, and other properties. Topics of this course include classifying materials; material structure; thermodynamics and phase transformations; material properties and testing; how solids bend, flow, and ultimately break; and how to choose the right material for design applications. Materials Science is a highly interdisciplinary field and as a result the course prerequisites are broad but also flexible. Interested students who are unsure about their preparation are strongly encouraged to contact the instructor.

Class Format: lecture (3 hours per week), plus three to four small-group laboratory sessions throughout the semester (to be scheduled with instructor)

Requirements/Evaluation: based on weekly problem sets, class participation, and midterm and final exams, all of which have a substantial quantitative component

Prerequisites: high school physics and chemistry, preferably at the AP level, and MATH 140 or AP Calculus (BC), and one 200-level PHYS, CHEM, or GEOS course; or permission of instructor

Enrollment Limit: 20
Enrollment Preferences: based on students' scientific background and seniority
Expected Class Size: 10
Distributions: (D3) (QFR)
Attributes: MTSC Courses;

Not offered current academic year

GEOS 255 (F) Environmental Observation
Crosslistings: GEOS255 / ENVI255

Primary Crosslisting
To study the environment, we need to observe and measure it. We collect data—numbers that represent system states—and analyze them to create understanding of the world we live in. Advances in technology create more opportunities to discover how the planet works. Through a survey of observational approaches (including weather stations, direct sampling, LIDAR/RADAR, community-based monitoring, and other techniques), this course will investigate the process of turning a physical property in the environment into a number on a computer and then into meaningful information.

We will explore both direct field measurements and remote sensing techniques, diving into how to choose the appropriate sensor for a scientific question, how sensors work, analysis approaches and statistical methods, and how to interpret the resulting data. We will also learn how to mitigate measurement bias through a combination of lab experiments and field work and how to make interpretations of measurements that accurately reflect what is being measured. The course will focus on the near-surface environment, including the atmosphere, water, biosphere, and erosion processes.

Students will carry out a research project using observation techniques covered in class to explore a part of the local environment.

Class Format: lecture
Requirements/Evaluation: Labs, one midterm exam, and a final project
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: at least one prior course in GEOS or ENVI
Enrollment Limit: 10
Enrollment Preferences: sophomores
Expected Class Size: 10
Distributions: (D3)
Attributes: ENVI Natural World Electives; EXPE Experiential Education Courses
GEOS 301 (F) Structural Geology (QFR)

The structure of the Earth's crust is constantly changing and the rocks making up the crust must deform to accommodate these changes. Rock deformation occurs over many scales ranging from individual mineral grains to mountain belts. This course deals with the geometric description of structures, stress and strain analysis, deformation mechanisms in rocks, and the large scale forces responsible for crustal deformation. The laboratories cover geologic maps and cross sections, folds and faults, stereonet analysis, field techniques, strain, and stress.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week

Requirements/Evaluation: evaluation will be based on weekly laboratory exercises, problem sets, a midterm exam, and a final exam; many of the labs and problem sets use geometry, algebra, and several projection techniques to solve common problems in structural geology

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: GEOS 101 or 102, or permission of instructor

Enrollment Limit: 16

Enrollment Preferences: Geosciences majors

Expected Class Size: 12

Distributions: (D3) (QFR)

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GEOS 302 (S) Sedimentology (WI)

Sediments and sedimentary rocks preserve information about the rocks that were eroded to form them, the fluids and forces that transported them, the mechanisms by which they were deposited, and the processes by which they were lithified. This course introduces the principles of sedimentology, including sediment composition, fluid mechanics, bedform analysis, and depositional environments.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week; two half-day and one all-day field trip

Requirements/Evaluation: evaluation based on lab work, writing assignments, participation in discussions, and a final paper

Extra Info: writing assignments will be thoroughly edited for style, grammar, and syntax; each student will compile their papers as a growing body of work, and each new assignment will be read and edited in the context of previous submissions

Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: any 100-level GEOS course AND GEOS 202 (which may be taken concurrently, with permission of instructor)

Enrollment Limit: 12

Expected Class Size: 12

Distributions: (D3) (WI)

Attributes: EXPE Experiential Education Courses; MAST Interdepartmental Electives;

Not offered current academic year

GEOS 303 (F) Igneous and Metamorphic Petrology

Using plate tectonics and the geologic assembly of New England as a template, this course explores the origin of crystalline rocks--volcanic, plutonic, and metamorphic--that comprise 94% of the Earth's crust. Field and lab studies are the crux of the course, supported by experimental work and thermodynamic principles. Chemical and mineralogical compositions and rock fabrics provide evidence for crystallization environments and tectonic settings, past and present.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week; several field trips including one full day trip to central New Hampshire

Requirements/Evaluation: evaluation will be based on lab work, one hour test, and a final exam
Over the last 542 million years of Earth history, five major mass extinctions have occurred, each dramatically changing the makeup and course of life on our planet. During some of these events, over 75% of all marine animal species went extinct and groups like the dinosaurs vanished from the planet after over 100 million years of ecological dominance. This tutorial course will explore the idea of extinction from the evolution of the concept in human thought to current research on the mechanisms and patterns of extinctions through time. We will examine what makes an extinction "mass", delve into the causes and consequences of the major mass extinction events of the phanerozoic, and discuss the potential human-induced "6th extinction" event occurring in the present day.

Class Format: tutorial

Requirements/Evaluation: evaluation will be based on four 4-5-page papers, one revision, tutorial presentations, the student's effectiveness as a critic, and 1 problem set

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: GEOS 101 or GEOS 212; or permission of instructor + any 200 level GEOS course

Enrollment Limit: 10

Enrollment Preferences: GEOS majors

Expected Class Size: 10

Distributions: (D3) (WI)

Not offered current academic year

In coastal communities, increasing flood damage from storm surges and chronic inundation by seawater are already happening as a result of sea level rise. How do we know what contributes to the observed change in sea level in the last century? What does the geological record teach us about what controls the natural variation in sea level on short and long timescales? How can we use this information to separate anthropogenic effects from natural change in modern systems? And how does this inform us on what to expect through the 21st century and beyond? In this course, we will examine how sea level is reconstructed using geological archives and how coral-based sea level data led to breakthroughs in our understanding of the long-term evolution of the ocean and climate, the controls in the timing of ice age cycles, and how high the future seas will rise. During Spring Break, the class will travel to Barbados, a renowned locality for Quaternary sea level reconstruction, to observe modern and ancient reefs, and collect samples that will be the basis of individual or group projects in the second half of the semester. Participation in the Spring Break trip is not required for successful completion of the course, but course enrollment is necessary to attend the trip.

Class Format: lecture/laboratory

Requirements/Evaluation: short papers, labs, participation in discussion, and a research project

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: GEOS 104 or GEOS 210 or GEOS 215 or MAST 311 or permission of instructor

Enrollment Limit: 10

Enrollment Preferences: Geoscience majors, students who commit to the Spring Break trip
Expected Class Size: 10

Distributions: (D3)

Attributes: ENVI Natural World Electives; EXPE Experiential Education Courses

Spring 2019

LEC Section: 01    TR 11:20 am - 12:35 pm    Mea S. Cook

LAB Section: 02    R 1:00 pm - 4:00 pm    Mea S. Cook

GEOS 401 (F)  Global Tectonics and the Rise of Mountains

Fifty years after the sea-floor spreading hypothesis was first verified using magnetic anomalies, we have spectacular data sets from paleomagnetism, seismology, volcanism, the Global Positioning System, and digital elevation models that provide rich details into the kinematics and mechanisms of present and past plate motions. After an introduction to the theory of plate tectonics, local field trips will illustrate how field observations can be used to reconstruct tectonic environments in ancient mountain belts. Digital elevation models integrated with geologic maps and cross-sections will be used to construct 3D models. We will also explore ways in which tectonics, climate, and erosion affect each other during the evolution of mountain ranges. Class meetings will include lectures and discussions of assigned reading. Labs will include field trips and computer-based projects.

Class Format: lecture/discussion, three hours per week; laboratory, three hours per week; five field trips including one all-day trip

Requirements/Evaluation: participation during class and field trip discussions; five lab reports based on field trips, and 3 four page papers based on journal articles

Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option

Prerequisites: GEOS 301 or 303 or permission of instructor

Enrollment Preferences: senior Geosciences majors

Distributions: (D3)

Attributes: EXPE Experiential Education Courses

Not offered current academic year

GEOS 404 (S)  Coastal Processes and Geomorphology (QFR)

Crosslistings: ENVI404 / MAST404 / GEOS404

Primary Crosslisting

Can people live safely along the coast? Recent events like SuperStorm Sandy and the Tohoku Tsunami have shown us how the ocean can rise up suddenly and wreak havoc on our lives and coastal infrastructure. Only educated geoscientists can evaluate the risks and define informed strategies to prevent future coastal catastrophes. Currently almost half the global population lives within 100 km of the coast, with a large percent of those living in densely populated cities (e.g., New York, New Orleans, Los Angeles, Shanghai, Hong Kong, Cape Town, Sydney, Mumbai). Despite the growing risks and challenges associated with climate change and rising sea levels, the coastal population continues to grow rapidly. To help ensure these growing populations can live safely along the coast requires a detailed understanding of the processes that shape the coastal zone. These processes act across a variety of scales, from deep-time geologic processes that dictate coastal shape and structure, to decadal-scale processes that determine shoreline position and evolution, to weekly and daily processes such as storms and tides. This course will provide an in-depth look at the forces--wind, waves, storms, and people--that shape the coastal zone, as well as the geologic formations--sandy beaches, rocky cliffs, barrier islands, deltas, and coral reefs--that are acted upon and resist these forces. Coastal dynamics are strongly affected by human interventions, such as seawalls, dredged channels, and sand dune removal, as well as by sea level rise and changes in storm frequency and magnitude associated with climate change. Finally, the course will provide students with a perspective on how the U.S. seeks to manage its coastal zone, focusing on sea level rise and coastal development. This class will include a quantitative lab that will use MATLAB software to model and evaluate various coastal processes. Students will gain a basic understanding of MATLAB functionality, and will be asked to independently apply what they have learned to various data sets provided by the instructor.

Class Format: lecture two times a week with a lab one time per week

Requirements/Evaluation: lab reports, tests, and an independent research project

Prerequisites: GEOS 104 or permission of instructor

Enrollment Limit: none
Expected Class Size: 10
Distributions: (D3) (QFR)
Attributes: ENVI Natural World Electives;

Spring 2019
LEC Section: 01    MWF 8:30 am - 9:45 am    Alex A. Apotsos

GEOS 405 (F) Geochemistry: Understanding Earth's Environment
Crosslistings: ENVI405 / GEOS405
Primary Crosslisting
Rocks, water, air, life: what comprises these interconnected components of the Earth system? How do they interact today, and how did these interactions differ in the past? In this course we will study how chemical elements are distributed in the Earth, cycle through the Earth system, and act together to produce a planet that is habitable. As Earth's landscapes and oceans, and the life they harbor, have evolved through time, they have left an imprint in the geological record that we can read using geochemical tools such as molecular fossils, elemental ratios, and stable and radioactive isotopes. Topics include the synthesis of elements in stars, the formation and differentiation of planet Earth; radiometric dating; the major constituents of the atmosphere, rain, rocks, rivers and the ocean; how they're linked by chemical weathering and biological activity; and reconstruction of past environments. Students will explore these topics through lecture; reading and discussing articles from the scientific literature; and collecting, analyzing and interpreting data from environmental samples.

Class Format: seminar/lab
Requirements/Evaluation: evaluation will be based on seminar discussions, papers, labs and final project
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Prerequisites: two 200-level GEOS courses and at least one of GEOS 302 or 303
Enrollment Limit: 10
Enrollment Preferences: senior Geosciences majors
Expected Class Size: 10
Distributions: (D3)
Attributes: ENVI Natural World Electives
Not offered current academic year

GEOS 411 (F) Geobiology
Geobiology--the study of interactions between earth and life over geologic timescales--is a new and interdisciplinary field that has grown out of exciting advances in earth and life sciences. During this course we will examine the many ways in which organisms -- from bacteria to trees -- have left their mark on our planet. Topics include the origin of life, the rise of oxygen in the earth's atmosphere, the evolution of biomineralization, the environmental context for animal evolution, the role of microbial communities in the earth system, the emergence of land plants, and the potential for planet-life interactions elsewhere in our solar system. Geobiology incorporates tools and ideas from geochemistry, paleontology, microbiology, and sedimentology. Class time will be divided between lectures and student-led discussions of primary literature. Labs will be varied and involve everything from growing our own microbial ecosystems to querying online databases and analyzing geological, geochemical, genetic, and paleontological data. Our field trip will take us to Upstate New York where we will sample water from a stratified lake and visit ancient microbial fossil reefs. The final project will involve writing a proposal in small groups on a geobiological topic based on the style and format of a National Science Foundation grant, and presenting the idea to the class.

Class Format: seminar; two lecture/seminars a week plus a lab
Requirements/Evaluation: labs, short papers, final grant proposal and presentation
Extra Info: may not be taken on a pass/fail basis
Prerequisites: GEOS 212 or GEOS 312T; or GEOS 101 + any 200-level GEOS course; or permission of instructor
Enrollment Limit: 15
Enrollment Preferences: Senior Geoscience majors
Expected Class Size: 10
Distributions: (D3)
Attributes: EXPE Experiential Education Courses

Fall 2018
SEM Section: 01  TR 9:55 am - 11:10 am    Phoebe A. Cohen
LAB Section: 02  R 1:00 pm - 4:00 pm    Phoebe A. Cohen

GEOS 493 (F)  Senior Thesis: Geosciences
Geosciences senior thesis.
Class Format: independent study
Extra Info: this is part of a full-year thesis (493-494)
Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option
Distributions: (D3)

Fall 2018
HON Section: 01  TBA    Mea S. Cook

GEOS 494 (S)  Senior Thesis: Geosciences
Geosciences senior thesis.
Class Format: independent study
Extra Info: this is part of a full-year thesis (493-494)
Extra Info 2: may not be taken on a pass/fail basis; not available for the fifth course option
Distributions: (D3)

Spring 2019
HON Section: 01  TBA    Mea S. Cook

GEOS 497 (F)  Independent Study: Geosciences
Geosciences independent study.
Class Format: independent study
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Distributions: (D3)

Fall 2018
IND Section: 01  TBA    Mea S. Cook

GEOS 498 (S)  Independent Study: Geosciences
Geosciences independent study.
Class Format: lecture/discussion
Extra Info: may not be taken on a pass/fail basis; not available for the fifth course option
Distributions: (D3)