GEOSCIENCES (GE)

GE 101 - Earth Systems Science with Lab
Credits: 4
Introduction to Earth's dynamic systems and geologic processes. Students will study the planet from its deep interior to its oceanic, surficial, and atmospheric components to develop a scientific understanding of Earth as a holistic environmental system, of which the biosphere, including humanity, is one component. Within this context, students will examine topics such as rocks and minerals, mountain building, earthquakes, volcanoes, glaciers, surface and groundwater, and resources while also developing quantitative reasoning skills. Students will extend their understanding of our place on Earth by considering the interactions between geologic processes and humans.
Prerequisites: *QR1 or MA 100 or placement at the FQR level or placement at the AQR level.*
Note(s): Five hours of lecture, guided activities, laboratory experiments, field trips, and problem-solving per week. Fulfills QR2 and Natural Science requirements; fulfills Fundamental QR and Scientific Inquiry requirements.

GE 102 - The History Of Earth, Life, And Global Change
Credits: 4
Introduction to the deep time history of biospheric responses to changes in Earth's climatologic and geologic systems. The course draws upon geologic principles and theories to explore the planet's origin and the processes that perpetually modify the global environment. Topics also include the origin of life, the causes and consequences of major environmental crises in Earth's history, and the role of humanity as an agent of global change.
Note(s): Three hours of lecture, two hours of lab per week. Fulfills Natural Sciences requirement; fulfills Scientific Inquiry requirement.

GE 105 - Earthquakes and Volcanoes: the Hazards of Plate Tectonics
Credits: 4
An introduction to the science behind the geologic hazards that result directly from plate tectonic processes: earthquakes and volcanic eruptions. Students will learn the fundamentals of plate tectonic theory and will gain an understanding of the processes responsible for earthquake generation and volcanic eruptions, the settings within which these hazards occur, and secondary hazards that result from earthquakes and volcanoes, such as tsunamis and landslides. Students will also learn how to identify evidence for earthquakes and volcanic eruptions in the ancient geologic record. Laboratory work, problem sets, and field trips will explore the insights and quantitative information that earthquakes and volcanoes provide about the structure, chemical evolution, and processes of the Earth; the preservation of these hazards in the geologic record; and their interactions with the atmosphere, biosphere, and human society.
Prerequisites: *QR1 or MA 100 or placement at the FQR level or placement at the AQR level.*
Note(s): Fulfills QR2 and Natural Sciences requirements; fulfills Fundamental QR and Scientific Inquiry requirements.

GE 112 - Oceanography: Introduction to the Marine Environment
Credits: 4
Introduction to the interaction of physical, chemical, geological, and biological processes operative in the great water bodies that cover nearly three-quarters of the earth's surface. Students will study basic principles of physical and chemical oceanography, marine biology, and marine geology while also developing quantitative reasoning skills. Five hours of lecture, guided activities, laboratory experiments, field trips, and problem-solving per week.
Prerequisites: *QR1 or MA 100 or placement at the FQR level or placement at the AQR level.*
Note(s): Three hours of lecture, two hours of lab per week. Fulfills QR2 and Natural Sciences requirements; fulfills Fundamental QR requirement and Scientific Inquiry requirements.

GE 177 - Introductory Seminar in Geosciences
Credits: 1
A discussion of research and communication in earth sciences, based on journal articles, student research, and oral presentations. Intended for students with little or no geosciences experience.

GE 203 - Material World: Introduction to Natural Resources
Credits: 3
If it's not grown, it must be mined. Without mineral resources, humans would all be living “naked and afraid”. In addition to making human civilization possible, these materials (i.e. metals, industrial minerals, gems, building materials) are the foundation of many national economies and have also complicated and contributed to geopolitical and environmental conflicts throughout history. Understanding Earth’s mineral resources from cradle to grave is an important component for an informed citizenry that is able to meet the wicked problems of an Earth with a growing population and ever changing technologies. In this course, students will learn about the geologic processes integral to the formation and distribution of mineral resources as well as methods of exploration for and extraction of these materials for our use. Related topics include the environmental impacts and remediation associated with resource extraction and resource depletion.
Note(s): Offered as letter only.

GE 204 - Structural Geology
Credits: 4
Bending, breaking, and flowing: Principles of structural geology and rock deformation - An introduction to structural geology, rock deformation, and their relation to plate tectonics. Students will learn the fundamentals of rock mechanics through examination of various structures (folds, faults, joints, shear zones, etc.) found in crustal rocks, and the mechanisms responsible for their formation. Laboratory exercises will emphasize hands-on characterization and data collection/analysis of geologic structures in the field, reading and interpretation of geologic maps, and numerical analysis of structural data. Lectures will cover descriptive analyses of geologic structures, strain and kinematic analysis, dynamic analysis, and how deformation mechanisms operating at the atomic scale control the rheologic behavior of mountain belts and the lithosphere as a whole.
Prerequisites: *GE 101.*

GE 205 - Introduction to Energy Resources
Credits: 3
An exploration of the earth materials and processes used to produce energy. Without energy resources, our days would be a lot darker, less comfortable, and less convenient. Students will learn about the formation and distribution of energy producing materials such as fossil fuels and uranium, increasing their understanding of how this impacts exploration for, extraction of and use of them. Students will also investigate how we harness earth processes like surface water flow, geothermal heat, solar and wind power to generate renewable energy. Throughout the course, students will consider how energy generation intersects with geopolitics, economics, environment, and society, increasing their comprehension of the complexity and nuance associated with using energy resources to meet growing demand and future needs.

GE 207 - Environmental Geology
Credits: 4
Investigation of Earth's environments as viewed through the study of surficial and crustal geologic processes. Emphasis is on natural and anthropogenic phenomena including earthquakes, volcanoes, floods, landslides, climate change, soil erosion, pollution, waste management, and energy resources. Laboratories and field trips highlight geologic perspectives on the environment.
Note(s): Three hours of lecture, three hours of lab per week. Fulfills Natural Sciences requirement; fulfills Scientific Inquiry requirement.

GE 209 - Earth Materials
Credits: 4
An exploration of the nature, compositions, and origins of Earth materials (i.e., rocks, minerals, mineraloids) that are central to understanding Earth system history. Students will study the attributes of the minerals, rocks, and soils of Earth's lithosphere focusing on petrogenic processes within the context of the tectonic history of North America. Field and laboratory work will provide students with the skills and methodologies required to prepare Earth materials for study and to conduct their own petrographic analyses. Lectures, discussions, and in-class student team presentations teach the concepts and insights required to interpret petrogenic processes and tectonic environments of Earth materials.
Prerequisites: *GE 101.*
Note(s): Three hours of lecture, three hours of lab per week.

GE 211 - Climatology
Credits: 4
Introduction to the basic components of Earth's climate system: the atmosphere, ocean, cryosphere, lithosphere, and biosphere. The course investigates the basic physical processes that determine climate and the links among the components of the climate system, including the hydrologic and carbon cycles and their roles in climate, climate stability, and global change. Topics also include climate patterns and forecasting climate, as well as their applications and human impacts.
Note(s): Three hours of lecture, two hours of lab per week. Fulfills Natural Sciences requirement; fulfills Scientific Inquiry requirement.

GE 215 - Climate Change Solutions: Intro to GeoEngineering
Credits: 3
An exploration of earth systems solutions to climate change. Wicked problems have many components, necessarily demanding a variety of approaches for their solutions. Geoengineering, the deliberate large-scale intervention in Earth's natural systems, refers to a suite of technologies and processes that could be used to reduce the amount of the sun's energy reaching the earth or capture and sequester carbon from the atmosphere. But just because we can do something, how do we decide if we should do it? And when? And who is doing the deciding? In this course, we will learn about the geologic materials and processes that make these methods scientifically feasible. We will evaluate the deployability and efficacy of these approaches through an interdisciplinary lens, bringing in political, economic, sociological, and technological considerations. Using those many approaches, we will ask can we afford to use these technologies? …or can we afford not to?

GE 216 - Sedimentology
Credits: 4
The scientific study of sedimentary bodies and the processes by which they form. Emphasis is placed on the actualistic application of Holocene models to the recognition and interpretation of ancient depositional environments. Field and laboratory work include the description, classification, and interpretation in outcrop, hand specimen and thin section.
Prerequisites: *GE 102 or GE 112.*
Note(s): Three hours of lecture, three hours of lab per week. Fulfills Natural Sciences requirement; fulfills Scientific Inquiry requirement.

GE 229 - Introduction to Geophysics
Credits: 4
A study of the active physical processes in the earth. Students will apply ideas and tools of physics to earth science problems by examining topics such as stress and strain, heat transport, fluid advection, gravity, seismology, and magnetism. Students will study earth phenomena including rock deformation, glacier mechanics, earthquakes, and earth's magnetic field, and conduct analysis of geophysical data and apply physical models to earth science problems. Four hours of combined lecture and lab per week.
Prerequisites: *MA 111 (can be taken concurrently) and one course in either physics or geosciences, or permission of the instructor.*
Note(s): Four hours of combined lecture and lab per week.

GE 235 - Data Analysis, Modeling, and Scientific Programming: Earth and Environmental Sciences
Credits: 4
An introduction to data analysis methods, modeling, and scientific programming using examples from climatology, geology, environmental science, and oceanography. Topics include descriptive statistics; sampling theory; least-squares fitting; timeseries analysis; data interpolation and contouring; modeling methods; and data visualization techniques. Students will write original computer scripts to manipulate data sets, model Earth and environmental processes, and solve quantitative problems. This course is appropriate for students pursuing computer programming skills for the earth and environmental sciences.
Prerequisites: *MA 109 or MA 111 and placement at the AQR level or completion of an FQR course or QR1 or permission of the instructor.*
Note(s): Fulfills Natural Science requirement; fulfills Applied QR requirement.

GE 251 - Special Topics in Geosciences
Credits: 1-4
A variety of topics at the intermediate level, for students with interest in geosciences. Topics may include geochemistry, planetary geology, global tectonics, petroleum geology, and global bio-events. Topics will be selected based on student interest and background. May be repeated multiple times for credit with different topics, pending department approval.
Prerequisites: *will vary based on course topic.*
Note(s): Courses offered for 1 or 2 credits will not count toward major or minor requirements.

GE 275 - Introductory Research in Geoscience
Credits: 1-3
An introductory exploration of research in the geosciences. Students plan, design, and implement a small research project from the laboratory or field in coordination with a faculty member. This experience allows students at various stages of their careers to sample research methodologies in particular subdisciplines of geosciences.
Prerequisites: *Completion of one 100-level course in the geosciences or requirements set forth by individual instructors plus permission of instructor.*

GE 301 - Hydrogeologic Systems
Credits: 4
An advanced course on the physical processes of water transport and accumulation on the surface and in the shallow subsurface environments, as well as environmental impacts on water quality. Students will learn the scientific principles of the hydrologic cycle, including precipitation, evapotranspiration, infiltration, surface runoff, groundwater flow, and surface-groundwater interaction. Students will apply these principles to investigate how land-use change, such as agriculture and urban development, change the quantity, quality, and distribution of water in our environment. Throughout the course, students will use case studies and field data to apply their knowledge to real-world problems.
Prerequisites: *GE 101 or GE 207 or ES 105.*
Note(s): Three hours of lecture, three hours of lab per week. Two mandatory Saturday field trips.

GE 302 - Reading the Sedimentary Record: Sedimentology and Stratigraphy
Credits: 4
The study of sedimentary processes and the sequence and architecture of sedimentary strata in relation to Earth history. Sediments and sedimentary rocks cover most of the Earth, house critical resources, and underpin our understanding of the history of plate tectonics and climate change, and the evolution of life. Students learn to apply modern-process-based models for recognizing and interpreting depositional environments. From this basis, students will then focus on the classification and correlation of more ancient sedimentary rocks and their interpretation, exploring the respective roles of tectonics, climate, and organisms in the development of continents and sedimentary basins over geologic time. Laboratory exercises emphasize characterization and data collection/analysis of sedimentary materials in the field, hand specimen and thin section, and data analysis including using data visualization tools.
Prerequisites: *GE 101 or GE 105 or GE 112 or GE 211 or permission of instructor.*

GE 304 - Geomorphology
Credits: 4
Analysis of the geologic and climatic factors that control the evolution of topography. Lab study is concentrated on the physical character of the United States and on the geologic configurations that determine landform distribution and therefore are the basis for physical subdivision.
Prerequisites: *GE 101 or GE 207 .*
Note(s): Two hours of lecture, three hours of lab per week.

GE 305 - Remote Sensing of the Earth and Environment
Credits: 4
An exploration of methods of remote sensing used in modern observations of Earth processes. Students will examine the physical principles of remote sensing within the context of key Earth systems such as the atmosphere, the cryosphere, and the terrestrial and ocean biospheres. Students will explore topics such as vegetation cycles, weather observations, the atmospheric ozone layer, and digital elevation model development. Laboratory work and student projects will include manipulation and interpretation of remote imagery to classify ground cover, detect environmental change, and observe spatial and temporal patterns in Earth processes. Three hours of lecture, 3 hours of lab per week.
Prerequisites: *GE 101 or concurrent enrollment in GE 101 and ID 210 or approved GIS course or permission of the instructor.*

GE 306 - Oceans and Global Change
Credits: 4
An exploration of accelerated change in Earth's systems and the profound effects that are occurring or are predicted to occur in the oceans. Students will explore topics such as the impacts of ice melt and increasing temperatures on ocean circulation, the spread of low-oxygen conditions and ocean acidification, shifts in marine species distributions and the loss of biodiversity, the implications of ocean-related geoengineering, and the effects of human resource extraction from the sea. Discussion and writing assignments will center around readings taken from the primary oceanographic literature and will emphasize the role of Earth system models in predictions of future change.
Prerequisites: *GE 112 or GE 211.*

GE 309 - Field Techniques
Credits: 4
An advanced course in the techniques used for field mapping. The course concentrates on the instruments of mapping and how to use them, including pace and compass, altimeter, plane table and alidade, topographic map and air photo base. In addition there is the study of some basic subsurface geologic techniques such as structural contour maps, isopach maps, and well log analysis and correlation.
Note(s): Two hours of lecture, three hours of lab, and one hour of discussion per week.

GE 310 - Paleobiology
Credits: 4
An advanced study of the morphology, taxonomy, and evolution of fossil organisms; the major events in the 3.6 billion-year history of Earth's biota; and the processes of fossil preservation/destruction. The ecology of fossil organisms, reconstruction of paleo-environments and paleocommunities, as well as the forcing mechanisms that perpetually alter Earth's marine and terrestrial environments are emphasized throughout. Laboratory and field work provide firsthand experience in the application of the fundamental concepts and principles of paleobiology to the observation, analysis, and interpretation of ancient life forms.
Prerequisites: *GE 102.*
Note(s): Three hours of lecture, three hours of lab per week.

GE 311 - Paleoclimatology
Credits: 3
An advanced course that examines the history of Earth's climate, the physical processes that influence it and their interaction, as well as controlling mechanisms. Emphasis is placed on biogeochemical cycles, atmospheric and oceanic chemistry and circulation patterns through time, the influences of volcanic aerosols and asteroid impacts on climate, icehouse and greenhouse cycles, and the climates of the Phanerozoic.
Prerequisites: *GE 101 or GE 102 or GE 211 or permission of instructor.*
Note(s): Optional Laboratory: Honors Add-on, HF3XX- Paleoclimatology Practicum. 1-credit.

GE 316 - Stratigraphy
Credits: 4
Study of lithologic and biologic units of sedimentary strata, their classification, correlation, and use in environmental and geographic reconstructions. Emphasis placed on the respective roles of organisms, geosynclines and tectonic events in the development of continents and sedimentary basins.
Prerequisites: *GE 216.*
Note(s): Three hours of lecture, three hours of lab per week.

GE 320 - Global Biogeochemical Cycles
Credits: 4
An introduction to global biogeochemical cycles, i.e., the transport and transformation of substances in the environment through physical, chemical, and biological processes with profound implications for climactic and ecological processes. In seminar, students will address methods used to measure and model elemental fluxes and decipher changes in biogeochemical cycles over time as well as examine processes and reactions controlling the distribution and fluxes of nutrients and other important chemical species within and between Earth's principle spheres. In laboratory, students will use Stella software to translate their conceptual knowledge of biogeochemical cycles into quantitative dynamic system models of the Earth System representing the past, present, or future in equilibrium and perturbed states.
Prerequisites: *MA 109 or MA 111 and prior fulfillment of the natural science requirement.*

GE 351 - Advanced Topics in Geology
Credits: 1-4
Offered to either small groups of students or on an individual basis, allowing the student to study in depth areas of the science that are not offered on a regular basis. Specific topics will vary each time the course is taught and might include hydrology, glaciology, micropaleontology, or computer applications in geology.
Prerequisites: *Two geology courses unless otherwise specified.*

GE 352 - Special Topics Geology
Credits: 3

GE 371 - Independent Study in Geosciences
Credits: 1-4
Advanced research in the geosciences, generated and designed by the student in consultation with and under the supervision of a member of the department. Although the ideal research project includes suitably balanced literature, field, laboratory, and interpretive components, the requirements of individual topics may dictate a focus on one or more of these aspects of conducting scientific research. Research results will include a written report submitted to the faculty supervisor and an oral presentation to the department.

GE 375 - Senior Research in Geosciences
Credits: 1-4
An opportunity for qualified seniors to plan, design, and implement a research project from the laboratory or field in coordination with a faculty member.
Prerequisites: *Permission of instructor and senior status.*

GE 377 - Senior Seminar In Geosciences
Credits: 1
A one-credit seminar designed to incorporate critical skills acquired throughout the student's undergraduate geosciences experience. In this course students will be part of a team that synthesizes and interprets primary date taken from the literature. During the first part of the seminar, student teams will participate in discussions of current geosciences literature selected within each faculty member's discipline, whereas for the rest of the course students are responsible for choosing literature according to their own interests, and leading discussions based on those texts.
Note(s): Fulfills Senior Experience Coda requirement.

GE 399 - Professional Internship in Geology
Credits: 1-4
Professional experience at an advanced subject level for juniors and seniors with substantial academic and cocurricular experience in the major field. With faculty sponsorship and department approval, students may extend their educational experiences by working on specialized research projects with outside professional earth scientists.
Note(s): Must be taken S/U.