**Geology**

**GEOL 102. Environment: Earth. 3 credits.**
A study of geological processes causing global change and their impact on human thought. The relationship between some geological processes and life on the Earth is also considered. Not available for major or minor credit in geology. Students may not receive credit for both GEOL 102 and ISCI 102.

**GEOL 110. Physical Geology. 3 credits.**
A systematic study of earth materials and the internal and external processes that affect earth structure and landforms. Topics include the genesis/properties of rocks and minerals, plate tectonics, and the agents of change that drive surface processes and land form development. The laboratory and lecture portions of GEOL 110 must be taken concurrently. Corequisite: GEOL 110L.

**GEOL 110L. Physical Geology Laboratory. 1 credit.**
This laboratory course is designed to complement and supplement the GEOL 110 course. The laboratory and lecture portions must be taken concurrently. Corequisite: GEOL 110 or permission of the instructor.

**GEOL 115. Earth Systems and Climate Change. 3 credits.**
This course explores cycles, trends and abrupt events in the Earth system. Analyses of the geologic record and global climate models provide perspective for understanding paleoclimate and future climate changes, including global warming. Current hypotheses for causes of climate change are evaluated, including plate tectonics, orbital cyclicity, variations in the sun’s strength and human activities. The two reoccurring questions of this class are: What are Earth’s climate stories? How do we know?

**GEOL 130. Quantitative Geology. 2 credits.**
An introduction to quantitative techniques used in descriptive and predictive aspects of the earth and environmental sciences, with emphasis on algorithmic approaches. The focus is on pragmatic application of mathematical methods to geologic problems, considering requirements, uses and limitations. Automatic computation is stressed.

**GEOL 167. History and Philosophy of the Geosciences. 3 credits.**
As an introductory experience in the Bachelor of Arts in Earth Science, students will be inculcated in the philosophy of geosciences as an interdisciplinary medium for extending classical science viewpoints to complex earth systems. Students will study the geosciences as distinct among sciences, establishing relevance and value of earth science literacy in professional and personal settings.

**GEOL 200. Evolutionary Systems (3, 2). 4 credits.**
An investment of a theoretical principle behind evolutionary systems of all types based on mathematical modeling in chaos, complexity theory and artificial life studies with extensive computer experimentation and examples drawn from physical, chemical,
biological, economic and social systems. The purpose is to explore what is common and universal to all evolutionary processes. May be used for general education credit.

**GEOL 210. Applied Physical Geology. 3 credits.**
A problem-based study of Earth materials and the processes that affect Earth structure and landforms. Topics include plate tectonics, the genesis/properties of rocks and minerals, and agents of change that drive surface processes and landform development. Quantitative problem-solving skills will be applied to case studies that address 3D visualization and time-based processes, such as Earth materials, solid earth and surface processes, natural hazards and engineering applications. May be used for general education credit.

**GEOL 211. Introduction to Oceanography. 3 credits.**
An introduction to the oceanography of coastal environs including barrier islands, estuaries and tidal marshes. The physical, geological and biochemical characteristics of coastal waters will be discussed in the context of the economic and social pressures brought to bear on these areas by an increasing global population. Cannot receive credit for both GEOL 211 and GEOL 401. May be used for general education credit.

**GEOL 230. Evolution of Earth (3, 2). 4 credits.**
An introduction to the evidence, methods and assumptions used by scientists to unravel the Earth’s origin and history. Emphasis on rock analysis/interpretation, modern and ancient processes of mountain building, origin and evolution of life and the history of the North American continent. Prerequisite: GEOL 110L or permission of the instructor.

**GEOL 272. Planetary Geology (2, 2). 3 credits.**
A survey of currently developing ideas in planetology including origin of the planets, meteorites and planetary interiors. Also included are geologic processes and land forms on the moon and terrestrial planets, their modification under various planetary environments, and analogies to familiar earth land forms. Includes laboratory. Prerequisite: GEOL 110L.

**GEOL 280. Mineralogy (3, 2). 4 credits.**
A comprehensive study of minerals, including: crystallography, mineral chemistry, x-ray diffraction, mineral optics with thin section recognition using petrographic microscope, and hand specimen identification of both silicate and non-silicate minerals. Prerequisite: GEOL 110L.

**GEOL 290. Optical Mineralogy (3, 2). 3 credits.**
A study of the optical properties of minerals and mineral identification with the petrographic microscope. Prerequisite: GEOL 280.

**GEOL 291. Writing and Communicating in the Geosciences. 1 credit.**
This course prepares students for independent research by providing them the fundamental skills in literature searches, writing, critical reading and communication in the geosciences. Prerequisite: GEOL 110 or GEOL 102 or GEOL 115; must take prior to senior year.

**GEOL 300. Introduction to Petrology (3, 3). 4 credits.**
Igneous and metamorphic processes explained using crystallization theory, phase diagrams, thermodynamics and geochemistry; laboratory study of rocks, their chemical and mineralogical signatures, and their geologic origins. Prerequisites: GEOL 280 and CHEM 131, or permission of the instructor.

**GEOL 301. Earth Sciences for Teachers. 4 credits.**
Earth science content is blended with a systems approach to provide pre-service teachers with an understanding of how the Earth works, as well as strategies for teaching it. Major content themes include reconstructing the geologic history of the mid-Atlantic, exploring the interaction of living things and the environment, and predicting how matter and energy circulate in the earth system.

**GEOL 302. Sedimentary Petrology. 1 credit.**
This is a course about sedimentary rocks in hand sample and thin section. With the polarizing microscope, students will study thin sections of outcrop and core samples. They will identify common minerals, textures and fabrics. They will identify the four components of all sedimentary rocks (framework grains, cements, matrix, pore types) and will make qualitative and quantitative measurements at a fundamentally different scale than is possible with just a field study of sedimentary rocks. **Prerequisite:** GEOL 280 or permission of the instructor.

**GEOL/GEOG 310 A-D. Environmental Impact. 2-3 credits, repeatable to 6 credits.**
Focuses on a selected environmental realm. The course will examine the interface between human activities and environmental systems. It will address the impacts of social, economic and political activities on the environment. A-Atmosphere (air pollution); B-Biosphere (vegetation/wildlife); C-Hydrosphere (water); D-Lithosphere (geologic hazards/land issues).

**GEOL 320. Meteorology. 3 credits.**
A survey of the science of weather including weather forecasting, weather maps and related atmospheric processes. Emphasis is placed on the dynamic aspects of meteorology and the interrelationships of atmospheric phenomena with land masses and the world ocean.

**GEOL 340. Environmental Soil Science (2, 2). 3 credits.**
The origin, distribution, and chemical, biological, and physical properties of soil are introduced. Processes responsible for soil properties are emphasized. Field trips highlight the stainability of soils, their distribution across the Shenandoah Valley and their role in biogeochemical cycles. **Prerequisite:** GEOL 110 or GEOL 210 or permission of the instructor may be granted for students with 4 hours of a lab course.

**GEOL/BIO 350. Paleobiology (3, 2). 4 credits.**
The evolution and ecological structure of the biosphere from the origin of life to the present, emphasizing the evolution and paleobiology of animal life as shown by the fossil record. Lectures discuss methods used to interpret the fossil record and cover topics such as phylogeny and systematics, functional morphology, biostratigraphy, paleoecology, evolution and extinction. Laboratories focus on the major groups of invertebrates that are common in the geologic record. **Prerequisite:** GEOL 230, BIO 114, BIO 150 or permission of the instructor.

**GEOL/CHEM 355. Geochemistry of Natural Waters. 3 credits.**
Study of chemical theory and reactions important in natural water systems. The role of atmospheric, geologic and biological inputs in determining the geochemistry of streams, rivers and oceans. **Prerequisites:** CHEM 131 and CHEM 132 or equivalent.

**GEOL 367. Genesis of Solid Earth Materials (3, 2). 4 credits.**
This course addresses the natural relationship between minerals and the rocks they make up. Using the concept of mineralizing environments, illustrated by classic examples, students will investigate minerals through the processes of mineral genesis and associated rock types. This approach provides insight and predictive value for
natural conditions in which specific minerals and rocks occur. Not acceptable for B.S. in geology. **Prerequisite:** GEOL 110L.

**GEOL 377. Earth Surface Processes (2, 2). 3 credits.**
The interrelationships among climate, landscapes, soils and bedrock geology are examined using the mid-Atlantic region as a conceptual laboratory. Course instruction includes lecture, laboratory and field trip meetings. The processes of rock weathering and erosion and soil formation are reinvestigated. Topographic maps and aerial photography are examined for landforms and landscape evolution. **Prerequisite:** GEOL 110L, GEOL 210 or permission of the instructor.

**GEOL 380. Genetic Mineralogy (2, 2). 3 credits.**
A study of mineral genesis. Emphasis is directed toward mineralogical environments, mineral associations and the geology/mineralogy of classical localities. An appreciation of mineral value and aesthetics is incorporated throughout the course. **Prerequisite:** GEOL 280.

**GEOL 387. Stratigraphy, Structure, and Tectonics (3, 2). 4 credits.**
Examination of how stratigraphic, structural, and tectonic principles control the character and distribution of rocks. Study of principles, regional patterns in sedimentary rocks, and stresses that deform rocks are explored in laboratory and field exercises. Topics and techniques are discussed within the framework of the 1.2 billion year geologic history of the VA region and its connection with tectonic processes throughout the rest of the world. **Prerequisites:** GEOL 110L and GEOL 230.

**GEOL 388. Advanced Stratigraphy, Structure, Tectonics (3, 2). 4 credits.**
Advanced concepts in structural geology (analyses of rheology, stress & strain, deformation fabrics, and chronologic constraints) applied to the tectonic evolution of orogens and basins. This will include exploration of the mechanisms controlling the stratigraphic record (auto- and allogenic mechanisms and sequence theory) of basins, as well as methods of dating the stratigraphic record (biofacies and biostratigraphy, geochronology and chronostratigraphy, and magneto and chemosтратigraphy). **Prerequisite:** GEOL 387.

**GEOL 390. Laboratory Techniques in Geology (2, 2). 3 credits.**
An elective course for science majors. A study of the basic theories and techniques of laboratory methods and instrumentation. Implementation and application of techniques to geological problems. **Prerequisites:** GEOL 280 and permission of the instructor.

**GEOL/MATS 395. Geologic Perspectives in Materials Science and Engineering. 3 credits.**
A one-semester course which emphasizes the commonalities between the geological sciences and materials science. Course includes topics from mineralogy, crystallography, petrology and structural geology which are also important in metallurgy and ceramics. **Prerequisites:** An introductory course in any physical science or integrated science and technology (GEOL 110, CHEM 131, PHYS 140 or ISAT 141) and at least one additional advanced course in the major.

**GEOL/MATS 396. X-ray Characterization of Solid Materials. 3 credits.**
Covers fundamental principles and theory behind two powerful, X-ray based, technologies: X-ray Diffraction and Energy Dispersive Analysis of X-rays (EDS). Students will collect and analyze data from a single crystal Gandolfi X-ray camera, automated powder diffraction system (focusing goniometer) and EDAX system (EDS). **Prerequisite:** GEOL 280, MATS/CHEM/PHYS 375 or ISAT 300.
GEOL 398. Topics in Geology. 1-4 credits.
Topics in geology at the advanced level. May be repeated for credit when course content changes. Topics selected may determine prerequisites. Students should consult the instructor prior to enrolling in the course. Prerequisite: Permission of the instructor.

GEOL 399. Field Geology. 6 credits.
Field Geology is the capstone course for geology majors. Students learn to recognize and interpret a wide variety of rocks and structures, as well as geomorphic, hydrologic, and other geologic features. Methods of mapmaking, data recording, and report preparation are emphasized. Projects from one to five days’ duration are conducted in regions where igneous, metamorphic, and sedimentary rocks, surficial deposits, and karst features are well-exposed. Prerequisites: GEOL 300 and GEOL 387 or permission of the instructor.

GEOL/BIO 400. Geology and Ecology of the Bahamas. 3 credits.
This course explores the geology and ecology of the shallow-water marine environment by examining the preeminent modern example, the Bahamas platform. The Bahamas provide an excellent model for understanding modern and ancient carbonate and reef deposits and a variety of terrestrial/aquatic habitats. Biological processes are responsible for many of the geological features of the Bahamas, so the course considers the biology/ecology of marine organisms in addition to geological topics. Prerequisites: GEOL 110 or GEOL 211 or a 200-level GEOL or BIO course; at least four hours of additional lab science, at least sophomore status, and permission of the instructor.

GEOL 401. Oceanography for Teachers. 3 credits.
A comprehensive study of the world’s oceans and the interrelationships among physical, chemical, biological and geological oceanography for pre- and in-service teachers. Special emphases on Virginia coastal oceanography, the National Ocean Literacy Principles and the integration of pedagogy applicable to K-12 instruction. Includes a field trip to the Virginia coast. Credit may not be earned in both GEOL 211 and GEOL 401.

GEOL/BIO 405. Vertebrate Paleontology. 3 credits.
A study of the origin and evolution of the vertebrates. Emphasis will be on understanding how the processes of earth evolution and biological evolution have interacted through time to produce a coherent picture of vertebrate history. Prerequisite: GEOL 230, BIO 114, BIO 150 or permission of the instructor.

GEOL 406. Paleoclimatology and Paleoceanography. 3 credits.
Investigate the methodologies and data used to reconstruct Earth’s climate history. Emphasis will be placed on the marine sediment and ice core records of the Cenozoic though detailed lecture and lab activities. Case studies include the Paleocene Eocene Thermal Maximum, the glaciation of Antarctica, Milankovitch cyclicity and Northern Hemisphere glaciation. Prerequisite: GEOL 230 or GEOL/BIO 350 or permission of the instructor.

GEOL 410. Engineering Geology (2, 2). 3 credits.
Study of the applications of geology to engineering practice. Topics include soil mechanics, foundations, engineering classification of soils, slope stability and mineral aggregates. Prerequisites: GEOL 110, GEOL 210 or GEOG 210, and either MATH 231 or MATH 235 or equivalent.

A systematic survey of the tectonic evolution of the North American continent and the corresponding evolution of depositional basins and paleoenvironments. **Prerequisites:** GEOL 387 and GEOL 388 or permission of the instructor.

**GEOL 440. Geophysics (3, 2).** 4 credits.
A survey of geophysical methods, with joint attention on near-surface and solid earth applications. Topics include seismology, heat flow, gravity, magnetism, electrical methods, ground penetrating radar and geophysical aspects of plate tectonics. Labs focus on practical experience with data acquisition, reduction, and interpretation and are a combination of field, classroom and computational activities. **Prerequisite:** GEOL 110L or PHYS 140-150 or PHYS 240-250 or permission of the instructor.

**GEOL 442. Field Geophysics.** 3 credits.
This course focuses on collection of geophysical data in the field and interpretation, analysis and technical reporting afterwards. Case studies discussed include applications to geology, archaeology, and engineering. Students will get hands-on experience with geophysical equipment and an understanding of how and where these tools can be applied. Topics include Ground Penetrating Radar, Electrical Resistivity, Magnetism, Seismic Refraction and Total Station Data. **Prerequisite:** GEOL 110 or GEOL 210 or ANTH 197 or consent of instructor.

**GEOL 444. Topics in Geophysics.** 1-4 credits.
An in-depth investigation into selected aspects of geophysics. Topics will be chosen by the instructor and students and may vary from year to year. Some common candidate issues include earthquake seismology, field survey planning and execution, geophysical interpretation theory and the geophysical underpinnings of plate tectonic theory. **Prerequisite:** Permission of the instructor.

**GEOL 450. Geology Seminar.** 1 credit.
An in-depth study of a particular problem in geology (e.g., plate tectonics, astrogeology, low-temperature geochemistry, etc.). Scientific literature will be reviewed and discussed. **Prerequisite:** 20 credits in geology.

**GEOL 460. Hydrogeology (2, 2).** 3 credits.
Basic concepts of subsurface water as a part of the hydrologic cycle. Topics include storativity and permeability in porous media, principles of flow, computer applications, groundwater exploration, and mapping and environmental aspects of groundwater. **Prerequisites:** GEOL 110L and two semesters of calculus or permission of the instructor.

**GEOL 477. Contemporary Issues in the Geosciences.** 3 credits.
As a capstone experience, this course serves as an opportunity for students to view issues of the Earth system from an Earth-based perspective. Building on previous course work in the major (physical geology, meteorology, oceanography, etc.), students will investigate such issues as global warming, population and sustainable development and environmental ethics. Particular emphasis is placed upon the Earth’s perspective from a historical viewpoint. **Prerequisites:** GEOL 211, GEOL 320, GEOL 367 and GEOL 377.

**GEOL 489. Quantitative Methods in Geology.** 3 credits.
An introduction to the mathematical methods and statistical techniques that are employed by scientists in the disciplines of geochemistry, geophysics, hydrology and the petroleum/mineral industry. The course provides the quantitative skills necessary to manipulate geological data.
GEOL 491. Geological Literature and Research. 2 credits.
Provides advanced instruction in literature research to meet the B.A. Earth Science and B.S. Geology research requirements. Activities include the identification of a literature-based research problem, literature research techniques, critical reading and discussion, and the preparation of individual review papers on each student’s research topic. Prerequisite: GEOL 291 or permission of the instructor.

GEOL 494. Internship in Geology. 1-3 credits.
Student conducts a research or applied project in geology outside of the university. Requires an approved proposal prior to registration and a final report at the culmination of the project. Prerequisites: Minimum of eight credit hours in geology, GEOL 291 and a geology GPA of 2.5 or higher.

GEOL 497. Problems in Geology. 1-3 credits.
An undergraduate research course in one of the fields of geology. Open to advanced students who have adequate preparation. Prerequisites: GEOL 291 and permission of the instructor.

GEOL 499A. Honors in Geology. 1 credit.
Prerequisites: GEOL 291 and 3.25 GPA or higher.

GEOL 499B. Honors in Geology. 2 credits.
Prerequisites: GEOL 291 and 3.25 GPA or higher.

GEOL 499C. Honors in Geology. 3 credits.
Prerequisites: GEOL 291 and 3.25 GPA or higher.