

# DEPARTMENT OF GEOLOGY

## College of Arts and Sciences

Department of Geology  
221 McGilvrey Hall  
Kent Campus  
330-672-2680  
geology@kent.edu  
www.kent.edu/geology

## Undergraduate Programs

- Earth Science - B.A.
- Geology - B.A.
- Geology - B.S.

## Minors

- Geology
- Earth Science
- Environmental Geology
- Paleontology

## Graduate Programs

- Applied Geology - Ph.D.
- Geology - M.S.

## Department of Geology Faculty

- Clement, Susanne M. (1995), Associate Professor, Ph.D., Kent State University, 2005
- Gallagher, Timothy M. (2020), Assistant Professor, Ph.D., University of Michigan, 2016
- Hacker, David B. (1989), Professor, Ph.D., Kent State University, 1998
- Jefferson, Anne (2012), Associate Professor, Ph.D., Oregon State University, 2006
- Ortiz, Joseph D. (2001), Professor, Ph.D., Oregon State University, 1995
- Rowan, Christopher (2013), Assistant Professor, Ph.D., University of Southampton, 2006
- Schweitzer, Carrie E. (1994), Professor, Ph.D., Kent State University, 2000
- Singer, David M. (2012), Associate Professor, Ph.D., Stanford University, 2008
- Singh, Kuldeep (2017), Assistant Professor, Ph.D., University of Texas at Austin, 2013
- Taylor, Eric S. (2012), Associate Professor, Ph.D., The Ohio State University, 2012
- Tessin, Allyson (2020), Assistant Professor, Ph.D, University of Michigan-Ann Arbor, 2016
- Wells, Neil A. (1984), Professor, Ph.D., University of Michigan-Ann Arbor, 1984
- Williams, Jeremy C. (2015), Assistant Professor, Ph.D., University of Massachusetts, Boston, 2014

## Geology (GEOL)

**GEOL 11040 HOW THE EARTH WORKS (KBS) 3 Credit Hours**  
Explores processes that shape Earth's landscapes (e.g., volcanism, flooding, landslides, sea-level rise, mountain building) and that are of vital interest to humans (e.g., earthquakes, groundwater, energy and mineral resources, climate change).

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, TAG Science, Transfer Module Natural Sciences

**GEOL 11041 HOW THE EARTH WORKS LABORATORY (KBS) (KLAB) 1 Credit Hour**

Students study earth materials (e.g., mineral crystals, common and unusual rock specimens) and Google Earth images. Students conduct experiments demonstrating processes at earth's surface such as groundwater pollution, flooding and earthquakes.

**Pre/corequisite:** GEOL 11040.

**Schedule Type:** Laboratory

**Contact Hours:** 3 lab

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Kent Core Basic Sciences Lab, TAG Science, Transfer Module Natural Sciences

**GEOL 11042 EARTH AND LIFE THROUGH TIME (KBS) 3 Credit Hours**

Explores major events in the history of Earth, including mass extinctions, Snowball Earth hypothesis, birth and death of oceans, growth of continents, explosion of life, dinosaurs and the inter-relatedness of earth and life processes.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, TAG Science, Transfer Module Natural Sciences

**GEOL 11043 EARTH AND LIFE THROUGH TIME LABORATORY (KBS) (KLAB) 1 Credit Hour**

Student conduct lab experiments with fossils, rocks and sedimentary features, a river process simulator and the concept of deep time.

**Pre/corequisite:** GEOL 11042.

**Schedule Type:** Laboratory

**Contact Hours:** 3 lab

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Kent Core Basic Sciences Lab, TAG Science, Transfer Module Natural Sciences

**GEOL 21062 ENVIRONMENTAL EARTH SCIENCE (KBS) 3 Credit Hours**

Application of Earth science to environmental problems, including natural resource extraction, water supply, pollution, waste disposal, landslides, floods and land use planning. Students take local field trips.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Transfer Module Natural Sciences

**GEOL 21080 ALL ABOUT THE OCEANS (KBS) 3 Credit Hours**

Explores the many fascinating (and some still little known) features and processes of the Earth's oceans, including mid-ocean ridges, hydrothermal vents, tsunamis, tides, rogue waves, marine life and the role of the ocean in climate change.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**Attributes:** Kent Core Basic Sciences, Transfer Module Natural Sciences

**GEOL 22000 DEGREE AND CAREER PATHS IN GEOLOGY (ELR) 1 Credit Hour**

Provides students with an overview of career paths and opportunities in the Geology and Earth Science majors. Components of the course include a journal club; informational presentations by geoscientists in industry, government and academia; and skills training needed for the majors.

Required overnight field trip.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**GEOL 23063 EARTH MATERIALS I 4 Credit Hours**

Occurrence, associations, characteristics, crystallography and crystal chemistry of common minerals. Laboratory identification emphasizing physical properties. Required field trip.

**Prerequisite:** GEOL 11040 and GEOL 11041.

**Pre/corequisite:** CHEM 10060.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 5 other

**Grade Mode:** Standard Letter

**Attributes:** TAG Science

**GEOL 31070 EARTH MATERIALS II (WIC) 4 Credit Hours**

Occurrence and origin of igneous, sedimentary and metamorphic rocks. Laboratory identification, description and classification of hand specimens. Required field trip.

**Prerequisite:** GEOL 23063.

**Schedule Type:** Laboratory, Lecture

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**Attributes:** Writing Intensive Course

**GEOL 31080 STRUCTURAL GEOLOGY 4 Credit Hours**

Mechanical principles of rock deformation. Structures in sedimentary igneous and metamorphic rocks. Lecture three hours lab two hours weekly. Required field trip.

**Prerequisite:** GEOL 11040 and GEOL 11041.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 5 other

**Grade Mode:** Standard Letter

**GEOL 32066 GEOMORPHOLOGY 4 Credit Hours**

Earth's surface features as functions of geological structures, processes and time. Landform analysis using topographic maps and some stereographic aerial photos. Trigonometry recommended.

**Prerequisite:** GEOL 11040 and GEOL 11041.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 4 other

**Grade Mode:** Standard Letter

**GEOL 33025 WATER AND THE ENVIRONMENT 3 Credit Hours**

How water moves on the surface and in the subsurface, with an emphasis on societal issues such as pollution, the conservation and management of water resources, and the impacts of environmental change.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 34061 PRINCIPLES OF PALEONTOLOGY 4 Credit Hours**

Concepts applied to study of commonly preserved invertebrate organisms; identification of common North American fossils. Required field trip.

**Prerequisite:** GEOL 11042 and GEOL 11043.

**Corequisite:** BSCI 10002 or BSCI 10110.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 5 other

**Grade Mode:** Standard Letter

**GEOL 40093 VARIABLE TITLE WORKSHOP IN GEOLOGY 1-8 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 50093 and GEOL 70093) Workshop and/or training program focused on a specific professional or disciplinary topic.

**Prerequisite:** Special approval.

**Schedule Type:** Workshop

**Contact Hours:** 1-8 other

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 40095 SELECTED TOPICS IN GEOLOGY 1-3 Credit Hours**

(Slashed with GEOL 50095)(Repeatable for credit) Selected topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** 20 credit hours of GEOL courses.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**GEOL 40096 INDIVIDUAL INVESTIGATION IN GEOLOGY 1-3 Credit Hours**

(Repeatable for credit) Directed field, laboratory and/or library research. Written report required. Maximum 3 credit hours applied toward bachelor's degree.

**Prerequisite:** Special approval.

**Schedule Type:** Individual Investigation

**Contact Hours:** 1-3 other

**Grade Mode:** Standard Letter-IP

**GEOL 40380 BIOGEOCHEMISTRY 3 Credit Hours**

(Cross-listed with BSCI 40380, BSCI 50380 and BSCI 70380) (Slashed with GEOL 50380) Biogeochemistry explores the chemical, physical, geological, and biological processes and reactions that shape the world around us, and provides tools for understanding human alterations to global systems. In this course, we will explore elemental cycles in diverse terrestrial and aquatic ecosystems, as well as assess how humans have drastically altered these elemental cycles on a global scale, and the implications of these changes for biological systems.

**Prerequisite:** Minimum C- grade in the following courses BSCI 10110 and BSCI 10120 or GEOL 11040 and (GEOL 11042 or GEOL 21062 or GEOL 21080); and CHEM 10060 and CHEM 10062.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41025 GENERAL GEOPHYSICS 3 Credit Hours**

(Slashed with GEOL 51025) Physics of Earth, seismology, geomagnetism, heat flow, radioactivity, geochronology, geotectonic models. Required field trip.

**Prerequisite:** GEOL 31070 and GEOL 31080 and MATH 12002; and PHY 13001 or PHY 23101.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41073 GEOLOGY OF OHIO 3 Credit Hours**

(Slashed with GEOL 51073) Minerals, rocks, fossils, structural geology, physiography, environmental geology and geologic resources. Required field trips. Does not count toward the Geology major.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41077 GEOLOGY OF THE NATIONAL PARKS 3 Credit Hours**

(Slashed with GEOL 51077) Introduction to the geology of selected major national parks, emphasizing basic geological principles and the processes that have produced the spectacular scenery, rocks and fossils in each park. Does not count toward the Geology major.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41079 ALL ABOUT DINOSAURS 3 Credit Hours**

(Slashed with GEOL 51079) Dinosaurs (and some relatives) and their world, emphasizing how to interpret evidence concerning their history, biology and evolutionary relationships. Does not count toward the Geology major.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41080 TECTONICS AND OROGENY 3 Credit Hours**

(Slashed with GEOL 51080) Introduces advanced concepts of plate tectonics and mountain building, with emphasis on Western United States and the Appalachians. Required field trip to New England.

**Prerequisite:** GEOL 31080.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41082 ADVANCED STRUCTURAL GEOLOGY 3 Credit Hours**

(Slashed with GEOL 51082) Theoretical and applied studies in structural geology, including mechanical, mathematical, model and field investigations. Required field trip.

**Prerequisite:** GEOL 31080.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41085 MASS EXTINCTIONS: CAUSES AND CONSEQUENCES 3 Credit Hours**

Investigation of causes and consequences of extinction to marine and terrestrial ecosystems using paleontological, geochemical, sedimentological, and stratigraphical information; emphasizing an Earth System Science approach to the Big Five mass extinctions as well as the possible 6th Extinction occurring now.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 41092 SUMMER FIELD CAMP (ELR) 6 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 51092) Five weeks devoted to geologic mapping and solving structural and stratigraphic problems in the Black Hills of South Dakota.

**Prerequisite:** GEOL 31070 and GEOL 31080.

**Schedule Type:** Practical Experience

**Contact Hours:** 42 other

**Grade Mode:** Standard Letter

**Attributes:** Experiential Learning Requirement

**GEOL 42030 REMOTE SENSING 3 Credit Hours**

(Cross-listed with GEOG 49230)(Slashed with GEOL 52030, GEOL 72030, GEOG 59230, GEOG 79230) Computer analysis of multispectral satellite datasets. Applications in terrestrial Earth science are emphasized.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 42035 SCIENTIFIC METHODS IN GEOLOGY 3 Credit Hours**

(Slashed with GEOL 52035) Applying scientific methods to geologic data in the field and laboratory; models and sampling procedures. Collecting and analyzing data. Formulating and testing hypotheses. Provides background necessary for upper-division geology courses.

**Prerequisite:** None.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**GEOL 42036 PHYSICAL HYDROGEOLOGY LABORATORY 1 Credit Hour**

(Slashed with GEOL 52036) Laboratory course offering fundamental training for professional hydrogeologists. Required weekend field trip.

**Prerequisite:** Junior standing.

**Corequisite:** GEOL 42066.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**GEOL 42065 WATERSHED HYDROLOGY 3 Credit Hours**

(Slashed with GEOL 52065) Study of water movement, storage and transformation across landscapes.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 42066 PHYSICAL HYDROGEOLOGY 3 Credit Hours**

(Slashed with GEOL 52066) Principles of water flow in hydrologic cycle, soil and aquifer hydraulic properties, groundwater flow, surface water-groundwater interactions and geochemical evolution of groundwater. Application of principles for evaluation of water resources; emphasizing utilization, conservation and management of groundwater resources in a changing environment.

**Prerequisite:** MATH 12002 or higher MATH course; and junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 42068 CONTAMINANT HYDROLOGY AND HYDROGEOLOGY 3 Credit Hours**

(Slashed with GEOL 52068) An introduction to the basic principles of chemical and physical behavior of contaminants introduced by humans into the environment. Students are expected to understand concepts and work practical quantitative problems.

**Prerequisite:** CHEM 10060 and CHEM 10061 and PHY 13001 and and PHY 13021 and GEOL 42066.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 42069 HYDROGEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 52069 and GEOL 72069) Processes and evolution of the chemical composition of water in the natural hydrologic cycle. Methods of hydrochemical interpretation applied to ground water and pollution problems.

**Prerequisite:** 10 credit hours of CHEM courses.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 42074 ENVIRONMENTAL CORE AND WELL LOGGING 3 Credit Hours**

(Slashed with GEOL 52074) Examination of subsurface processes and the distribution of stratigraphic layers using core and well-logging techniques and based on analysis of physical properties of sediment, rock and pore fluids. Applications to paleoclimate, hydrogeology, engineering geology, oil and gas exploration and environmental remediation.

**Prerequisite:** GEOL 31070.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 42078 ENGINEERING GEOLOGY 4 Credit Hours**

(Slashed with GEOL 52078) Engineering properties of soils and rocks. Site evaluation for building foundations, dams, tunnels and highways. Slope stability.

**Prerequisite:** Geology or Earth Science major; and junior standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 4 other

**Grade Mode:** Standard Letter

**GEOL 43040 PRINCIPLES OF GEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 53040) Introduction to chemical thermodynamics and its applications in solving geochemical problems. Distributions of elements and isotopes in the Earth and laws governing these distributions.

**Prerequisite:** CHEM 10060 and CHEM 10061 and GEOL 31070 and MATH 12002.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 43042 ENVIRONMENTAL GEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 53042 and GEOL 73042) Explores chemical processes that influence the natural environment, including anthropogenic impacts. Topics include atmospheric chemistry and air pollution, energy and climate change, toxic organic compounds, water chemistry and water pollution, metals, soils, sediments and waste disposal. Environmental problem-solving using steady state and non-steady state box models, thermodynamics and energy transfer and chemical reactions and equilibria. Required half-day field trip.

**Prerequisite:** CHEM 10060 and CHEM 10061.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 43043 ENVIRONMENTAL MINERALOGY 3 Credit Hours**

(Slashed with GEOL 53043) Explores reactions between minerals and aqueous solutions, focusing on their role in chemical weathering, contaminant mobility, microbe-mineral interactions and an understanding of mineral-water interface processes and mechanisms at the molecular level. Through a series of case studies, the course explores the societal impacts of environmental contaminants and the potential role of remediation.

**Prerequisite:** GEOL 23063; and junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 43044 ENVIRONMENTAL ISOTOPES 3 Credit Hours**

(Slashed with GEOL 53044 and GEOL 73044) Deals with the fundamentals of isotope geochemistry and the application of primarily light stable isotopes (H, O, C, N) to Earth system processes (involving the hydrosphere, biosphere and upper geosphere).

**Prerequisite:** CHEM 10060 and CHEM 10061.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 44025 GEOLOGIC HAZARDS AND DISASTERS 3 Credit Hours**

(Slashed with GEOL 44025) Explores the geological processes that drive a broad range of different natural hazards (including earthquakes, volcanoes, landslides and floods), and how they interact with human behavior to produce geological risks and disasters. Through discussion of historical and topical events, students focus on the dual challenges of combining uncertain and incomplete information from various geological and historical sources into realistic assessments of future risks; and the communication of accurate, relevant, actionable information about these risks to the public and authorities.

**Prerequisite:** Junior standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 44052 GLACIERS AND GLACIATION 3 Credit Hours**

(Cross-listed with GEOG 41052, GEOG 51052, GEOG 71052)(Slashed with GEOL 54052, GEOL 74052) Examination of how glacial ice masses change the shape of the earth's surface, how they are integral to climate and sea level change, and how they pose high risk hazards.

**Prerequisite:** GEOG 21062 or GEOL 11040.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 44070 SEDIMENTOLOGY AND STRATIGRAPHY 4 Credit Hours**

(Slashed with GEOL 54070) Students are introduced to the principles regarding the systematics of sedimentary rocks and the relationships between geologic formations at various spatial and temporal scales. Lectures are integrated with readings from the open literature and required labs and field trips.

**Prerequisite:** GEOL 31070.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**GEOL 44072 MARINE PROCESSES 3 Credit Hours**

(Slashed with GEOL 54072) This course is an exploration of the mechanisms (geological, physical, chemical, and biological) through which the ocean operates, and how it influences climate on seasonal, inter-annual, glacial-interglacial and over deep time. Emphasis will be placed on understanding the relative importance of these processes and how they have varied through time, and the potential outcomes of human-induced changes to these processes.

**Prerequisite:** Special approval.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 44074 PALEOCEANOGRAPHY 3 Credit Hours**

(Slashed with GEOL 54074) A broad spectrum of geological approaches. Paleontology, geochemistry and stratigraphy are employed to interpret the history of earth's oceans.

**Prerequisite:** None.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 50093 VARIABLE TITLE WORKSHOP IN GEOLOGY 1-8 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 40093 and GEOL 70093) Workshop or training program focused on a specific professional or disciplinary topic within geology.

**Prerequisite:** Graduate standing; and special approval.

**Schedule Type:** Workshop

**Contact Hours:** 1-8 other

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 50095 SELECTED TOPICS IN GEOLOGY 1-3 Credit Hours**

(Slashed with GEOL 50095)(Repeatable for credit) Selected topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**GEOL 50380 BIOGEOCHEMISTRY 3 Credit Hours**

(Cross-listed with BSCI 40380, BSCI 50380 and BSCI 70380) (Slashed with GEOL 40380) Biogeochemistry explores the chemical, physical, geological, and biological processes and reactions that shape the world around us, and provides tools for understanding human alterations to global systems. In this course, we will explore elemental cycles in diverse terrestrial and aquatic ecosystems, as well as assess how humans have drastically altered these elemental cycles on a global scale, and the implications of these changes for biological systems.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 51025 GENERAL GEOPHYSICS 3 Credit Hours**

(Slashed with GEOL 41025) Physics of Earth, seismology, geomagnetism, heat flow, radioactivity, geochronology, geotectonic models. Required field trip.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 51073 GEOLOGY OF OHIO 3 Credit Hours**

(Slashed with GEOL 41073) Minerals, rocks, fossils, structural geology, physiography, environmental geology and geologic resources. Required field trips. Does not count toward the Geology major.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 51077 GEOLOGY OF THE NATIONAL PARKS 3 Credit Hours**

(Slashed with GEOL 41077) Introduction to the geology of selected major national parks, emphasizing basic geological principles and the processes that have produced the spectacular scenery, rocks and fossils in each park. Does not count toward the Geology major.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 51079 ALL ABOUT DINOSAURS 3 Credit Hours**

(Slashed with GEOL 41079) Dinosaurs (and some relatives) and their world, emphasizing how to interpret evidence concerning their history, biology and evolutionary relationships. Does not count toward the Geology major.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 51080 TECTONICS AND OROGENY 3 Credit Hours**

(Slashed with GEOL 41080) Introduces advanced concepts of plate tectonics and mountain building, with emphasis on Western United States and the Appalachians. Required field trip to New England.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 51082 ADVANCED STRUCTURAL GEOLOGY 3 Credit Hours**

(Slashed with GEOL 41082) Theoretical and applied studies in structural geology, including mechanical, mathematical, model and field investigations. Required field trip.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 51092 SUMMER FIELD CAMP 6 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 41092) Five weeks devoted to geologic mapping and solving structural and stratigraphic problems in the Black Hills of South Dakota.

**Prerequisite:** Graduate standing.

**Schedule Type:** Practical Experience

**Contact Hours:** 42 other

**Grade Mode:** Standard Letter-IP

**GEOL 52030 REMOTE SENSING 3 Credit Hours**

(Cross-listed with GEOG 51052, GEOG 41052, GEOG 71052) (Slashed with GEOL 42030, GEOL 72030) Computer analysis of multispectral satellite datasets. Applications in terrestrial Earth science are emphasized.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 52035 SCIENTIFIC METHODS IN GEOLOGY 3 Credit Hours**

(Slashed with GEOL 42035) Applying scientific methods to geologic data in the field and laboratory; models and sampling procedures. Collecting and analyzing data. Formulating and testing hypotheses.

**Prerequisite:** Graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**GEOL 52036 PHYSICAL HYDROGEOLOGY LAB 1 Credit Hour**

(Slashed with GEOL 52036) Laboratory course offering fundamental training for professional hydrogeologists. Required weekend field trip.

**Prerequisite:** Graduate standing.

**Corequisite:** GEOL 52066.

**Schedule Type:** Laboratory

**Contact Hours:** 2 lab

**Grade Mode:** Standard Letter

**GEOL 52065 WATERSHED HYDROLOGY 3 Credit Hours**

(Slashed with GEOL 42065) Study of water movement, storage and transformation across landscapes.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 52066 PHYSICAL HYDROGEOLOGY 3 Credit Hours**

(Slashed with GEOL 42066) Principles of water flow in hydrologic cycle, soil and aquifer hydraulic properties, groundwater flow, surface water-groundwater interactions and geochemical evolution of groundwater. Application of principles for evaluation of water resources; emphasizing utilization, conservation and management of groundwater resources in a changing environment.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 52068 CONTAMINANT HYDROLOGY AND HYDROGEOLOGY 3 Credit Hours**

(Slashed with GEOL 42068) An introduction to the basic principles of chemical and physical behavior of contaminants introduced by humans into the environment. Students are expected to understand concepts and work practical quantitative problems.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 52069 HYDROGEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 42069 and GEOL 72069) Processes and evolution of the chemical composition of water in the natural hydrologic cycle. Methods of hydrochemical interpretation applied to ground water and pollution problems.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 52074 ENVIRONMENTAL CORE AND WELL LOGGING 3 Credit Hours**

(Slashed with GEOL 42074) Examination of subsurface processes and the distribution of stratigraphic layers using core and well-logging techniques and based on analysis of physical properties of sediment, rock and pore fluids. Applications to paleoclimate, hydrogeology, engineering geology, oil and gas exploration and environmental remediation.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 52078 ENGINEERING GEOLOGY 4 Credit Hours**

(Slashed with GEOL 42078) Engineering properties of soils and rocks. Site evaluation for building foundations, dams, tunnels and highways. Slope stability.

**Prerequisite:** Graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 4 other

**Grade Mode:** Standard Letter

**GEOL 53040 PRINCIPLES OF GEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 43040) Introduction to chemical thermodynamics and its applications in solving geochemical problems. Distributions of elements and isotopes in the Earth and laws governing these distributions.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 53042 ENVIRONMENTAL GEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 43042 and GEOL 73042) Explores chemical processes that influence the natural environment, including anthropogenic impacts. Topics include atmospheric chemistry and air pollution, energy and climate change, toxic organic compounds, water chemistry and water pollution, metals, soils, sediments and waste disposal. Environmental problem-solving using steady state and non-steady state box models, thermodynamics and energy transfer and chemical reactions and equilibria. Required half-day field trip.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 53043 ENVIRONMENTAL MINERALOGY 3 Credit Hours**

(Slashed with GEOL 43043) Explores reactions between minerals and aqueous solutions, focusing on their role in chemical weathering, contaminant mobility, microbe-mineral interactions and an understanding of mineral-water interface processes and mechanisms at the molecular level. Through a series of case studies, the course explores the societal impacts of environmental contaminants and the potential role of remediation.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 53044 ENVIRONMENTAL ISOTOPES 3 Credit Hours**

(Slashed with GEOL 43044 and GEOL 73044) Deals with the fundamentals of isotope geochemistry and the application of primarily light stable isotopes (H, O, C, N) to Earth system processes (involving the hydrosphere, biosphere and upper geosphere).

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 54025 GEOLOGIC HAZARDS AND DISASTERS 3 Credit Hours**

(Slashed with GEOL 44025) Explores the geological processes that drive a broad range of different natural hazards (including earthquakes, volcanoes, landslides and floods), and how they interact with human behavior to produce geological risks and disasters. Through discussion of historical and topical events, students focus on the dual challenges of combining uncertain and incomplete information from various geological and historical sources into realistic assessments of future risks; and the communication of accurate, relevant, actionable information about these risks to the public and authorities.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 54052 GLACIERS AND GLACIATION 3 Credit Hours**

(Cross-listed with GEOG 51052, GEOG 41052, GEOG 71052)(Slashed with GEOL 44052, GEOL 74052) Examination of how glacial ice masses change the shape of the earth's surface, how they are integral to climate and sea level change and how they pose high risk hazards.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 54070 SEDIMENTOLOGY AND STRATIGRAPHY 4 Credit Hours**

(Slashed with GEOL 44070) Students are introduced to the principles regarding the systematics of sedimentary rocks and the relationships between geologic formations at various spatial and temporal scales. Lectures are integrated with readings from the open literature and required labs and field trips.

**Prerequisite:** Graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab, 1 other

**Grade Mode:** Standard Letter

**GEOL 54072 MARINE PROCESSES 3 Credit Hours**

(Slashed with GEOL 44072) This course is an exploration of the mechanisms (geological, physical, chemical, and biological) through which the ocean operates, and how it influences climate on seasonal, inter-annual, glacial-interglacial and over deep time. Emphasis will be placed on understanding the relative importance of these processes and how they have varied through time, and the potential outcomes of human-induced changes to these processes.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 54074 PALEOCEANOGRAPHY 3 Credit Hours**

(Slashed with GEOL 44074) A broad spectrum of geological approaches. Paleontology, geochemistry and stratigraphy are employed to interpret the history of earth's oceans.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 60080 RESEARCH ORIENTATION 1 Credit Hour**

(Slashed with GEOL 70080) Faculty research presentations; thesis/dissertation proposal preparation; discussion of professional organizations, preparation of manuscripts and oral presentation of papers.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 60084 GEOLOGY GRADUATE STUDENT ORIENTATION 1 Credit Hour**

(Slashed with GEOL 70084) Introduction to departmental resources, procedures and expectations, as well as approaches to successfully conduct research at a graduate level. Training and experience in presentation of data and college teaching of applied geology, as well as a discussion forum on professional ethics and responsibilities.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 60091 SEMINAR 1-2 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 70091) Topics in geology varies per course offering.

**Prerequisite:** Graduate standing.

**Schedule Type:** Seminar

**Contact Hours:** 1-2 other

**Grade Mode:** Standard Letter

**GEOL 60095 SELECTED TOPICS IN GEOLOGY 1-3 Credit Hours**

(Repeatable for credit)Selected topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**GEOL 60098 RESEARCH 1-15 Credit Hours**

(Repeatable for credit) Research for master's level students. Credits earned may be applied toward degree if department approves.

**Prerequisite:** Graduate standing.

**Schedule Type:** Research

**Contact Hours:** 1-15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**GEOL 60199 THESIS I 2-6 Credit Hours**

Thesis students must register for a total of 6 hours, 2 to 6 hours in a single semester distributed over several semesters if desired.

**Prerequisite:** Graduate standing.

**Schedule Type:** Masters Thesis

**Contact Hours:** 2-6 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**GEOL 60299 THESIS II 2 Credit Hours**

Thesis students must continue registration each semester until all degree requirements are met.

**Prerequisite:** GEOL 60199; and graduate standing.

**Schedule Type:** Masters Thesis

**Contact Hours:** 2 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**GEOL 61093 WORKSHOP IN COLLEGE TEACHING 1-2 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 71093) Workshop in college teaching.

**Prerequisite:** Graduate standing.

**Schedule Type:** Workshop

**Contact Hours:** 1-2 other

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 62011 HYDROLOGY 3 Credit Hours**

(Slashed with GEOL 72011) Introduction to hydrologic measurements, properties of water precipitation, evapotranspiration runoff computations, streamflow and flood routing.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 62068 ADVANCED HYDROGEOLOGY 3 Credit Hours**

(Slashed with GEOL 72068) Quantitative approach to occurrence of ground water; methods of investigation, evaluation and development of ground water resources emphasizing optimization and maximal exploitation without environmental changes.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 62079 ADVANCED ENGINEERING GEOLOGY 3 Credit Hours**

(Slashed with GEOL 72079) Role of geology in site selection, design and construction relative to dams, tunnels, highways, slope stability and nuclear power plants. Selected case histories. Field trip and term paper required.

**Prerequisite:** GEOL 52078; and graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 62082 INTRODUCTION TO SOIL MECHANICS 4 Credit Hours**

(Slashed with GEOL 72082) Engineering properties and engineering behavior of soils, including classification properties, compaction permeability strength and compressibility.

**Prerequisite:** Graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 5 other

**Grade Mode:** Standard Letter

**GEOL 62083 ROCK SLOPE STABILITY 3 Credit Hours**

(Slashed with GEOL 72083) Provide information used to recognize, avoid, design for, control and correct slope movements in rocks; determination of shear strength along rock discontinuities; stability analysis of rock slopes.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 62084 FOUNDATION ENGINEERING 3 Credit Hours**

(Slashed with GEOL 72084) Seepage and drainage of foundation soils. Subsurface investigations. Principles, design and construction of shallow and deep foundations. Earth retaining structures.

**Prerequisite:** GEOL 52078 or GEOL 72082; and graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 63063 SEDIMENTARY PETROLOGY 3 Credit Hours**

(Slashed with GEOL 73063) Classification, texture, composition, provenance and diagenesis of sandstones and carbonates, following review of optical mineralogy. Petrographic microscopy and other laboratory techniques are emphasized.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 64028 PALEOECOLOGY 3 Credit Hours**

(Slashed with GEOL 74028) Relationships between ancient organisms and their environments, as interpreted from fossils, enclosing rock strata and recent analogs. Field and laboratory studies. Saturday field trips.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 64030 SYSTEMATIC INVERTEBRATE PALEONTOLOGY I 3 Credit Hours**

(Slashed with GEOL 74030) Detailed investigation and examination of important literature concerning taxonomic characters of invertebrate phyla: Protista, Porifera, Cnidaria and Bryozoa. Numerous oral reports, specimen examination.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter



**GEOL 64032 SYSTEMATIC INVERTEBRATE PALEONTOLOGY II 3 Credit Hours**

(Slashed with GEOL 74032) Detailed investigation and examination of important literature concerning taxonomic characters of invertebrate phyla: Brachiopoda, Mollusca, Arthropoda and Echinodermata. Numerous oral reports, specimen examination.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 64036 CENOZOIC CLIMATE CHANGE 3 Credit Hours**

(Slashed with GEOL 74036) An overview of the concepts and principles involved in interpreting global and hemispheric Cenozoic climate change (past 65 million years). Emphasis on particular temporal and spatial scales and cycles. Extensive reading in scientific journals.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 64038 PALEOLIMNOLOGY 3 Credit Hours**

(Slashed with GEOL 74038) An overview of significant topics and applications in paleolimnology of Holocene (last 10,000 years) and Pleistocene (last two million years) records, including current issues in environmental and climatic reconstruction. Extensive reading expected.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 70080 RESEARCH ORIENTATION 1 Credit Hour**

(Slashed with GEOL 60080) Faculty research presentations; thesis/dissertation proposal preparation; discussion of professional organizations, preparation of manuscripts and oral presentation of papers.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 70084 GEOLOGY GRADUATE STUDENT ORIENTATION 1 Credit Hour**

(Slashed with GEOL 60084) Introduction to departmental resources, procedures and expectations, as well as approaches to successfully conduct research at a graduate level. Training and experience in presentation of data and college teaching of applied geology, as well as discussion forum on professional ethics and responsibilities.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 70091 SEMINAR 1-2 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 60091) Topics in geology varies per course offering.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Seminar

**Contact Hours:** 1-2 other

**Grade Mode:** Standard Letter

**GEOL 70093 VARIABLE TITLE WORKSHOP IN GEOLOGY 1-8 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 40093 and GEOL 50093) Workshop and/or training program, of varying duration focused on a specific professional or disciplinary topic.

**Prerequisite:** Doctoral standing; and special approval.

**Schedule Type:** Workshop

**Contact Hours:** 1-8 other

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 71093 WORKSHOP IN COLLEGE TEACHING 1-2 Credit Hours**

(Repeatable for credit)(Slashed with GEOL 61093) Workshop in college teaching.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Workshop

**Contact Hours:** 1-2 other

**Grade Mode:** Satisfactory/Unsatisfactory

**GEOL 72011 HYDROLOGY 3 Credit Hours**

(Slashed with GEOL 62011) Introduction to hydrologic measurements, properties of water precipitation, evapotranspiration, runoff computations, streamflow and flood routing.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 72030 REMOTE SENSING 3 Credit Hours**

(Cross-listed with GEOG 71052, GEOG 41052, GEOG 51052) (Slashed with GEOL 42030, GEOL 52030) Computer analysis of multispectral satellite datasets. Applications in terrestrial Earth science are emphasized.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 72068 ADVANCED HYDROGEOLOGY 3 Credit Hours**

(Slashed with GEOL 62068) Quantitative approach to occurrence of ground water; methods of investigation evaluation and development of ground water resources emphasizing optimization and maximal exploitation without environmental changes.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 72069 HYDROGEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 42069 and GEOL 52069) Processes and evolution of the chemical composition of water in the natural hydrologic cycle. Methods of hydrochemical interpretation applied to ground water and pollution problems.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 72079 ADVANCED ENGINEERING GEOLOGY 3 Credit Hours**

(Slashed with GEOL 62079) Role of geology in site selection, design and construction relative to dams, tunnels, highways, slope stability and nuclear power plants. Selected case histories. Field trip and term paper required.

**Prerequisite:** GEOL 52078; and doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 72082 INTRODUCTION TO SOIL MECHANICS 4 Credit Hours**

(Slashed with GEOL 62082) Engineering properties and engineering behavior of soils, including classification properties, compaction permeability strength and compressibility.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 5 other

**Grade Mode:** Standard Letter

**GEOL 72083 ROCK SLOPE STABILITY 3 Credit Hours**

(Slashed with GEOL 62083) Provide information used to recognize, avoid, design for control and correct slope movements in rocks; determination of shear strength along rock discontinuities; stability analysis of rock slopes.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 72084 FOUNDATION ENGINEERING 3 Credit Hours**

(Slashed with GEOL 62084) Seepage and drainage of foundation soils. Subsurface investigations. Principles, design and construction of shallow and deep foundations. Earth retaining structures.

**Prerequisite:** GEOL 52078 or GEOL 72082; and doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 73042 ENVIRONMENTAL GEOCHEMISTRY 3 Credit Hours**

(Slashed with GEOL 43042 and GEOL 53042) Explores chemical processes that influence the natural environment, including anthropogenic impacts. Topics include atmospheric chemistry and air pollution, energy and climate change, toxic organic compounds, water chemistry and water pollution, metals, soils, sediments and waste disposal. Environmental problem-solving using steady state and non-steady state box models, thermodynamics and energy transfer and chemical reactions and equilibria. Required half-day field trip.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 73044 ENVIRONMENTAL ISOTOPES 3 Credit Hours**

(Slashed with GEOL 43044 and GEOL 53044) Deals with the fundamentals of isotope geochemistry and the application of primarily light stable isotopes (H, O, C, N) to Earth system processes (involving the hydrosphere, biosphere and upper geosphere).

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 73063 SEDIMENTARY PETROLOGY 3 Credit Hours**

(Slashed with GEOL 63063) Classification, texture, composition, provenance and diagenesis of sandstones and carbonates, following review of optical mineralogy. Petrographic microscopy and other laboratory techniques are emphasized.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 74028 PALEOECOLOGY 3 Credit Hours**

(Slashed with GEOL 64028) Relationships between ancient organisms and their environments, as interpreted from fossils, enclosing rock strata and recent analogs. Field and laboratory studies. Saturday field trips.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 74030 SYSTEMATIC INVERTEBRATE PALEONTOLOGY I 3 Credit Hours**

(Slashed with GEOL 64030) Detailed investigation and examination of important literature concerning taxonomic characters of invertebrate phyla: Protista, Porifera, Cnidaria and Bryozoa. Numerous oral reports, specimen examination.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 74032 SYSTEMATIC INVERTEBRATE PALEONTOLOGY II 3 Credit Hours**

(Slashed with GEOL 64032) Detailed investigation and examination of important literature concerning taxonomic characters of invertebrate phyla: Brachiopoda, Mollusca, Arthropoda and Echinodermata. Numerous oral reports, specimen examination.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 74036 CENOZOIC CLIMATE CHANGE 3 Credit Hours**

(Slashed with GEOL 64036) An overview of the concepts and principles involved in interpreting global and hemispheric Cenozoic climate change (past 65 million years). Emphasis on particular temporal and spatial scales and cycles. Extensive reading in scientific journals.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 74038 PALEOLIMNOLOGY 3 Credit Hours**

(Slashed with GEOL 64038) An overview of significant topics and applications in paleolimnology of Holocene (last 10,000 years) and Pleistocene (last two million years) records, including current issues in environmental and climatic reconstruction. Extensive reading expected.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 74052 GLACIERS AND GLACIATION 3 Credit Hours**

(Cross-listed with GEOG 71052, GEOG 41052, GEOG 51052) (Slashed with GEOL 44052, GEOL 54052) Examination of how glacial ice masses change the shape of the earth's surface, how they are integral to climate and sea level change and how they pose high risk hazards.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**GEOL 80095 ADVANCED TOPICS IN GEOLOGY 1-3 Credit Hours**

(Repeatable for credit) Advanced topics presented by visiting professors or one-time offerings presented by regular faculty.

**Prerequisite:** Doctoral standing; and special approval.

**Schedule Type:** Lecture

**Contact Hours:** 1-3 lecture

**Grade Mode:** Standard Letter

**GEOL 80098 RESEARCH 1-15 Credit Hours**

(Repeatable for credit) Research for doctoral students. Credits earned may be applied toward degree with departmental approval.

**Prerequisite:** Doctoral standing.

**Schedule Type:** Research

**Contact Hours:** 1-15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**GEOL 80199 DISSERTATION I 15 Credit Hours**

(Repeatable for credit) Doctoral dissertation, for which registration in at least two semesters is required first of which will be semester in which dissertation work is begun and continuing until the completion of 30 hours. rerequisite: Admission to candidacy for doctoral degree; and doctoral standing.

**Schedule Type:** Dissertation

**Contact Hours:** 15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**GEOL 80299 DISSERTATION II 15 Credit Hours**

(Repeatable for credit) Continuing registration required of doctoral students who have completed the initial 30 hours of dissertation, continuing until all degree requirements are met.

**Prerequisite:** GEOL 80199; and doctoral standing.

**Schedule Type:** Dissertation

**Contact Hours:** 15 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP