

# GEOLOGY (GEO)

## Geology (GEO) Courses

### **GEO 5013. Volcanology. (3-0) 3 Credit Hours.**

Prerequisite: GEO 3043 or consent of instructor. A survey of volcanoes and volcanic processes, including historically important volcanic eruptions and the prediction and mitigation of volcanic hazards. Field trips may be required. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5023. Bid Data Analysis for Extreme Environments. (3-0) 3 Credit Hours.**

This course will touch on three basic aspects of data science and technology: geospatial data, data assimilation and modeling, and cloud computation and dig data analytics. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5033. Geographical Information Systems. (2-2) 3 Credit Hours.**

Application of the computer to environmental planning and management problems through a Geographical Information System (GIS). Using the computer as a mapping device for query, analysis, creation and display of spatially related data. Additional topics include using the Global Positioning System (GPS) for data acquisition. (Same as CE 5293. Credit cannot be earned for both CE 5293 and GEO 5033.) Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5043. Introduction to Earth System Science and Remote Sensing. (3-0) 3 Credit Hours.**

This course is designed for students in sciences or engineering to get basic knowledge about the earth system and some compelling science problems related to ice, snow, water, atmosphere, and ocean. The second part of the course will include some basic knowledge of remote sensing and how different remote sensing technology can be used to sense these different types of earth environments. Differential Tuition: \$150. Course Fees: \$90.

### **GEO 5063. Applied Statistics for Geoinformatics. (3-0) 3 Credit Hours.**

Prerequisites: CS 1063, MAT 1073, and STA 1053, or consent of instructor. This course will cover both the basic statistics and in depth coverage of analytical methods used in the analysis of geospatial data. Descriptive clustering methods for spatial data and in depth coverage of linear models used in the analysis of geospatial data will also be covered. Variogram models and kriging techniques will also be covered. All course materials will be taught using the programming language R. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5073. Mountain Environments and Climate Change. (3-0) 3 Credit Hours.**

Prerequisite: ES 2113, GEO 2113 or GEO 3343, or consent of instructor. In-depth survey on current scientific questions and methods applied to study mountain environments, with a special focus on glaciers, snow, permafrost and streamflow. Application of remote sensing, GIS, modeling, and fieldwork techniques commonly utilized to study these regions. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5103. Current Topics in the Geosciences. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing in geology or consent of instructor. Evaluation of current research trends and methodology in the geosciences. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5113. Research Design in the Geosciences. (3-0) 3 Credit Hours.**

Prerequisite: GEO 5103 or consent of instructor. Development of research projects, including literature review, methodology, and data analysis. Elements of project management will also be covered. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5213. Aqueous Geochemistry. (3-0) 3 Credit Hours.**

Prerequisite: GEO 3374 or consent of instructor. This course will facilitate to understand in detail the fundamental (primarily thermodynamic) controls on the composition of natural waters and the response of natural waters to variations in various physico-chemical parameters. Characterization of dissolved organic matter in natural waters will be introduced. This course will explore applications to environmental problems like contaminants migration in waters (ground waters, surface waters), weathering, etc., and students will be given the opportunity to learn to solve numerical problems related to the behavior of chemical components in natural waters, and gain familiarity with simple analytical techniques for the characterization of natural waters. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5303. Petroleum Geology. (3-0) 3 Credit Hours.**

Prerequisites: GEO 3103 and GEO 3123, or consent of instructor. Integrated study of the generation, migration, and entrapment of petroleum. Survey of surface and subsurface geological and geophysical techniques for exploration and production. Case studies of petroleum systems including economic aspects of the petroleum industry. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5413. River Science. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing in biology, environmental science, geology, or civil engineering, or consent of instructor. An in-depth examination of river sediment transport principles. Topics include water and sediment supply, sediment dynamics, river morphology, and channel instability. Field trips may be required. (Formerly GEO 5414. Same as CE 5323. Credit can be earned for only one of the following: CE 5323, CE 5653, GEO 5414, or GEO 5413.) Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5434. Fluvial Processes and Deposits. (3-3) 4 Credit Hours.**

Prerequisite: GEO 4113 or GES 3723, or consent of instructor. An in-depth examination of the interface between fluvial geomorphology and sedimentology. Differential Fee: \$200. Course Fees: GS01 \$120.

### **GEO 5454. Advanced Paleontology. (3-3) 4 Credit Hours.**

Prerequisite: GEO 3063 or consent of instructor. In-depth paleontological analyses. Current literature and scientific deliberations will be emphasized. Topic 1: Focused Paleontology. Detailed study of one to three taxonomic groups. Topic 2: Paleocology. Study of fossil organisms in relation to their past environments, and their interactions in extinct ecological communities. Topic 3: Micropaleontology. Study of microscopic fossil organisms that commonly produced a fossil record. Emphasis on taxonomy, evolution, and processing methods. May be repeated for credit when topics vary. Field trips may be required. Differential Tuition: \$200. Course Fees: GS01 \$120.

### **GEO 5483. Environmental Hydrogeology. (3-0) 3 Credit Hours.**

Focuses on the physical and chemical processes that control natural variation in the chemical and isotopic composition of groundwater, fate and transport of groundwater contaminants, and modeling of groundwater quality using publicly available computer programs. Field trips may be required. Differential Tuition: \$150. Course Fees: GS01 \$90.

### **GEO 5504. Advanced Stratigraphy. (3-3) 4 Credit Hours.**

Prerequisites: GEO 3123 and GEO 3131, or consent of instructor. Chronologic study of stratigraphic systems, physical properties and facies, depositional and paleogeographic implications, correlation, nomenclature, and biostratigraphy. Sequence stratigraphy and seismic and log analyses are studied. Field trips may be required. Differential Tuition: \$200. Course Fees: GS01 \$120.

**GEO 5603. Physical Hydrogeology. (3-0) 3 Credit Hours.**

Prerequisite: GEO 4623 with a grade of "C-" or better, or consent of instructor. Geologic principles governing the flow of subsurface water with an emphasis on physical hydrogeology, interaction of surface and groundwater, hydrogeologic properties and their measurement, flow in the unsaturated zone, mass transport, evolution of aquifer systems, and an introduction to groundwater modeling. Field trips may be required. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 5713. Groundwater Modeling. (3-0) 3 Credit Hours.**

Prerequisite: GEO 5603 or consent of instructor. Focus is on using MODFLOW code to model the occurrence and movement of groundwater. Course will discuss hydrogeologic data for modeling, modeling protocol, and MODFLOW packages. Multiple graphics-rich user model interfaces commonly used in groundwater science will be learned. Other computer programs for simulating flow of subsurface fluids may be included. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 5803. Planetary Geology. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 or consent of instructor. This course is designed for students in the Sciences or Engineering and no prior Geological knowledge is assumed, although Earth will be our point of reference. Survey of the interior and surface geology of solid bodies in our Solar System and beyond (planets, moons, asteroids, comets, Kuiper Belt Objects and exoplanets). Topics will include bulk composition and differentiation of planetary interiors, surface processes such as (cryo-)volcanism and meteorite impacts, erosion and sedimentation by fluids and wind, and heat transfer styles. There will be an emphasis on how we know things and what we do not know, quantifying uncertainties in measurements and models, and the nature of planetary scientific inquiry. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 5894. Advanced Structural Geology. (3-3) 4 Credit Hours.**

Prerequisites: GEO 3103 and GEO 3111, or consent of instructor. In-depth study of the various aspects of structural geology: stress and strain, behavior of materials, failure criteria, fault analysis, rheological properties of geologic materials, fold analysis, and subsurface analysis. Field trips may be required. Differential Tuition: \$200. Course Fees: GS01 \$120.

**GEO 5904. Carbonate Petrology. (3-3) 4 Credit Hours.**

Prerequisites: GEO 3043, GEO 3051, GEO 3123, and GEO 3131, or consent of instructor. Thin-section analysis and hand-specimen study of carbonate sediment and rocks, carbonate classifications, carbonate facies, models, and carbonate diagenesis. Field trips required. Differential Tuition: \$200. Course Fees: GS01 \$120.

**GEO 5954. Sandstone Petrology. (3-3) 4 Credit Hours.**

Prerequisites: GEO 3043, GEO 3051, GEO 3123, and GEO 3131, or consent of instructor. Thin-section analysis and hand-specimen study of clastic rocks, classifications, interpretation of provenance, clastic sedimentary facies, and clastic diagenesis. Field trips may be required. Differential Tuition: \$200. Course Fees: GS01 \$120.

**GEO 5971. Directed Research. (0-0) 1 Credit Hour.**

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve a laboratory, field-based, or theoretical problem. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 5972. Directed Research. (0-0) 2 Credit Hours.**

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve a laboratory, field-based, or theoretical problem. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$100. Course Fees: GS01 \$60.

**GEO 5973. Directed Research. (0-0) 3 Credit Hours.**

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve a laboratory, field-based, or theoretical problem. May be repeated for credit, but not more than 3 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 5991. Graduate Seminar in Geology. (1-0) 1 Credit Hour.**

Prerequisite: Graduate standing in geology or consent of the Graduate Advisor of Record. Topical issues chosen by faculty and current research seminars presented by faculty, visiting lecturers, and Master's degree candidates. May be repeated for credit but only 2 hours may be applied toward the Master's degree. The grade report for the course is either "CR" (satisfactory performance) or "NC" (unsatisfactory performance). Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 6011. Seminar in Geospatial Science and Applications. (1-0) 1 Credit Hour.**

Seminar will focus on literature review of cutting-edge research in remote sensing, GIS, geoinformatics, and their applications to water resources, surface hydrology and cryosphere. Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 6021. Welcome to the Anthropocene. (1-0) 1 Credit Hour.**

A reading seminar to understand how the Anthropocene and its collateral concepts (e.g., planetary boundaries) have become ubiquitous denominations to encompass all the consequences of human impacts on the global environment. Select theoretical and applied case studies from the peer-review literature will be analyzed in order to understand the implications for Geoscience practitioners. Differential Tuition: \$50. Course Fees: \$30.

**GEO 6043. Global Change. (3-0) 3 Credit Hours.**

Prerequisite: Graduate standing in the program or consent of instructor. Changes in the global distribution of plants and animals and the causes of the changes will be examined. Factors that are apparently coupled to changes in the atmosphere and environmental temperature will be examined. (Same as CE 6113 and ES 5043. Formerly GEO 5043. Credit can be earned for only one of the following: CE 6113, ES 5043, GEO 5043, or GEO 6043.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6053. Remote Sensing. (2-2) 3 Credit Hours.**

Prerequisites: MAT 1073, and PHY 1603 or PHY 1943. Fundamental remote sensing theory and technology will be introduced and emphasized as well as remote sensing applications to land surface, ocean, and atmosphere. Emphasis will be on the interaction of electromagnetic energy with the Earth's surface and different types of remote sensing for data collection. (Formerly GEO 5053. Credit cannot be earned for both GEO 5053 and GEO 6053.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6063. Ocean Remote Sensing. (3-0) 3 Credit Hours.**

Prerequisites: MAT 1073 or equivalent, and PHY 1603 or PHY 1943 or equivalent. This course provides an overview of applications of satellite remote sensing to the study of the physics and biology of the oceans. The physical principles behind each type of ocean observing satellite system is presented as well as the various possible satellite orbits and sampling patterns. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6083. Remote Sensing Image Processing and Analysis. (2-2) 3 Credit Hours.**

Prerequisite: GEO 4093 or GEO 6053, or consent of instructor. Fundamentals, algorithms, and techniques of remote sensing image processing, information extraction and analysis, including radiometric and geometric corrections, image enhancement, image sharpening, principal components analysis, image classification, spectral analysis, vectorization, integration with GIS, etc. (Formerly GEO 5083. Credit cannot be earned for both GEO 5083 and GEO 6083.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6093. Remote Sensing in Hydrology. (2-2) 3 Credit Hours.**

Prerequisite: GEO 4093 or GEO 6053, or consent of instructor. Apply remote sensing to derive parameters of surface hydrology and hydrometeorology such as precipitation, land surface temperature and emissivity, heat flux, evaporation, evapotranspiration, soil moisture, surface water, water quality, snow and ice, and soil erosion. The contents will also include radar hydrology, microwave techniques and mapping of soil moisture and precipitation, and remote sensing in hydrologic modeling. (Formerly GEO 5093. Credit cannot be earned for GEO 5093 and GEO 6093.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6183. Basin Analysis and Sedimentary Geology. (3-0) 3 Credit Hours.**

An interdisciplinary integration of geodynamics, mathematical and physical modeling, and sedimentary geology. Emphasizes basin formation, nature and maturation of the basin fill, and timing of events. Case histories of various basins illustrate approaches. Field trips may be required. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6304. Isotope Geochemistry. (3-2) 4 Credit Hours.**

Prerequisite: GEO 3374. The course will cover an introduction to isotope theory, and its utility in geological science and related fields. Focus will be on methods, data acquisition, data corrections, and interpretation. Laboratory methods for isotope sample preparation and hands-on experience with isotope ratio-mass spectrometry (IRMS) and peripherals. Differential Tuition: \$200. Course Fees: GS01 \$120.

**GEO 6403. Advanced Geophysics. (3-0) 3 Credit Hours.**

Prerequisite: GEO 3383 or consent of instructor. Application of fundamentals of geophysical properties of the earth, specifically the propagation of seismic energy and electromagnetic (EM) fields in earth materials, toward an advanced analysis of seismic, EM prospection techniques, and well-logging methods. Techniques addressed will be specifically relevant to the petroleum and mineral extraction industries. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6513. Advanced GIS. (2-2) 3 Credit Hours.**

Prerequisite: CE 5293 or GEO 5033, or consent of instructor. Geographic Information Systems (GIS) is an excellent tool for modeling, analyzing, and managing environmental systems. This course teaches advanced concepts and applications of industry standard GIS software, including spatial analysis, spatial statistics, geostatistical analysis, 3-D analysis, and geoprocessing. The emphasis of this course is on understanding the underlying principles of those tools and on how to apply them to solve real-world problems. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6523. GIS for Water Resources. (3-0) 3 Credit Hours.**

Prerequisites: GEO 4623 and GEO 6513, or consent of instructor. Current approaches for using GIS to acquire, process and analyze spatial data for surface water and groundwater systems. Course will introduce watershed delineation techniques, spatial interpolation methods for analysis of precipitation and groundwater data, and GIS-based modeling of hydrologic mass-balance in watersheds. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6533. Programming for Geospatial Application. (2-2) 3 Credit Hours.**

Prerequisite: CE 5293 or GEO 5033, or consent of instructor. This course teaches one or more programming languages with high-level toolkits suitable for GIS (Geographic Information System) application and development in a variety of open source environments. The course introduces key GIS concepts such as location, distance, units, projections, datum, and GIS data formats, examines a number of libraries of programming languages (e.g., Python or others), and explores how to combine these with geo-spatial data to accomplish a variety of tasks. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6543. Web GIS. (2-2) 3 Credit Hours.**

Prerequisites: ES 2113, GEO 2113, or GEO 3343; and GEO 5033, or consent of instructor. This course will focus upon developing GIS applications to be served out via the Internet or a local Area Network (LAN). Additional topics include the use of Web authoring software. The course presents and introductory level skill set for the creation and publishing of Web mapping applications using the ESRI ArcGIS Online resources and available tools. (Formerly EES 6543. Credit cannot be earned for both EES 6543 and GEO 6543.) Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6623. Rheology of Earth Materials. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 or consent of instructor. This course is designed for graduate students in the Sciences or Engineering and no prior Geological knowledge is assumed. Survey of the rheological behavior of solid Earth materials (rocks and ices) and fluids (brines, hydrocarbons, magma and lava). The course will include empirical and thermodynamic models for the viscosity of fluids, three-phase suspension rheology (solid+liquid+gas), and statistical fitting of experimental data. Examples of applied rheology will include lava flows and the deformation of continents, and various foods will be studied as analog materials. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6813. Water Resources. (3-0) 3 Credit Hours.**

Application of management principles to the efficient use of water resources by people and their public and private institutions. Water is examined in terms of its value, use, and changing role in the context of economics, history, politics, and technology. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6951. Independent Study. (0-0) 1 Credit Hour.**

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 6952. Independent Study. (0-0) 2 Credit Hours.**

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$100. Course Fees: GS01 \$60.

**GEO 6953. Independent Study. (0-0) 3 Credit Hours.**

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6961. Comprehensive Examination. (0-0) 1 Credit Hour.**

Prerequisite: Approval of the appropriate Graduate Program Committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 6973. Special Problems. (3-0) 3 Credit Hours.**

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when the topics vary, but not more than 6 hours, regardless of discipline, will apply to a Master's degree. Field trips may be required. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 6981. Master's Thesis. (0-0) 1 Credit Hour.**

Prerequisites: Permission from the Graduate Advisor of Record and thesis director. Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 6982. Master's Thesis. (0-0) 2 Credit Hours.**

Prerequisites: Permission from the Graduate Advisor of Record and thesis director. Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. Differential Tuition: \$100. Course Fees: GS01 \$60.

**GEO 6983. Master's Thesis. (0-0) 3 Credit Hours.**

Prerequisites: Permission from the Graduate Advisor of Record and thesis director. Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 7211. Doctoral Research. (0-0) 1 Credit Hour.**

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 7212. Doctoral Research. (0-0) 2 Credit Hours.**

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. Differential Tuition: \$100. Course Fees: GS01 \$60.

**GEO 7213. Doctoral Research. (0-0) 3 Credit Hours.**

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

**GEO 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.**

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. Differential Tuition: \$50. Course Fees: GS01 \$30.

**GEO 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.**

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. Differential Tuition: \$100. Course Fees: GS01 \$60.

**GEO 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.**

Prerequisite: Admission to candidacy for the Doctoral degree. May be repeated for credit, but no more than 15 hours may be applied to the Doctoral degree. Differential Tuition: \$150. Course Fees: GS01 \$90.