Prerequisite: GEOL 300 or approval of instructor.

GEOL 610 Field Methods in Hydrogeology
Credits 3. 1 Lecture Hour. 6 Lab Hours.
Field methods in hydrogeology; including ground water drilling technology and law; investigation and planning of well sites; installation of ground water wells; field testing of aquifer properties and analysis of field data. Field trips may be required for which departmental fees may be assessed to cover costs.
Prerequisite: GEOL 410 or approval of instructor.

GEOL 612 Structural Geology
Credits 3. 3 Lecture Hours.
Mechanical principles important to structural geology and experimental results relating to rock deformation followed by applications to natural deformation; mechanisms, rather than geometries. Primarily for students not concentrating in structural geology but who desire an advanced general course.
Prerequisite: Approval of instructor.

GEOL 614 Advanced Hydrogeology
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Geologic conditions determining the distribution and movement of ground water and their effect on the hydrologic properties of aquifers.
Prerequisites: MATH 151 and MATH 152, or equivalent.

GEOL 616 Petroleum Systems Analysis and Basin Modeling
Credits 3. 3 Lecture Hours.
Geological processes in sedimentary basins; petroleum system elements and modeling; hydrocarbon generation, expulsion, migration, accumulation; fluid analysis; multi-disciplinary data integration; basin modeling software and simulation.

GEOL 617 Introduction to the Petroleum Industry
Credits 3. 3 Lecture Hours.
Introduction to the petroleum industry and geoscience issues associated with the full petroleum cycle from resource discovery to marketing of refined petroleum products; focuses on the role of geoscientists in all facets of the business.
Prerequisite: Graduate classification or approval of instructor.

GEOL 619 Petroleum Geology
Credits 3. 3 Lecture Hours.
Properties of reservoir rocks; origin, migration and accumulation of petroleum; geologic interpretation of borehole logs and fluid-pressure measurements and the role of hydrostatic and hydrodynamic pressures in oil accumulation.
Prerequisite: Approval of instructor.

GEOL 621 Contaminant Hydrogeology
Credits 3. 3 Lecture Hours.
Physical concepts of mass transport; dispersion; diffusion; advection; geochemical processes including surface reaction; hydrolysis; biodegradation; aspects of modeling; process and parameter; and remediation.
Prerequisite: GEOL 410 or approval of instructor.

GEOL 622 Stratigraphy
Credits 3. 3 Lecture Hours.
Principles for correlating and naming stratigraphic units; controls on stratigraphic development (sediment supply, base-level change, subsidence, climate, and compaction); principles and application of sequence stratigraphy; subsurface stratigraphy; facies analysis and stratigraphic architecture.
Prerequisite: Graduate classification or approval of instructor.

GEOL 623 Carbonate Rocks
Credits 3. 3 Lecture Hours.
Principles of carbonate sedimentology; carbonate depositional sequences defined in modern environments and utilized to interpret the rock record; introduction to depositional and diagenetic microfacies; shelves, ramps and isolated platforms and their tectonosedimentary significance; suggested for geoscience majors.
Prerequisites: A basic understanding of sedimentology and the associated terminology; graduate classification.

GEOL 624 Carbonate Reservoirs
Credits 3. 3 Lecture Hours.
Recognition and description of hydrocarbon reservoirs in carbonate rocks; classification of carbonate porosity; capillary pressure curves and pore types; pore characteristics as proxies for permeability in reservoir modeling; techniques for mapping flow units.
Prerequisites: Graduate classification and approval of instructor.

GEOL 625 Applied Ground Water Modeling
Credits 3. 3 Lecture Hours.
Concept of groundwater flow and contaminant transport; numerical simulations of solving flow and transport equations; finite difference and finite element methods; software structures of groundwater flow, contaminant transport, density-dependent fluid flow and hydrocarbon remediations; real case applications of software including geological, physical, chemical, biological and hydrological information.
Prerequisite: GEOL 410 or approval of instructor.

GEOL 629 Regional Geology of North America
Credits 3. 3 Lecture Hours.
Regional geology of North America, examining the accumulation and deformation of the rock units involved; structural form and style emphasized; entire geologic history investigated.
Prerequisite: Graduate classification or approval of instructor.

GEOL 631 Engineering Geomorphology
Credits 3. 3 Lecture Hours.
Active surface processes as they influence engineering construction; erosion, rivers and floods, slope processes, subsidence, coastal processes, ice, weathering and ground water.
Prerequisites: Graduate classification in engineering or geosciences; GEOG 331 or approval of instructor.

GEOL 633 River Restoration
Credits 3. 3 Lecture Hours.
Geologic, geomorphic and geomechanical principles applied to the investigation, design, construction, and maintenance of river restoration projects.
Prerequisite: GEOL 631 or GEOG 626 or approval of instructor.

GEOL 635 Engineering Geology
Credits 3. 3 Lecture Hours.
Geological principles applied to the investigation design, construction and maintenance of engineering projects; history, development and role of engineering geologic practice as applied to dams, waste disposal, surface and ground water, tunneling, quarrying and construction materials.
GEOL 640/WMHS 640 Geochemistry of Natural Fresh Waters
Credits 3. 3 Lecture Hours.
Chemistry of aqueous solutions; weathering/redox reactions and controls on fresh waters; natural and anthropogenic factors affecting major, minor, and trace elements in fresh waters; evaluation of fresh water composition; application of water-quality measurements to quantitative hydrology.
Cross Listing: WMHS 640/GEOL 640.

GEOL 641 Environmental Geochemistry
Credits 3. 3 Lecture Hours.
Geochemical processes affecting the fate and transport of inorganic and organic pollutants in terrestrial systems; equilibrium and kinetic modeling.
Prerequisite: GEOL 451 or approval of instructor.

GEOL 643 Introduction to Electron Microprobe Analysis
Credits 2. 1 Lecture Hour. 3 Lab Hours.
Digital imaging and qualitative and quantitative chemical analysis of geological and material science samples using the electron microprobe; emphasis on quantitative chemical analysis using WDS (wavelength-dispersive spectrometry) methods; use the electron microprobe and correctly interpret analytical results.
Prerequisite: Approval of instructor.

GEOL 645 Geochronology
Credits 3. 3 Lecture Hours.
Earth's 4.5 billion-year history is divided into units of geologic time based on the observed changes in the rock record: the timing of those changes is quantified by numerical dating methods: this course examines both dating methods and physical and biological changes observed in the rock record.
Prerequisite: Graduate classification or approval of instructor.

GEOL 647 Radiogenic Isotope Geology
Credits 3. 3 Lecture Hours.
Use of radiogenic isotopes in addressing problems in high- and low-temperature geochemistry; their use as tracers for past and present-day processes at the surface and interior of the Earth.
Prerequisite: Approval of instructor.

GEOL 648 Stable Isotope Geology
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Stable isotopes of oxygen, carbon, sulfur and hydrogen applied to problems in paleontology and paleoecology; carbonate diagenesis, petroleum exploration, and igneous and metamorphic petrology; isotopic paleotemperatures; analytical methods; theory of isotopic fractionation.
Prerequisite: GEOL 451 or approval of instructor.

GEOL 650 Paleoecology
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Interrelationships of organisms and environment in the fossil record; methods and criteria available for interpreting ancient environments; critical review of classical studies and current research in paleoecology.
Prerequisite: Approval of instructor.

GEOL 651 Paleoeological Community Analysis
Credits 3. 3 Lecture Hours.
Quantitative analysis of multivariate paleoecological community data; measurement of diversity; cluster analysis; gradient analysis by standard and canonical ordination techniques.
Prerequisite: A basic course in statistics or approval of instructor.

GEOL 652 Biogeology
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Major trends and processes in the evolution of life through geologic time. Interrelationships of biological and physical processes in earth history; application of paleontology to current problems in geology; critical review of modern developments in biogeology.
Prerequisite: GEOL 305 or approval of instructor.

GEOL 653 Geobiological Research
Credits 3. 1 Lecture Hour. 6 Lab Hours.
Team-based research in modern or historical geobiology; definition of questions and hypothesis testing; analytical techniques; project lifecycle; reporting of results. May be taken two times for credit.
Prerequisite: Approval of instructor.

GEOL 654 Evolutionary Patterns and Theory
Credits 3. 3 Lecture Hours.
Evolutionary patterns in the fossil record and application of evolutionary theory to understanding these patterns; comparisons of neo-Darwinian and punctuational hypotheses; events and processes pertaining to microevolutionary and macroevolutionary change; and methods of determine phylogenies of organisms.
Prerequisite: Graduate classification in geological or biological sciences.

GEOL 658 Earth Systems Through Deep Time: Global Change, Paleoclimate and Life
Credits 3. 3 Lecture Hours.
History and cause of global change in the earth system, Archean to Holocene; Impact of biotic change on the earth system; influence of tectonics on paleochemistry and climate change; influence of climate on tectonics; methods and models for evaluating global change.
Prerequisite: Graduate classification.

GEOL 663 Fracture and Faulting of Rocks
Credits 3. 3 Lecture Hours.
The structure of fractures and faults in the Earth's crust at the macroscopic and microscopic scale; formation and evolution of faults, faults networks and fault zones; fault-related rocks and faulting mechanisms; influence of faults on fluid flow properties; seismic faulting and creep; current problems and research opportunities.
Prerequisite: Graduate classification.

GEOL 664 Mechanical Analysis in Geology
Credits 3. 3 Lecture Hours.
Mechanical analysis of geological problems based on concepts of stress, strain, strength, elasticity, viscosity and plasticity; folding, faulting, dike formation, hydraulic fracturing, magma and glacial flow, and cooling of magmatic bodies.
Prerequisites: MATH 253; approval of instructor.

GEOL 665 Structural Petrology
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Mechanisms of rock deformation from single crystal to mountain range; techniques for mapping stresses and strains and for inferring physical conditions and mechanical behavior at time of deformation; laboratory assignments on descriptive techniques include petrographic microscope-universal stage methods, field procedures and data analysis.
Prerequisite: Approval of instructor.
GEOL 668 Clastic Sedimentology and Sedimentary Petrology
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Detailed analyses of clastic sedimentary rocks: relationships of facies and depositional environments with emphasis on continental, coastal and shallow shelf clastic sediments; petrography and diagenesis of modern and ancient clastic sediments.
Prerequisites: Optical mineralogy course and sedimentology (undergraduate); graduate classification.

GEOL 678 Earth Science Modeling
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Techniques for building, solving and analyzing numerical models applied to a wide variety of problems in geology, geochemistry, geobiology and geophysics; derivation and scaling of conservation laws; finite difference and finite element techniques and error analysis; programming in MATLAB or a high-level language.

GEOL 681 Seminar
Credit 1. 1 Lecture Hour.
Reports and discussions of current research and selected topics from geologic literature.
Prerequisite: Graduate classification.

GEOL 685 Directed Studies
Credits 1 to 12. 1 to 12 Other Hours.
Enables graduate students to undertake limited investigations not within their thesis or dissertation research and not covered in established curricula.
Prerequisites: Graduate classification and approval of instructor.

GEOL 689 Special Topics in...
Credits 1 to 4. 1 to 4 Lecture Hours. 1 to 7 Lab Hours.
Selected topics in an identified area of geology. May be repeated for credit.
Prerequisite: Approval of instructor.

GEOL 691 Research
Credits 1 to 23. 1 to 23 Other Hours.
Original research on problems in various phases of geology. Research for thesis or dissertation.