GEOLOGICAL ENGINEERING (GEGN)

GEGN101. EARTH AND ENVIRONMENTAL SYSTEMS. 4.0 Semester Hrs.
Equivalent with SYGN101,
(I, II, S) Fundamental concepts concerning the nature, composition and evolution of the lithosphere, hydrosphere, atmosphere and biosphere of the earth integrating the basic sciences of chemistry, physics, biology and mathematics. Understanding of anthropological interactions with the natural systems, and related discussions on cycling of energy and mass, global warming, natural hazards, land use, mitigation of environmental problems such as toxic waste disposal, exploitation and conservation of energy, mineral and agricultural resources, proper use of water resources, biodiversity and construction. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEGN203. ENGINEERING TERRAIN ANALYSIS. 3.0 Semester Hrs.
Geomorphology of landscapes and the physical processes that shape them. Landform morphology, evolution and complex connections to climatic, tectonic, geologic, biotic, anthropogenic and geomorphic processes. Theoretical and practical introduction to weathering, hillslopes, drainage systems, rivers and glaciers. Collection, analysis and interpretation of geomorphic data and maps. Applications of geomorphic information to solve geological engineering problems with emphasis on ethical and environmental considerations. Course will include fieldwork in Colorado, with analysis of landforms and geomorphic processes. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: GEGN101, MATH111.

GEGN204. GEOLOGIC PRINCIPLES AND PROCESSES. 3.0 Semester Hrs.
Processes and deposits on the Earth and other Celestial bodies that shape the worlds around us. Formation of the Earth and our Solar System. Evolution of the Earth as we know it today including the continents, oceans and processes that form and mold the natural world. Scientific methods for how we learn about our worlds Examination of the influences on energy and mineral resource development and distribution, as well as the impact of extraction and utilization in the built world. Collection and analysis of data from modern systems and application to understanding ancient systems imaged in seismic, geophysical borehole, and reflected in the occurrence of ancient fauna and flora. Data collection and application for assessing risk and solving geologic questions of past world and future environmental and engineering challenges. Course will include in-class exercises in interpretation of ancient landscapes, seascapes and deposits utilizing a variety of different types of data. Prerequisite: GEGN101.

GEGN212. THE ROCK CYCLE. 4.0 Semester Hrs.
Introduction to Earth materials. This course will teach foundations of mineralogy and petrology in lecture, including an introduction to crystal chemistry and mineral classification schemes and the concepts of rock forming processes as a basis for rock classification. Students will be able to link chemistry, mineralogy, and tectonic processes to rock forming processes and the associated rock classification. The associated laboratory will focus on practical skills used to identify minerals and rocks in hand sample. Prerequisite: CHGN122 or CHGN125. Co-requisite: GEGN217.
Course Learning Outcomes

- Students will be able to: 1. Analyze physical properties of minerals for identification and recall chemical information based on mineral ID.
- Students will be able to: 2. Classify minerals based on crystallographic structures and relate mineral structure to physical properties.
- Students will be able to: 3. Describe igneous, metamorphic, and sedimentary rocks and classify them according to standard classification schemes.
- Students will be able to: 4. Construct conceptual models of tectonic environments and compare temperature and pressure gradients between different environments.
- Students will be able to: 5. Relate rock composition and texture to tectonic environments and construct rock history from observations.

GEGN217. GEOLOGIC FIELD METHODS. 2.0 Semester Hrs.
Methods and techniques of geologic field observations and interpretations. Lectures in field techniques and local geology. Laboratory and field project in diverse sedimentary, igneous, metamorphic, structural, and surficial terrains using aerial photographs and topographic maps. Geologic cross sections, maps, and reports. Weekend exercises required. Prerequisite: GEGN101.
Course Learning Outcomes

- Students will be able to: 1. Systematically describe sedimentary, igneous and metamorphic rocks in the field
- Students will be able to: 2. Read and interpret topographic maps and construct topographic profiles
- Students will be able to: 3. Measure and record structural data and plot data on a map
- Students will be able to: 4. Interpret the nature of geological contacts in the field (conformable, unconformable, fault and intrusive contacts) and map locations on a base map
- Students will be able to: 5. Construct 1:1 scale geological cross sections
- Students will be able to: 6. Interpret geological histories from geological maps and cross sections

GEGN298. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN299. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study?

form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEGN307. PETROLOGY. 4.0 Semester Hrs.
Equivalent with GEOL307,
An introduction to igneous, sedimentary and metamorphic processes, stressing the application of chemical and physical mechanisms to study the origin, occurrence, and association of rock types. Emphasis on the megascopic and microscopic classification, description, and interpretation of rocks. Analysis of the fabric and physical properties. Prerequisite: GEOL321.
Course Learning Outcomes

- No change

GEGN316. FIELD GEOLOGY. 5.0 Semester Hrs.
Six weeks of field work, stressing geology of the Southern Rocky Mountain Province. Mapping of igneous, metamorphic, and sedimentary terrain using air photos, topographic maps, and other methods. Diversified individual problems in petroleum geology, mining geology, engineering geology, structural geology, and stratigraphy. Formal reports submitted on several problems. Frequent evening lectures and discussion sessions. Field trips emphasize regional geology as well as mining, petroleum, and engineering projects. Prerequisite: GEGN203, GEGN204, GEGN212 or GEOL314, GEGN317.
Course Learning Outcomes

- No changes

GEGN317. GEOLOGIC FIELD SKILLS. 1.0 Semester Hr.
Advanced methods and techniques of geologic field observations and interpretations. Field mapping projects in diverse sedimentary, igneous, metamorphic, structural, and surficial terrains using aerial photographs and topographic maps. Geologic cross sections, maps, and reports. Weekend exercises required. Course includes an introduction to camping skills and working in remote field locations. Prerequisite: GEGN217, GEGN212, GEOL309. Co-requisite: GEOL314.
Course Learning Outcomes

- Students will be able to: 1. Describe, name and interpret sedimentary, igneous and metamorphic rocks in the field and use their interpretations to develop geological models.
- Students will be able to: 2. Measure and record complex structural data and plot data both on a map and stereonet. Use a stereonet to interpret structural domains and kinematics.
- Students will be able to: 3. Interpret complex geological contacts and juxtapositions in the field and map these contacts carefully and accurately on a base map.
- Students will be able to: 4. Construct 1:1 scale geological cross sections of deformed terrains from map and notebook data.
- Students will be able to: 5. Interpret geological histories from geological maps and cross sections and relate these interpretations to regional tectonic processes.

GEGN330. GEOSCIENTISTS THERMODYNAMICS. 3.0 Semester Hrs.
Introduction to fundamental principles of thermodynamics applied to geosciences and geoengineering. Thermodynamics are used as a tool for evaluating the stability and chemical transformation of minerals and rocks, evolution of vapors and liquids and their reaction paths when subjected to different P-T geological regimes. The course will focus on basic principles of thermodynamics and make use of examples relevant to geoscientists encompassing: i) calculation of thermodynamic properties (volume, heat capacity, enthalpy and entropy) as a function of pressure, temperature and composition, ii) the study of heat transfer and volume change associated to chemical reactions and iii) evaluation of phase stabilities using Gibbs energy minimization and law of mass action. Introduction to pure phase properties, ideal and non-ideal solutions, activities, equilibrium constants, chemical potential, electrolytes, phase rule and Gibbs energy function. May not also receive credit for CHGN209 or CBEN210. Prerequisite: CHGN121, CHGN122 or CHGN125, MATH111, MATH112.
Course Learning Outcomes

- - Introduce basic principles of thermodynamics and their application to geological systems.
- - Predict the stability of minerals, liquids and vapors as a function of pressure and temperature.
- - Link thermodynamic predictions and basic principles with geological processes.
- - Learn to use the GEM-selektor software for calculation of thermodynamic properties as a function of pressure and temperature.

GEGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 1 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

GEGN342. ENGINEERING GEOMORPHOLOGY. 3.0 Semester Hrs.
Study of interrelationships between internal and external earth processes, geologic materials, time, and resulting landforms on the Earth's surface. Influences of geomorphic processes on design of natural resource exploration programs and siting and design of geotechnical and geohydrologic projects. Laboratory analysis of geomorphic and geologic features utilizing maps, photo interpretation and field observations. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: GEGN101.

GEGN351. GEOLOGICAL FLUID MECHANICS. 3.0 Semester Hrs.
Properties of fluids; Bernoulli's energy equation, the momentum and mass equations; laminar and turbulent flow in pipes, channels, machinery, and earth materials; subcritical and supercritical flow in channels; Darcy's Law; the Coriolis effect and geostrophic flow in the oceans and atmosphere; sediment transport. 3 hours lecture; 3 semester hours. Prerequisite: CEEN241.

GEGN398. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN399. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEGN401. MINERAL DEPOSITS. 4.0 Semester Hrs.
Introductory presentation of magmatic, hydrothermal, and sedimentary metallic ore deposits. Chemical, petrologic, structural, and sedimentological processes that contribute to ore formation. Description of classic deposits representing individual deposit types. Review of exploration sequences. Laboratory consists of hand specimen study of

host rock-ore mineral suites and mineral deposit evaluation problems. Prerequisite: GEGN307, GEGN316.

Course Learning Outcomes

- Understand what economic geologists do (exploration and mining geologists)
- Understand the interface between geology and mining engineering, metallurgy, and environmental science) .
- Understand the basic types of metallic mineral deposits through lectures, readings, and laboratory examination of samples.
- Enhance student's reading and writing skills.
- Enhance student's ability to solve mineral exploration problems utilizing geologic maps and cross sections.

GEGN403. MINERAL EXPLORATION DESIGN. 3.0 Semester Hrs.
(WI) Exploration project design: commodity selection, target selection, genetic models, alternative exploration approaches and associated costs, exploration models, property acquisition, and preliminary economic evaluation. Lectures and laboratory exercises to simulate the entire exploration sequence from inception and planning through implementation to discovery, with initial ore reserve calculations and preliminary economic evaluation. Prerequisite: GEGN401, GEGN475 (or concurrent enrollment).

Course Learning Outcomes

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GEGN404. ORE MICROSCOPY. 3.0 Semester Hrs.
Identification of ore minerals using reflected light microscopy, micro-hardness, and reflectivity techniques. Interpretation of common ore mineral textures, including those produced by magmatic segregation, open space filling, replacement, exsolution, and recrystallization. Guided research on the ore mineralogy and ore textures of classical ore deposits. Prerequisite: GEOL321, GEGN401. 6 hours lab; 3 semester hours.

GEGN432. GEOLOGICAL DATA MANAGEMENT. 3.0 Semester Hrs.
(I, II, S) Techniques for managing and analyzing geological data, including statistical analysis procedures and computer programming. Topics addressed include elementary probability, populations and distributions, estimation, hypothesis testing, analysis of data sequences, mapping, sampling and sample representativity, linear regression, and overview of univariate and multivariate statistical methods. Practical experience with principles of software programming and statistical analysis for geological applications via suppled software and data sets from geological case histories. Prerequisites: Junior standing in Geological Engineering. 2 hours lecture; 3 hours lab; 3 semester hours.

Course Learning Outcomes

- 1. This course is intended to produce "computationally and statistically literate" geological engineers.
- 2. It combines experiences in computer programming with basic statistical methods useful to geologists and geological engineers.
- 3. Students will be exposed to "hands-on" data analysis and management issues with data sets representing various areas of geological study.

GEGN438. PETROLEUM GEOLOGY. 4.0 Semester Hrs.
Source rocks, reservoir rocks, types of traps, temperature and pressure conditions of the reservoir, theories of origin and accumulation of petroleum, geology of major petroleum fields and provinces of the world, and methods of exploration for petroleum. Term report required. Laboratory consists of study of well log analysis, stratigraphic correlation, production mapping, hydrodynamics and exploration exercises. Prerequisite: GEOL308 or GEOL309 and GEOL314 or GEOL315; and GEGN316 or GPGN486 or PEGN316. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN439. PETROLEUM EXPLORATION DESIGN. 3.0 Semester Hrs.
Equivalent with PEGN439,
(WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geology, geophysics, and petroleum exploration. Students work both individually and in teams on multiple open-ended design problems in oil and gas exploration, including integration of well and seismic reflection databases, seismic interpretation in different tectonostratigraphic settings, and the development of a prospects in a variety of exploration plays. Several detailed written and oral presentations are made throughout the semester. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: GEOL309, GEOL314, GEGN438.

Course Learning Outcomes

- Make internally consistent interpretations of a complex 3D dataset.
- Develop a strong skill set in seismic interpretation using Petrel.
- Develop integrated geological (structural and stratigraphic) interpretations of 3D seismic data.
- Integrate geological interpretations with geophysics and petroleum engineering sections in a design project to assess the petroleum potential of an area through presentations and reports.

GEGN466. GROUNDWATER ENGINEERING. 3.0 Semester Hrs.
Theory of groundwater occurrence and flow. Relation of groundwater to surface water; hydraulic head distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Prerequisites:MATH213 or MATH223, MATH225 or MATH235.

Course Learning Outcomes

- No changes to current class outcomes

GEGN466L. GROUNDWATER ENGINEERING. 1.0 Semester Hr.
Laboratory and field methods for groundwater hydrology, including groundwater occurrence and flow and contaminant transport. Prerequisite: MATH213 or MATH223, MATH225 or MATH235. Co-requisite: GEGN466.

GEGN468. ENGINEERING GEOLOGY AND GEOTECHNICS. 4.0 Semester Hrs.
Application of geology to evaluation of construction, mining, and environmental projects such as dams, water ways, tunnels, highways, bridges, buildings, mine design, and land-based waste disposal facilities. Design projects including field, laboratory, and computer analysis are an important part of the course. Prerequisite: MNGN321 and CEEN312/CEEN312L. 3 hours lecture, 3 hours lab, 4 semester hours.

GEGN469. ENGINEERING GEOLOGY DESIGN. 3.0 Semester Hrs.
(WI) This is a capstone design course that emphasizes realistic engineering geologic/geotechnics projects. Lecture time is used to introduce projects and discussions of methods and procedures for project work. Several major projects will be assigned and one to two field trips will be required. Students work as individual investigators and in teams. Final written design reports and oral presentations are required. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: GEGN468.

GEGN470. GROUND-WATER ENGINEERING DESIGN. 3.0 Semester Hrs.
(WI) Application of the principles of hydrogeology and ground-water engineering to water supply, geotechnical, or water quality problems

involving the design of well fields, drilling programs, and/or pump tests. Engineering reports, complete with specifications, analysis, and results, will be required. 2 hours lecture, 3 hours lab; 3 semester hours. Prerequisite: GEGN 466 and 466L or equivalent, and GEGN351 or CEEN 310 or MEGN 351.

Course Learning Outcomes

- No change

GEGN473. GEOLOGICAL ENGINEERING SITE INVESTIGATION. 3.0 Semester Hrs.

Methods of field investigation, testing, and monitoring for geotechnical and hazardous waste sites, including: drilling and sampling methods, sample logging, field testing methods, instrumentation, trench logging, foundation inspection, engineering stratigraphic column and engineering soils map construction. Projects will include technical writing for investigations (reports, memos, proposals, workplans). Class will culminate in practice conducting simulated investigations (using a computer simulator).

Course Learning Outcomes

- No changes

GEGN475. APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS. 3.0 Semester Hrs.

An introduction to Geographic Information Systems (GIS) and their applications to all areas of geology and geological engineering. Lecture topics include: principles of GIS, data structures, digital elevation models, data input and verification, data analysis and spatial modeling, data quality and error propagation, methods of GIS projects, as well as video presentations. Prerequisite: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN481. ANALYTICAL HYDROLOGY. 3.0 Semester Hrs.

Equivalent with GEGN581,

Introduction to the theory, and hydrological application of, probability, statistics, linear algebra, differential equations, numerical analysis, and integral transforms. Prerequisites: GEGN466. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- To introduce the student to the analysis of many types of hydrologic data using the tools from several mathematics courses, including basic probability and statistics, linear algebra, differential equations, and numerical. The course is also designed to develop the analytic skills necessary to understand and quantify hydrologic processes and problems.
- The class is designed to meet the Hydrologic Science and Engineering admission prerequisite of one semester each of Differential Equations and Probability/ Statistics.

GEGN483. MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS. 3.0 Semester Hrs.

Lectures, assigned readings, and direct computer experience concerning the fundamentals and applications of analytical and finite-difference solutions to ground water flow problems as well as an introduction to inverse modeling. Design of computer models to solve ground water problems. Prerequisites: Familiarity with computers, mathematics through differential and integral calculus, and GEGN466. 3 hours lecture; 3 semester hours.

GEGN498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GEGN499. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEGN501. MINERAL DEPOSITS. 4.0 Semester Hrs.

Introductory presentation of magmatic, hydrothermal, and sedimentary metallic ore deposits. Chemical, petrologic, structural, and sedimentological processes that contribute to ore formation. Description of classic deposits representing individual deposit types. Review of exploration sequences. Laboratory consists of hand specimen study of host rock-ore mineral suites and mineral deposit evaluation problems. Prerequisite: GEGN307, GEGN316.

Course Learning Outcomes

- Understand what economic geologists do (exploration and mining geologists).
- Understand the interface between geology and mining engineering, metallurgy, and environmental science).
- Understand the basic types of metallic mineral deposits through lectures, readings, and laboratory examination of samples.
- Enhance student's reading and writing skills.
- Enhance student's ability to solve mineral exploration problems utilizing geologic maps and cross sections.

GEGN502. MINERAL EXPLORATION DESIGN. 3.0 Semester Hrs.

Exploration project design: commodity selection, target selection, genetic models, alternative exploration approaches and associated costs, exploration models, property acquisition, and preliminary economic evaluation. Lectures and laboratory exercises to simulate the entire exploration sequence from inception and planning through implementation to discovery, with initial ore reserve calculations and preliminary economic evaluation. Prerequisite: GEGN501, GEGN475 (or concurrent enrollment).

Course Learning Outcomes

- Same

GEGN503. INTEGRATED EXPLORATION AND DEVELOPMENT. 3.0 Semester Hrs.

(I) Students work alone and in teams to study reservoirs from fluvial-deltaic and valley fill depositional environments. This is a multidisciplinary course that shows students how to characterize and model subsurface reservoir performance by integrating data, methods and concepts from geology, geophysics and petroleum engineering. Activities include field trips, computer modeling, written exercises and oral team presentations. Prerequisite: none. 2 hours lecture, 3 hours lab; 3 semester hours. Offered fall semester, odd years.

Course Learning Outcomes

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GEGN504. INTEGRATED EXPLORATION AND DEVELOPMENT. 3.0 Semester Hrs.
(I) Students work in multidisciplinary teams to study practical problems and case studies in integrated subsurface exploration and development. The course addresses emerging technologies and timely topics with a general focus on carbonate reservoirs. Activities include field trips, 3D computer modeling, written exercises and oral team presentation. Prerequisite: none. 3 hours lecture and seminar; 3 semester hours. Offered fall semester, even years.
Course Learning Outcomes

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GEGN508. ADVANCED ROCK MECHANICS. 3.0 Semester Hrs.
Equivalent with MNGN418, Analytical and numerical modeling analysis of stresses and displacements induced around engineering excavations in rock. Insitu stress. Rock failure criteria. Complete load deformation behavior of rocks. Measurement and monitoring techniques in rock mechanics. Principles of design of excavation in rocks. Analytical, numerical modeling and empirical design methods. Probabilistic and deterministic approaches to rock engineering designs. Excavation design examples for shafts, tunnels, large chambers and mine pillars. Seismic loading of structures in rock. Phenomenon of rock burst and its alleviation. Prerequisite: MNGN321.
Course Learning Outcomes

- Identical to MNGN508 ADVANCED ROCK MECHANICS course

GEGN509. INTRODUCTION TO AQUEOUS GEOCHEMISTRY. 3.0 Semester Hrs.
(I) Analytical, graphical and interpretive methods applied to aqueous systems. Thermodynamic properties of water and aqueous solutions. Calculations and graphical expression of acid-base, redox and solution-mineral equilibria. Effect of temperature and kinetics on natural aqueous systems. Adsorption and ion exchange equilibria between clays and oxide phases. Behavior of trace elements and complexation in aqueous systems. Application of organic geochemistry to natural aqueous systems. Light stable and unstable isotopic studies applied to aqueous systems. Prerequisite: DCGN209 or equivalent. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

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GEGN520. INDUSTRIAL MINERALS AND ROCKS. 3.0 Semester Hrs.
Introduction to the Industrial Minerals industry via appreciation of geologic occurrence, physical and chemical material properties, mining and processing considerations, and marketing of various commodities. Development of skills in preparation of commodity surveys, reserves and resources classifications, and project appraisals. Required field trips to operational sites and trip reports. Mid-term and final exams. Individual student commodity term project and presentation. Prerequisite: Senior or graduate status in earth resources field. 3 hours lecture/seminar; 3 semester hours. Offered alternate years when student demand is sufficient.
Course Learning Outcomes

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GEGN527. ORGANIC GEOCHEMISTRY OF FOSSIL FUELS AND ORE DEPOSITS. 3.0 Semester Hrs.
(II) A study of organic carbonaceous materials in relation to the genesis and modification of fossil fuel and ore deposits. The biological origin of the organic matter will be discussed with emphasis on contributions of microorganisms to the nature of these deposits. Biochemical and thermal changes which convert the organic compounds into petroleum, oil shale, tar sand, coal, and other carbonaceous matter will be studied. Principal analytical techniques used for the characterization of organic matter in the geosphere and for evaluation of oil and gas source potential will be discussed. Laboratory exercises will emphasize source rock evaluation, and oil-source rock and oil-oil correlation methods. Prerequisite: CHGN221, GEGN438. 2 hours lecture; 3 hours lab; 3 semester hours. Offered alternate years.
Course Learning Outcomes

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GEGN530. CLAY CHARACTERIZATION. 2.0 Semester Hrs.
Equivalent with GEOL530,
(I) Clay mineral structure, chemistry and classification, physical properties (flocculation and swelling, cation exchange capacity, surface area and charge), geological occurrence, controls on their stabilities. Principles of X-ray diffraction, including sample preparation techniques, data collection and interpretation, and clay separation and treatment methods. The use of scanning electron microscopy to investigate clay distribution and morphology. Methods of measuring cation exchange capacity and surface area. Prerequisites: GEGN206. 1 hour lecture, 3 hours lab; 2 semester hours.
Course Learning Outcomes

- No change

GEGN532. GEOLOGICAL DATA ANALYSIS. 3.0 Semester Hrs.
(II) Techniques and strategy of data analysis in geology and geological engineering: basic statistics review, mapping, sampling and sample representativity, univariate and multivariate statistics, regression, hypothesis testing, cluster and discriminant analysis, principal component analysis, geostatistics. Practical experience in learning to write code in Matlab and use of data sets from case histories. 3 hours lecture; 3 semester hours. Prerequisite: MATH201 or MATH530 and MATH 332 or equivalent.
Course Learning Outcomes

- 1) Demonstration of exemplary disciplinary expertise. 2) Demonstration of a set of professional skills necessary to succeed in a student's chosen career path.

GEGN542. ADVANCED DIGITAL TERRAIN ANALYSIS. 3.0 Semester Hrs.
Application of GIS and Remote Sensing principles to solve geoscience and geological engineering problems, with an emphasis on modeling and visualizing the surface of the Earth, performing analysis and support decision making for a variety of applications. Course will present in-depth analysis of specific digital terrain analysis techniques, followed by application exercises. Topics will include analysis and hazard studies of erosion, landslides, stream restoration, wildfire, and environmental issues.
Course Learning Outcomes

- Identification dominant geologic processes operating on an area and estimate the process rate, maturity of the resulting landscape, and the associated hazards and other impacts to infrastructure and natural resources
- Selection and application of analytical tools to interpret geomorphological data to provide quantitative assessment of

processes, predict future landscape response, and assess hazard and risk
- Use GIS tools and remote sensing data to analyze landscape features and quantify hazards.

GEGN561. UNDERGROUND CONSTRUCTION ENGINEERING LABORATORY 1. 0.5 Semester Hrs.
(I) This course provides students with hands-on experience with tools and skills which are commonly used in the underground construction industry. Bi-weekly labs integrate with other courses in the field of Underground Construction and Tunnel Engineering. Co-requisites: CEEN513. 1.5 hours lab; 0.5 semester hours.
Course Learning Outcomes

- Reinforce concepts learned in lecture courses
- Provide students with hands-on experience with common tools in the UC industry

GEGN562. UNDERGROUND CONSTRUCTION ENGINEERING LABORATORY 2. 0.5 Semester Hrs.
(II) This course provides students with hands-on experience with tools and skills which are commonly used in the underground construction industry. Bi-weekly labs integrate with other courses in the field of Underground Construction and Tunnel Engineering. Co-requisites: MNGN504 or CEEN523. 1.5 hours lab; 0.5 hours.
Course Learning Outcomes

- Reinforce concepts learned in lecture courses
- Provide students with hands-on experience with common tools in the UC industry

GEGN563. APPLIED NUMERICAL MODELLING FOR GEOMECHANICS. 3.0 Semester Hrs.
(I) Course focuses on a comprehensive suite of numerical analysis techniques suited to geotechnical design with a focus on excavations in rock/soil and landslides. Finite element, finite difference, discrete/distinct element and boundary element methods are all discussed with hands-on application workshops using state-of-the-art geomechanics software. Analytical models and pre- and post- processing techniques suited to typical rock engineering problems are developed through assignments. Strength criteria and non-linear inelastic constitutive models for continuum plasticity, brittle fracture and discontinuum deformation are explored in detail. Projects involving real case histories are undertaken to highlight the application of and engineering judgment associated with numerical analysis for problems involving rockmasses. Prerequisites: GEGN468, MNGN321 or CEEN312. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- Understand the fundamentals of various computation techniques
- Utilize numerical modelling software to solve geomechanics design problems
- Think critically about the practical strengths and limitations of different modelling approaches

GEGN566. GROUNDWATER ENGINEERING. 3.0 Semester Hrs.
(I) Theory of groundwater occurrence and flow. Relation of groundwater to surface water; hydraulic head distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. 3 hours lecture, 3 semester hours. Prerequisite: Calc III (MATH213 or MATH223) and DiffEQ (MATH225 or MATH235) and GEGN351 or MEGN351.
Course Learning Outcomes

- No changes to current class outcomes.

GEGN568. POINT CLOUD DATA ANALYSIS IN EARTH SCIENCE AND ENGINEERING. 3.0 Semester Hrs.
This course is intended to expose students to the fundamentals of point cloud data collection, processing and analysis. In-class exercises, homework assignments and readings will expose students to a broad array of earth science and geological engineering applications and provide hands-on experience with current academic/government/industry standard software. In consultation with the instructors, each student will design and implement a unique term project using point cloud data to advance their own research interests and goals.
Course Learning Outcomes

- 1)
- 2)
- 3)
- 4)

GEGN570. CASE HISTORIES IN GEOLOGICAL ENGINEERING AND HYDROGEOLOGY. 3.0 Semester Hrs.
(I) Case histories in geological and geotechnical engineering, ground water, and waste management problems. Students are assigned problems and must recommend solutions and/or prepare defendable work plans. Discussions center on the role of the geological engineer in working with government regulators, private-sector clients, other consultants, and other special interest groups. Prerequisite: GEGN467, GEGN468, GEGN469, GEGN470. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

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GEGN571. ADVANCED ENGINEERING GEOLOGY. 3.0 Semester Hrs.
Emphasis will be on engineering geology mapping methods, and geologic hazards assessment applied to site selection and site assessment for a variety of human activities. Prerequisite: GEGN468 or equivalent. 2 hours lecture, 3 hours lab; 3 semester hours. Offered alternate years.
Course Learning Outcomes

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GEGN572. ENGINEERING GEOLOGY AND GEOTECHNICS. 4.0 Semester Hrs.
(I) Application of geology to evaluation of construction, mining, and environmental projects such as dams, water ways, tunnels, highways, bridges, buildings, mine design, and land-based waste disposal facilities. Design projects including field, laboratory, and computer analysis are an important part of the course. 3 hours lecture, 3 hours lab, 4 semester hours. Prerequisite: MNGN321, CEEN312, CEEN312L.
Course Learning Outcomes

- Describe key engineering properties and behaviors of commonly encountered geomaterials
- Recognize the key geological factors relevant to dam siting, foundation stability, earthquake hazards, tunnel design, and slope stability
- Identify which earth material behaviors and hazards are relevant to a given engineering geology design problem
- Assess the adequacy of different material characterization and technical analysis tools for investigation of a given engineering geology problem

- Analyze engineering geology problems using methods and tools commonly applied in industry
- Design solutions to mitigate geological risks associated with natural and man-made slopes and underground excavations in rock
- Concisely communicate data collection, data analysis, and design processes and results to a technical audience in written and oral formats using appropriate technical vocabulary and graphical aids

GEGN573. GEOLOGICAL ENGINEERING SITE INVESTIGATION. 3.0 Semester Hrs.
Methods of field investigation, testing, and monitoring for geotechnical and hazardous waste sites, including: drilling and sampling methods, sample logging, field testing methods, instrumentation, trench logging, foundation inspection, engineering stratigraphic column and engineering soils map construction. Projects will include technical writing for investigations (reports, memos, proposals, workplans). Class will culminate in practice conducting simulated investigations (using a computer simulator).
Course Learning Outcomes

- No change

GEGN575. APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS. 3.0 Semester Hrs.
An introduction to Geographic Information Systems (GIS) and their applications to all areas of geology and geological engineering. Lecture topics include: principles of GIS, data structures, digital elevation models, data input and verification, data analysis and spatial modeling, data quality and error propagation, methods of GIS evaluation and selection. Laboratories will use Macintosh and DOS-based personal computer systems for GIS projects, as well as video-presentations. Visits to local GIS laboratories, and field studies will be required. 2 hours lecture, 3 hours lab; 3 semester hours.
Course Learning Outcomes

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GEGN578. GIS PROJECT DESIGN. 1-3 Semester Hr.
(I, II) Project implementation of GIS analysis. Projects may be undertaken by individual students, or small student teams. Documentation of all project design stages, including user needs assessment, implementation procedures, hardware and software selection, data sources and acquisition, and project success assessment. Various GIS software may be used; projects may involve 2-dimensional GIS, 3-dimensional subsurface models, or multi-dimensional time-series analysis. Prerequisite: none. Variable credit, 1-3 semester hours, depending on project. Offered on demand.
Course Learning Outcomes

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GEGN579. PYTHON SCRIPTING FOR GEOGRAPHIC INFORMATION SYSTEMS. 3.0 Semester Hrs.
(I) Students will learn to use Python scripting with ArcGIS to perform common GIS tasks and to develop their own standalone Python scripts for GIS-based problem solving, automating repetitive or complex geoprocessing work flows, and preparing GIS-based maps. Specific topics include: (1) using Python for basic GIS tasks including field manipulation (e.g. adding, deleting, joining, or calculating fields), file manipulation (e.g., creating, deleting, moving, renaming files), and performing basic spatial analyses; (2) creating stand-alone Python scripts and tools; (3) Using the Python mapping module to control map elements in map layouts; and (4) problem solving to explore more advanced features of Python with ArcGIS. 2 hours lecture, 3 hours lab; 3 semester hours.
Course Learning Outcomes

- See GEGN579_Syllabus_2019.

GEGN580. APPLIED REMOTE SENSING FOR GEOENGINEERING AND GEOSCIENCES. 3.0 Semester Hrs.
This course offers an introduction to remote sensing in general and radar remote sensing and optical remote sensing in specific as well as their applications to all areas of geoengineering and geosciences. Lecture topics include: principles SAR (Synthetic Aperture Radar) and InSAR (Interferometry of Synthetic Aperture Radar) and their applications, as well as basic concepts of optical remote sensing and its application in geoengineering and geosciences. Topics include various sensors and platforms of SAR data acquisition, SAR data access, SAR data processing, data acquisition and processing of optical remote sensing images.
Course Learning Outcomes

- 1. Learn basic concepts and principals of SAR and InSAR through classroom lectures and lab exercises. These skills will be of importance in most geosciences and geoengineering careers that you will follow. 2. Learn basic optical remote sensing concepts and principals through classroom lectures and lab exercises. These skills will also be of importance in most geosciences and geoengineering careers that you will follow. 3. Learn and use many skills necessary for project design and planning, as well as ideas and means of facilitating problem solving in science/engineering projects.

GEGN581. ANALYTICAL HYDROLOGY. 3.0 Semester Hrs.
Equivalent with GEGN481,
(I) Introduction to the theory, and hydrological application of, probability, statistics, linear algebra, differential equations, numerical analysis, and integral transforms. The course will require more challenging assignments and exams commensurate with graduate credit. Prerequisites: GEGN467. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- To introduce the student to the analysis of many types of hydrologic data using the tools from several mathematics courses, including basic probability and statistics, linear algebra, differential equations, and numerical. The course is also designed to develop the analytic skills necessary to understand and quantify hydrologic processes and problems.
- The class is designed to meet the Hydrologic Science and Engineering admission prerequisite of one semester each of Differential Equations and Probability/Statistics.

GEGN582. INTEGRATED SURFACE WATER HYDROLOGY. 3.0 Semester Hrs.
This course provides a quantitative, integrated view of the hydrologic cycle. The movement and behavior of water in the atmosphere (including boundary layer dynamics and precipitation mechanisms), fluxes of water between the atmosphere and land surface (including evaporation, transpiration, precipitation, interception and through fall) and connections between the water and energy balances (including radiation and temperature) are discussed at a range of spatial and temporal scales. Additionally, movement of water along the land surface (overland flow and snow dynamics) and in the subsurface (saturated and unsaturated flow) as well as surface-subsurface exchanges and runoff generation are also covered. Finally, integration and connections within the hydrologic

cycle and scaling of river systems are discussed. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- .No change

GEGN583. MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS. 3.0 Semester Hrs.
(II) Lectures, assigned readings, and direct computer experience concerning the fundamentals and applications of finite-difference and finite-element numerical methods and analytical solutions to ground water flow and mass transport problems. Prerequisite: A knowledge of FORTRAN programming, mathematics through differential and integral calculus, and GEGN467. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

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GEGN584. FIELD METHODS IN HYDROLOGY. 3.0 Semester Hrs.
Design and implementation of tests that characterize surface and subsurface hydrologic systems, including data logger programming, sensor calibration, pumping tests, slug tests, infiltration tests, stream gauging and dilution measurements, and geophysical (EM, resistivity, and/or SP) surveys. Prerequisites: Groundwater Engineering (GEGN466, Integrated Surface Water Hydrology (GEGN582) or equivalent classes. 2 hours lecture; 5 hours lab and field exercises one day of the week. Days TBD by instructor; 3 semester hours.
Course Learning Outcomes

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GEGN585. FLUID MECHANICS FOR HYDROLOGY. 2.0 Semester Hrs.
(I) This class focuses on the fundamental concepts of engineering fluid mechanics as they relate to the study of hydrology. Topics include fluid statics, dynamics, continuity, energy and momentum, dimensional analysis and open channel flow. 2 hours lecture; 2 semester hours.
Course Learning Outcomes

- 1. Students will solve problems on fundamental fluid mechanics concepts including hydrostatics, momentum, pressure and flow and energy systems.
- 2. Students will conduct simple dimensional analysis and explain its application to hydrologic research.
- 3. . Students will solve problems related to flow measurement, fluid properties, and fluid statics.
- 4. Students will solve problems related to energy, impulse, and momentum equations.
- 5. Students will solve problems related to pipe and other internal flow.
- 6. Student will explain (or demonstrate or predict or describe or evaluate) how fluid mechanics relates to hydrological systems.

GEGN586. NUMERICAL MODELING OF GEOCHEMICAL SYSTEMS. 3.0 Semester Hrs.
(II) This course provides quantitative methods for evaluating the geochemical characteristics of geological systems. The course is project based with lectures to provide information about the topic and use of geochemical modeling software. Student projects consist of chemical speciation of waters, activity diagrams, reaction progress models, water-rock interactions, sorption and surface complexation, and kinetic mineral reactions. Students complete an individual project on the geochemical system of their choice and present it to the class. Prerequisite: CEEN550 or CHGC509. 3 hours lecture, 3 semester hours. Offered spring semester, odd years.
Course Learning Outcomes

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GEGN587. HYDROCHEMICAL AND TRANSPORT PROCESSES. 3.0 Semester Hrs.
(II) Analysis of the chemistry of natural waters in the context of hydrologic systems. The course focuses on sources and dynamic behavior of common natural and anthropogenically introduced solutes of interest, their interactions with minerals, and fate and transport in subsurface and surface environments. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- 1. Evaluate the chemistry of groundwater and surface water samples
- 2. Understand the sources and behavior of common solute of interest in natural systems
- 3. Apply chemical reaction kinetic equations to evaluate the dynamic behavior of common solutes of interest in natural systems
- 4. Evaluate fate and transport of contaminants in surface water and groundwater systems.

GEGN588. ADVANCED PLANETARY GEOGRAPHIC INFORMATION SYSTEMS. 3.0 Semester Hrs.
(I, II, S) This course offers a unique opportunity to expand your knowledge and skills in the new and emerging field of planetary mapping and analysis. Upon completing this course, students will possess the knowledge and skills necessary to perform independent planetary GIS tasks, contributing to the advancement of planetary science and space exploration in the student?s area of expertise. Throughout the course, we will learn about planetary GIS fundamentals, an overview of historical and contemporary remote sensing space missions, locating open source planetary GIS datasets, organizing GIS data, planetary mapping, geospatial analyses, and digital terrain modeling. We will explore these topics through class discussions, lab exercises, and peer reviews, culminating in an individual planetary GIS project that allows students to investigate a matter of their choosing in-depth. After completing this course, students can locate and integrate planetary GIS datasets for planetary mapping and space resource characterization. Prerequisite: GEGN575, GEGN542, or equivalent. Asynchronous online, 3.0 semester hours. Prerequisite: GEGN575, GEGN432, or equivalent.
Course Learning Outcomes

- See GEGN588_Syllabus_9_4_2018.docx

GEGN598. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

GEGN599. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/ experience and maximums vary by department. Contact the Department for credit limits toward the degree.

GEGN669. ADVANCED TOPICS IN ENGINEERING HYDROGEOLOGY. 1-2 Semester Hr.
(I, II) Review of current literature and research regarding selected topics in hydrogeology. Group discussion and individual participation. Guest speakers and field trips may be incorporated into the course. Prerequisite: none. 1 to 2 semester hours; may be repeated for credit.

GEGN670. ADVANCED TOPICS IN GEOLOGICAL ENGINEERING. 3.0 Semester Hrs.
(I, II) Review of current literature and research regarding selected topics in engineering geology. Group discussion and individual participation. Guest speakers and field trips may be incorporated into the course. Prerequisite: none. 3 hours lecture; 3 semester hours. Repeatable for credit under different topics.
Course Learning Outcomes

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GEGN671. LANDSLIDES: INVESTIGATION, ANALYSIS & MITIGATION. 3.0 Semester Hrs.
(I) Geological investigation, analysis, and design of natural rock and soil slopes and mitigation of unstable slopes. Topics include landslide types and processes, triggering mechanisms, mechanics of movements, landslide investigation and characterization, monitoring and instrumentation, soil slope stability analysis, rock slope stability analysis, rock fall analysis, stabilization and risk reduction measures. 3 hours lecture; 3 semester hours. Prerequisite: GEGN468, EGGN361, MNGN321, (or equivalents).
Course Learning Outcomes

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GEGN672. ADVANCED GEOTECHNICS. 3.0 Semester Hrs.
Practical analysis and application of techniques in weak rock engineering, ground-water control in construction, fluvial stabilization and control, earthquake hazard assessment, engineering geology in construction, engineering geology in dam investigation, and other current topics in geotechnics practice. Prerequisite: GEGN468, CEEN312, CEEN312L and MNGN321. 3 hours lecture; 3 semester hours. Offered alternate years.
Course Learning Outcomes

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GEGN673. ADVANCED GEOLOGICAL ENGINEERING DESIGN. 3.0 Semester Hrs.
(II) Application of geological principles and analytical techniques to solve complex engineering problems related to geology, such as mitigation of natural hazards, stabilization of earth materials, and optimization of construction options. Design tools to be covered will include problem solving techniques, optimization, reliability, maintainability, and economic analysis. Students will complete independent and group design projects, as well as a case analysis of a design failure. 3 hours lecture; 3 semester hours. Offered alternate years.
Course Learning Outcomes

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GEGN681. VADOSE ZONE HYDROLOGY. 3.0 Semester Hrs.
(II) Study of the physics of unsaturated groundwater flow and contaminant transport. Fundamental processes and data collection methods will be presented. The emphasis will be on analytic solutions to the unsaturated flow equations and analysis of field data. Application to non-miscible fluids, such as gasoline, will be made. The fate of leaks from underground tanks will be analyzed. Prerequisites: GEGN467 or equivalent; Math through Differential Equations. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

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GEGN682. FLOW AND TRANSPORT IN FRACTURED ROCK. 3.0 Semester Hrs.
(I) Explores the application of hydrologic and engineering principles to flow and transport in fractured rock. Emphasis is on analysis of field data and the differences between flow and transport in porous media and fractured rock. Teams work together throughout the semester to solve problems using field data, collect and analyze field data, and do independent research in flow and transport in fractured rock. 3 hours lecture; 3 credit hours. Prerequisite: GEGN581.
Course Learning Outcomes

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GEGN683. ADVANCED GROUND WATER MODELING. 3.0 Semester Hrs.
(II) Flow and solute transport modeling including: 1) advanced analytical modeling methods; 2) finite elements, random-walk, and method of characteristics numerical methods; 3) discussion of alternative computer codes for modeling and presentation of the essential features of a number of codes; 4) study of selection of appropriate computer codes for specific modeling problems; 5) application of models to ground water problems; and 6) study of completed modeling projects through literature review, reading and discussion. Prerequisite: GEGN509/CHGC509 or GEGN583. 2 hours lecture, 3 hours lab; 3 semester hours.
Course Learning Outcomes

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GEGN698. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

GEGN699. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/ experience and maximums vary by department. Contact the Department for credit limits toward the degree.

GEGN707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.
(I, II, S) Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.
Course Learning Outcomes

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