# Geology and Geological Engineering

## Program Description

A Bachelor of Science degree in Geological Engineering is the basis for careers concentrating on the interaction of humans and the earth. Geological Engineers deal with a wide variety of the resource and environmental problems that come with accommodating more and more people on a finite planet. Geologic hazards and conditions must be recognized and considered in the location and design of foundations for buildings, roads and other structures; waste disposal facilities must be properly located, designed and constructed; contaminated sites and ground water must be accurately characterized before cleanup can be accomplished; water supplies must be located, developed and protected; and new mineral and energy resources must be located and developed in an environmentally sound manner. Geological Engineers are the professionals trained to meet these challenges.

The Geological Engineering curriculum provides a strong foundation in the basic sciences, mathematics, geological science and basic engineering along with specialized upper level instruction in integrated applications to real problems. Engineering design is integrated throughout the four year program, beginning in Design I (Freshman year) and ending with the capstone design courses in the senior year.

The program leading to the degree of Bachelor of Science in Geological Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Students have the background to take the Fundamentals of Engineering Exam, the first step in becoming a registered Professional Engineer.

Graduates follow five general career paths:

**Engineering Geology and Geotechnics.** Careers in site investigation, design and stabilization of foundations and slopes; site characterization, design, construction and remediation of waste disposal sites or contaminated sites; and assessment of geologic hazards for civil, mining or environmental engineering projects.

**Ground-Water Engineering.** Careers in assessment and remediation of ground-water contamination, design of ground-water control facilities for geotechnical projects and exploration for and development of ground-water supplies.

**Petroleum Exploration and Development Engineering.** Careers in search for and development of oil and gas and their efficient extraction.

**Mineral Exploration and Development Engineering.** Careers in search for and development of natural deposits of metals, industrial materials and rock aggregate.

**Geological Science.** Students are also well prepared to pursue careers in basic geoscience. Graduates have become experts in fields as divergent as global climate change, the early history of the Earth, planetary science, fractal representation of ground-water flow and simulation of sedimentary rock sequences, to name a few. Careers are available in research and education.

The curriculum may be followed along two concentration paths with slightly different upper division requirements. Both concentrations are identical in the first two years as students study basic science, mathematics, engineering science, and geological science. In the junior year those students pursuing careers in ground-water engineering, engineering geology and geotechnics, or geoenvironmental engineering applications follow the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration. Students anticipating careers in resource exploration and development or who expect to pursue graduate studies in geological sciences follow the Mineral and Petroleum Exploration Engineering Concentration.

At all levels the Geological Engineering Program emphasizes laboratory and field experience. All courses have a laboratory session, and after the junior year students participate in a field course, which is six weeks of geologic and engineering mapping and direct observation. The course involves considerable time outdoors in the mountains and canyons of Utah and southwestern Colorado.

At the senior level, students begin to focus on a career path by taking course sequences in at least two areas of geological engineering specialization. The course sequences begin with a 4 unit course in the fundamentals of a field of geological engineering which is followed by a 3 unit design-oriented course that emphasizes experience in direct application of principles through design projects.

## Combined Undergraduate/Graduate Programs

Several degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Degree, or Master Degree while completing the requirements for their Bachelor Degree. These programs can give students a head start on graduate education. An overview of these combined programs and description of the admission process and requirements are found in the Graduate Degrees and Requirements section of the Graduate Catalog.

## Program Educational Objectives (Bachelor of Science in Geological Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Geological Engineering Program at CSM has established the following program educational objectives, which students are expected to attain within a few years of graduation:

1. Demonstrate a high level of technical competence
2. Demonstrate prowess in written, oral and graphical communication
3. Experience good teamwork and leadership practices

## Program Requirements

In order to achieve the program goals listed above, every student working toward the Bachelor of Science Degree in Geological Engineering must complete the following requirements:

## Degree Requirements (Geological Engineering)

Following the sophomore year, Geological Engineering students choose from one of two concentrations:

1. Minerals and Petroleum Exploration Engineering
2. Environmental, Engineering Geology and Geotechnics, and Ground-water Engineering

## Minerals and Petroleum Exploration Engineering Concentration

*Recommended for students intending careers in exploration and development of mineral and fuels resources, or intending careers in geoscience research and education.*

**Freshman**

| Fall | | lec | lab | em.hrs |
|---|---|---|---|---|
| GEGN101 | EARTH AND ENVIRONMENTAL SYSTEMS | 3.0 | 3.0 | 4.0 |
| MATH111 | CALCULUS FOR SCIENTISTS AND ENGINEERS I | 4.0 | | 4.0 |
| CHGN121 | PRINCIPLES OF CHEMISTRY I | 3.0 | 3.0 | 4.0 |
| EDNS151 | DESIGN I | | | 3.0 |
| CSM101 | FRESHMAN SUCCESS SEMINAR | 0.5 | | 0.5 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | | | 0.5 |
| | | | | 16.0 |
| **Spring** | | **lec** | **lab** | **em.hrs** |
| PHGN100 | PHYSICS I - MECHANICS | 3.5 | 3.0 | 4.5 |
| MATH112 | CALCULUS FOR SCIENTISTS AND ENGINEERS II | 4.0 | | 4.0 |
| CHGN122 | PRINCIPLES OF CHEMISTRY II (SC1) or 125 | 3.0 | 3.0 | 4.0 |
| HASS100 | NATURE AND HUMAN VALUES | | | 4.0 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | | | 0.5 |
| | | | | 17.0 |

**Sophomore**

| Fall | | lec | lab | em.hrs |
|---|---|---|---|---|
| GEGN203 | ENGINEERING TERRAIN ANALYSIS | 2.0 | | 2.0 |
| GEGN204 | GEOLOGIC PRINCIPLES AND PROCESSES | 2.0 | | 2.0 |
| GEGN205 | ADVANCED PHYSICAL GEOLOGY LABORATORY | | 3.0 | 1.0 |
| MATH213 | CALCULUS FOR SCIENTISTS AND ENGINEERS III | 4.0 | | 4.0 |
| CEEN241 | STATICS | 3.0 | | 3.0 |
| HASS200 | GLOBAL STUDIES | | | 3.0 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | 0.5 | | 0.5 |
| | | | | 15.5 |
| **Spring** | | **lec** | **lab** | **em.hrs** |
| EDNS264 | DESIGN II: GEOLOGY GIS | 2.0 | 3.0 | 3.0 |
| GEGN206 | EARTH MATERIALS | 2.0 | 3.0 | 3.0 |
| PHGN200 | PHYSICS II-ELECTROMAGNETISM AND OPTICS | 3.5 | 3.0 | 4.5 |
| MATH225 | DIFFERENTIAL EQUATIONS | | | 3.0 |
| CEEN311 | MECHANICS OF MATERIALS | 3.0 | | 3.0 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | 0.5 | | 0.5 |
| | | | | 17.0 |

**Junior**

| Fall | | lec | lab | em.hrs |
|---|---|---|---|---|
| GEOL309 | STRUCTURAL GEOLOGY AND TECTONICS | 3.0 | 3.0 | 4.0 |
| GEOL321 | MINERALOGY AND MINERAL CHARACTERIZATION | 2.0 | 3.0 | 3.0 |
| GEGN330 | GEOSCIENTISTS THERMODYNAMICS, CHGN 209, or MEGN 361 | | | 3.0 |
| EBGN201 | PRINCIPLES OF ECONOMICS | 3.0 | | 3.0 |
| CEEN312 | SOIL MECHANICS or MNGN 321 | | | 3.0 |
| | | | | 16.0 |
| **Spring** | | **lec** | **lab** | **em.hrs** |
| GEGN307 | PETROLOGY | 2.0 | 3.0 | 3.0 |
| GEGN317 | GEOLOGIC FIELD METHODS | 1.0 | 8.0 | 2.0 |
| GEOL314 | STRATIGRAPHY | 3.0 | 3.0 | 4.0 |
| GEGN351 | GEOLOGICAL FLUID MECHANICS | 3.0 | | 3.0 |
| TECH ELECT | Tech Elective II* | 3.0 | | 3.0 |
| GEGN432 | GEOLOGICAL DATA MANAGEMENT | | | 3.0 |
| | | | | 18.0 |
| **Summer** | | **lec** | **lab** | **em.hrs** |
| GEGN316 | FIELD GEOLOGY | | 6.0 | 6.0 |
| | | | | 6.0 |

**Senior**

| Fall | | lec | lab | em.hrs |
|---|---|---|---|---|
| GEGN ELECT | GEGN4xx Option Elective | 3.0 | 3.0 | 4.0 |
| GEGN ELECT | GEGN4xx Option Elective | 3.0 | 3.0 | 4.0 |
| HASS/EBGN | HASS Mid-Level Restricted Elective | 3.0 | | 3.0 |
| HASS/EBGN | HASS Mid-Level Restricted Elective | 3.0 | | 3.0 |
| FREE | Free Elective | | | 3.0 |
| | | | | 17.0 |
| **Spring** | | **lec** | **lab** | **em.hrs** |
| GEGN ELECT | GEGN4xx Design Elective | 2.0 | 3.0 | 3.0 |
| GEGN ELECT | GEGN4xx Design Elective | 2.0 | 3.0 | 3.0 |
| HASS/EBGN | HASS 400-Level Restricted Elective | 3.0 | | 3.0 |
| FREE | Free Elective | | | 3.0 |
| FREE | Free Elective | | | 3.0 |
| | | | | 15.0 |

Total Semester Hrs: 137.5

* Technical Electives I & II: Either MNGN321 or CEEN312 is required as ONE of the technical electives. An additional technical elective must be selected from a department list of approved courses. The technical elective credits must total a minimum of 6 hours of engineering topics with a minimum of 3 credit hours of engineering design.

**Option Electives**

| | | |
|---|---|---|
| Student must take TWO of the following four courses: | | 8.0 |
| GEGN401 | MINERAL DEPOSITS | |

| | | |
|---|---|---|
| GEGN438 | PETROLEUM GEOLOGY | |
| GEGN467 | GROUNDWATER ENGINEERING | |
| GEGN468 | ENGINEERING GEOLOGY AND GEOTECHNICS | |
| **Design Electives** | | |
| Students must take TWO of the following design courses, corresponding in subject area to the Option Elective: | | 6.0 |
| GEGN403 | MINERAL EXPLORATION DESIGN | |
| GEGN439 | MULTIDISCIPLINARY PETROLEUM DESIGN | |
| GEGN469 | ENGINEERING GEOLOGY DESIGN | |
| GEGN470 | GROUND-WATER ENGINEERING DESIGN | |

## Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration

*Recommended for students intending careers in geotechnical engineering, hydrogeology, or other environmental engineering careers.*

**Freshman**

| **Fall** | | **lec** | **lab** | **em.hrs** |
|---|---|---|---|---|
| GEGN101 | EARTH AND ENVIRONMENTAL SYSTEMS | 3.0 | 3.0 | 4.0 |
| MATH111 | CALCULUS FOR SCIENTISTS AND ENGINEERS I | 4.0 | | 4.0 |
| CHGN121 | PRINCIPLES OF CHEMISTRY I | 3.0 | 3.0 | 4.0 |
| EDNS151 | DESIGN I | | | 3.0 |
| CSM101 | FRESHMAN SUCCESS SEMINAR | 0.5 | | 0.5 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | | | 0.5 |
| | | | | 16.0 |
| **Spring** | | **lec** | **lab** | **em.hrs** |
| PHGN100 | PHYSICS I - MECHANICS | 3.5 | 3.0 | 4.5 |
| MATH112 | CALCULUS FOR SCIENTISTS AND ENGINEERS II | 4.0 | | 4.0 |
| CHGN122 | PRINCIPLES OF CHEMISTRY II (SC1) or 125 | 3.0 | 3.0 | 4.0 |
| HASS100 | NATURE AND HUMAN VALUES | | | 4.0 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | | | 0.5 |
| | | | | 17.0 |

**Sophomore**

| **Fall** | | **lec** | **lab** | **em.hrs** |
|---|---|---|---|---|
| GEGN203 | ENGINEERING TERRAIN ANALYSIS | 2.0 | | 2.0 |
| GEGN204 | GEOLOGIC PRINCIPLES AND PROCESSES | 2.0 | | 2.0 |
| GEGN205 | ADVANCED PHYSICAL GEOLOGY LABORATORY | | 3.0 | 1.0 |
| MATH213 | CALCULUS FOR SCIENTISTS AND ENGINEERS III | 4.0 | | 4.0 |
| CEEN241 | STATICS | 3.0 | | 3.0 |
| HASS200 | GLOBAL STUDIES | | | 3.0 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | | | 0.5 |
| | | | | 15.5 |

| **Spring** | | **lec** | **lab** | **em.hrs** |
|---|---|---|---|---|
| EDNS264 | DESIGN II: GEOLOGY GIS | | | 3.0 |
| GEGN206 | EARTH MATERIALS | 2.0 | 3.0 | 3.0 |
| PHGN200 | PHYSICS II-ELECTROMAGNETISM AND OPTICS | 3.5 | 3.0 | 4.5 |
| MATH225 | DIFFERENTIAL EQUATIONS | | | 3.0 |
| CEEN311 | MECHANICS OF MATERIALS | 3.0 | | 3.0 |
| PAGN Elective | PHYSICAL ACTIVITY COURSE | | | 0.5 |
| | | | | 17.0 |

**Junior**

| **Fall** | | **lec** | **lab** | **em.hrs** |
|---|---|---|---|---|
| GEGN212 | PETROLOGY FOR GEOLOGICAL ENGINEERS | 1.0 | 3.0 | 2.0 |
| GEOL309 | STRUCTURAL GEOLOGY AND TECTONICS | 3.0 | 3.0 | 4.0 |
| GEGN330 | GEOSCIENTISTS THERMODYNAMICS, CHGN 209, or MEGN 361 | | | 3.0 |
| EBGN201 | PRINCIPLES OF ECONOMICS | 3.0 | | 3.0 |
| CEEN312 | SOIL MECHANICS | | | 3.0 |
| CEEN312L | SOIL MECHANICS LABORATORY | | | 1.0 |
| | | | | 16.0 |
| **Spring** | | **lec** | **lab** | **em.hrs** |
| GEGN317 | GEOLOGIC FIELD METHODS | 1.0 | 8.0 | 2.0 |
| GEOL314 | STRATIGRAPHY | 3.0 | 3.0 | 4.0 |
| GEGN351 | GEOLOGICAL FLUID MECHANICS | 3.0 | | 3.0 |
| GEGN432 | GEOLOGICAL DATA MANAGEMENT | | | 3.0 |
| HASS/EBGN | HASS Mid-Level Restricted Elective | 3.0 | | 3.0 |
| MNGN321 | INTRODUCTION TO ROCK MECHANICS | 2.0 | 3.0 | 3.0 |
| | | | | 18.0 |
| **Summer** | | **lec** | **lab** | **em.hrs** |
| GEGN316 | FIELD GEOLOGY | | 6.0 | 6.0 |
| | | | | 6.0 |

**Senior**

| **Fall** | | **lec** | **lab** | **em.hrs** |
|---|---|---|---|---|
| GEGN468 | ENGINEERING GEOLOGY AND GEOTECHNICS | 3.0 | 3.0 | 4.0 |
| GEGN467 | GROUNDWATER ENGINEERING | 3.0 | 3.0 | 4.0 |
| GEGN473 | GEOLOGICAL ENGINEERING SITE INVESTIGATION | | | 3.0 |
| HASS/EBGN | HASS Mid-Level Restricted Elective | 3.0 | | 3.0 |
| FREE | Free Elective | 3.0 | | 3.0 |
| | | | | 17.0 |
| **Spring** | | **lec** | **lab** | **em.hrs** |
| GEGN469 | ENGINEERING GEOLOGY DESIGN | 3.0 | | 3.0 |
| GEGN470 | GROUND-WATER ENGINEERING DESIGN | 3.0 | | 3.0 |
| HASS/EBGN | HASS 400-Level Restricted Elective | 3.0 | | 3.0 |
| FREE | Free Elective | 3.0 | | 3.0 |

| | | | |
|---|---|---|---|
| FREE | Free Elective | 3.0 | 3.0 |
| | | | 15.0 |

Total Semester Hrs: 137.5

Students in the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration may further specialize by utilizing their free elective courses to emphasize a specific specialty. Suggested courses are presented below and should be selected in consultation with the student's advisor. The emphasis area is an informal designation only and it will not appear on the transcript.

## Engineering Geology and Geotechnics Emphasis

| | | |
|---|---|---|
| CEEN415 | FOUNDATION ENGINEERING | 3.0 |
| GEGN475 | APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS | 3.0 |
| EBGN321 | ENGINEERING ECONOMICS | 3.0 |
| GEGN399 | INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY | 1-6 |
| GEGN499 | INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY | 1-6 |
| GEGN307 | PETROLOGY | 3.0 |
| GEOL321 | MINERALOGY AND MINERAL CHARACTERIZATION | 3.0 |
| CSCI261 | PROGRAMMING CONCEPTS | 3.0 |
| MNGN404 | TUNNELING | 3.0 |
| MNGN408 | UNDERGROUND DESIGN AND CONSTRUCTION | 2.0 |
| MNGN410 | EXCAVATION PROJECT MANAGEMENT | 2.0 |
| MNGN445/545 | ROCK SLOPE ENGINEERING | 3.0 |

## Water Engineering Emphasis

| | | |
|---|---|---|
| CEEN301 | FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER | 3.0 |
| CEEN302 | FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT | 3.0 |
| CEEN461 | FUNDAMENTALS OF ECOLOGY | 3.0 |
| CEEN470 | WATER AND WASTEWATER TREATMENT PROCESSES | 3.0 |
| CEEN471 | WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN | 3.0 |
| CEEN475 | SITE REMEDIATION ENGINEERING | 3.0 |
| CEEN480 | CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT | 3.0 |
| CSCI260 | FORTRAN PROGRAMMING | 2.0 |
| CSCI261 | PROGRAMMING CONCEPTS | 3.0 |
| EBGN321 | ENGINEERING ECONOMICS | 3.0 |
| CHGN403 | INTRODUCTION TO ENVIRONMENTAL CHEMISTRY | 3.0 |
| CEEN492 | ENVIRONMENTAL LAW | 3.0 |
| GEGN475 | APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS | 3.0 |
| GEGN481 | ANALYTICAL HYDROLOGY | 3.0 |
| GEGN483 | MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS | 3.0 |
| GEGN499 | INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY | 1-6 |
| GEOL321 | MINERALOGY AND MINERAL CHARACTERIZATION | 3.0 |
| HASS487 | ENVIRONMENTAL POLITICS AND POLICY | 3.0 |
| HASS488 | GLOBAL WATER POLITICS AND POLICY | 3.0 |
| MATH332 | LINEAR ALGEBRA | 3.0 |
| MEGN451 | FLUID MECHANICS II | 3.0 |

## Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- GEGN100 through GEGN599 inclusive
- GEGX100 through GEGX599 inclusive
- GEOC100 through GEOC599 inclusive
- GEOL100 through GEOL599 inclusive

General CSM Minor/ASI requirements can be found here (catalog.mines.edu/undergraduate/undergraduateinformation/minorasi).

## Geological Engineering Minor and Area of Special Interest

To receive a minor or ASI, a student must take at least 12 (ASI) or 18 (minor) hours of a logical sequence of courses. This may include GEGN101 (4 hours) and up to 4 hours at the 200-level.

Students must consult with the Department to have their sequence of courses approved before embarking on a minor program.

## Professor and Department Head

Wendy Bohrson

## Professors

David A. Benson

Zhaoshan Chang, Charles F. Fogarty Endowed Chair

Wendy J. Harrison

Reed M. Maxwell, Rowlinson Professor of Hydrology

Alexei Milkov, Director of Potential Gas Agency

Paul M. Santi

Kamini Singha, Associate Department Head

Stephen A. Sonnenberg, Charles Boettcher Distinguished Chair in Petroleum Geology

Lesli J. Wood, Weimer Distinguished Chair

## Associate Professors

Yvette Kuiper

Thomas Monecke, Co-Director of CMRS

Piret Plink-Bjorklund

Alexis Navarre-Sitchler

Bruce Trudgill

Wendy Zhou

## Assistant Professors

Alexander Gysi

Richard M. Palin

Danica Roth

Gabriel Walton

## Teaching Professor

Christian V. Shorey

## Research Professors

Marsha French

Richard Goldfarb

Zane Jobe, Director of the Chevron Center of Research Excellence

David Leach

J. Fredrick Sarg

## Research Assistant Professors

Mary Carr

Nigel Kelly

Katharina Pfaff

Theresa Schwartz

## Professors Emerita

Eileen Poeter

## Professors Emeriti

John B. Curtis

Thomas L.T. Grose

John D. Haun

Jerry D. Higgins

Murray W. Hitzman

Neil F. Hurley

Keenan Lee

Samuel B. Romberger

Keith A. Turner

John E. Warme

Robert J. Weimer

Richard F. Wendlandt

## Associate Professors Emeriti

L. Graham Closs

Timothy A. Cross

Gregory S. Holden

## Courses

**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. 2.0 Semester Hrs.**
(I) Analysis of landforms, geologic processes, principles of geomorphology, mapping, air photo and map interpretation, and engineering uses of geologic information.. Geomorphology of glacial, volcanic, arid, karst, and complex geological landscapes. Introduction to weathering, soils, hillslopes, and drainage systems. Prerequisite: GEGN101. Must be taken concurrently with GEGN204 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

**GEGN204. GEOLOGIC PRINCIPLES AND PROCESSES. 2.0 Semester Hrs.**
(I) Introduction to advanced concepts of physical and historical geology from a scientific perspective. Development of the geologic time scale, relative time, and geochronology. Chemical composition and cycling of elements in the Earth. Plate tectonics and how tectonics influence sea-level history and sedimentation patterns. Evolution and the fossil record. Critical events in Earth history with a focus on North America and Colorado geology. Prerequisite: GEGN101. Must be taken concurrently with GEGN203 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

**GEGN205. ADVANCED PHYSICAL GEOLOGY LABORATORY. 1.0 Semester Hr.**
(I) Basic geologic mapping and data gathering skills, with special emphasis on air photos and topographic and geologic maps. Course will include fieldwork in geomorphic regions of Colorado, with analysis of landforms and geologic processes. Applications of geologic information to solve geologic engineering problems. Prerequisite: GEGN101. Must be taken concurrently with GEGN203 and GEGN204 for GE majors. 3 hours laboratory, 1 semester hour.

**GEGN206. EARTH MATERIALS. 3.0 Semester Hrs.**
(II) Introduction to Earth Materials, emphasizing the structure, composition, formation, and behavior of minerals. Laboratories emphasize the recognition, description, and engineering evaluation of earth materials. Prerequisite: GEGN101, GEGN203, GEGN204, GEGN205. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN212. PETROLOGY FOR GEOLOGICAL ENGINEERS. 2.0 Semester Hrs.**
(I) Introduction to concepts of rock forming processes as a basis for rock classification. The course will teach practical skills allowing identification of common rock types in hand specimen and in outcrop. Subsurface and nearsurface alteration and weathering processes will be covered, emphasizing recognition of secondary mineral products and the changes to the physical properties of these minerals in the rock masses. Prerequisites: GEGN206. 1 hour lecture, 3 hours lab; 2 semester hours.

**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. 3.0 Semester Hrs.**
Equivalent with GEOL307,
(II) 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, CHGN209. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN316. FIELD GEOLOGY. 6.0 Semester Hrs.**
(S) 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. Prerequisites: GEGN203, GEGN204, GEGN205, GEGN206, GEGN212 or GEGN307, GEOL314, GEOL309, and GEGN317. 6 semester hours (Summer Term).

**GEGN317. GEOLOGIC FIELD METHODS. 2.0 Semester Hrs.**
(II) 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. Prerequisites: GEGN203, GEGN204, GEGN205, GEOL309 or GEOL308, GEGN212 or completion or concurrent enrollment in GEGN307, and completion or concurrent enrollment in GEOL314. 1 hour lecture, 8 hours field; 2 semester hours.

**GEGN330. GEOSCIENTISTS THERMODYNAMICS. 3.0 Semester Hrs.**
(I) 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. Prerequisites: CHGN121, CHGN122 or CHGN125, MATH111, MATH112, GEGN206. May not also receive credit for CHGN209 or CBEN210. 3 hours lecture; 3 semester hours.

**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.**
(I) 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. Prerequisite: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN351. GEOLOGICAL FLUID MECHANICS. 3.0 Semester Hrs.**
(II) 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. Prerequisite: CEEN241. 3 hours lecture; 3 semester hours.

**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.**
(I) 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: GEGN330 or CHGN209, GEGN307, and GEGN316. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEGN403. MINERAL EXPLORATION DESIGN. 3.0 Semester Hrs.**
(II) (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 and EDNS251. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN404. ORE MICROSCOPY. 3.0 Semester Hrs.**
(II) 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.

**GEGN438. PETROLEUM GEOLOGY. 4.0 Semester Hrs.**
(I) 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. MULTIDISCIPLINARY PETROLEUM DESIGN. 3.0 Semester Hrs.**
Equivalent with PEGN439,
(II) (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. Prerequisites: GEOL309, GEOL314, GEGN438, and EDNS264. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN466. GROUNDWATER ENGINEERING. 3.0 Semester Hrs.**
(I) Theory of groundwater occurrence and flow. Relation of groundwater to surface; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Prerequisites: Calc III (MATH213 or MATH223 or MATH224) and DiffEQ (MATH225 or MATH235) and GEGN351 or MEGN351. 3 hours lecture, 3 semester hours.

**GEGN467. GROUNDWATER ENGINEERING. 4.0 Semester Hrs.**
(I) Theory of groundwater occurrence and flow. Relation of groundwater to surface water; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Laboratory sessions on water budgets, water chemistry, properties of porous media, solutions to hydraulic flow problems, analytical and digital models, and hydrogeologic interpretation. Prerequisites: Calc III (MATH213, MATH223 or MATH224) and DiffEQ (MATH225 or MATH235) and GEGN351 or MEGN351. 3 hours lecture, 3 hours lab, 4 semester hours.

**GEGN468. 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. Prerequisite: MNGN321 and CEEN312/CEEN312L. 3 hours lecture, 3 hours lab, 4 semester hours.

**GEGN469. ENGINEERING GEOLOGY DESIGN. 3.0 Semester Hrs.**
(II) (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. Prerequisite: GEGN468 and EDNS264. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN470. GROUND-WATER ENGINEERING DESIGN. 3.0 Semester Hrs.**
(II) (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. Prerequisite: GEGN467 or equivalent and EPIC264. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN473. GEOLOGICAL ENGINEERING SITE INVESTIGATION. 3.0 Semester Hrs.**
(II) 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). 3 hours lecture; 3 semester hours.

**GEGN475. APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS. 3.0 Semester Hrs.**
(II) 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,
(I) Introduction to the theory, and hydrological application of, probability, statistics, linear algebra, differential equations, numerical analysis, and integral transforms. Prerequisites: GEGN467. 3 hours lecture; 3 semester hours.

**GEGN483. MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS. 3.0 Semester Hrs.**
(II) 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 GEGN467. 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.

**GEOC407. ATMOSPHERE, WEATHER AND CLIMATE. 3.0 Semester Hrs.**
(II) An introduction to the Earth?s atmosphere and its role in weather patterns and long term climate. Provides basic understanding of origin and evolution of the atmosphere, Earth?s heat budget, global atmospheric circulation and modern climatic zones. Long- and short-term climate change including paleoclimatology, the causes of glacial periods and global warming, and the depletion of the ozone layer. Causes and effects of volcanic eruptions on climate, El Nino, acid rain, severe thunderstorms, tornadoes, hurricanes, and avalanches are also discussed. Microclimates and weather patterns common in Colorado. Prerequisite: Completion of CSM freshman technical core, or equivalent. 3 hours lecture; 3 semester hours. Offered alternate years.

**GEOC408. INTRODUCTION TO OCEANOGRAPHY. 3.0 Semester Hrs.**
(II) An introduction to the scientific study of the oceans, including chemistry, physics, geology, biology, geophysics, and mineral resources of the marine environment. Lectures from pertinent disciplines are included. Recommended background: basic college courses in chemistry, geology, mathematics, and physics. 3 hours lecture; 3 semester hours. Offered alternate years.

**GEOL102. INTRODUCTION TO GEOLOGICAL ENGINEERING. 1.0 Semester Hr.**
(II) Presentations by faculty members and outside professionals of case studies to provide a comprehensive overview of the fields of Geology and Geological Engineering and the preparation necessary to pursue careers in those fields. A short paper on an academic professional path will be required. Prerequisite: GEGN101 or concurrent enrollment. 1 hour lecture; 1 semester hour.

**GEOL198. 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.

**GEOL199. INDEPENDENT STUDY IN GEOLOGY. 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.

**GEOL201. PLATE TECTONICS. 3.0 Semester Hrs.**
(II) An introduction to the theory of plate tectonics as a first-order framework with which the temporal and spatial evolution of the Earth?s surface and interior may be described and understood. Key topics include the mechanisms of mountain building, crustal growth and destruction, volcanism and seismicity in intraplate and plate-margin settings, and secular changes in plate tectonic processes and products over geological time. Laboratory exercises will involve individual and group exercises that utilize qualitative and quantitative analysis of geophysical, geochemical, geochronological, and petrological datasets to constrain the large-scale dynamics of the Earth. Prerequisite: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEOL298. 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.

**GEOL308. INTRODUCTORY APPLIED STRUCTURAL GEOLOGY. 3.0 Semester Hrs.**
(II) Nature and origin of structural features of Earth?s crust emphasizing structural controls on oil and gas entrapment. Structural patterns and associations are discussed in context of plate tectonic theories, using examples from across the globe. In class exercises and field projects in structural geometry, mapping and cross section construction and seismic reflection data interpretation. Course required of all PEGN and GPGN students. Prerequisite: GEGN101. 3 hours lecture; 3 semester hours.

**GEOL309. STRUCTURAL GEOLOGY AND TECTONICS. 4.0 Semester Hrs.**
(I) (WI) Recognition, habitat, and origin of deformational structures related to stresses and strains (rock mechanics and microstructures) and plate tectonics. Structural development of mountain belts, rift, strike-slip and salt systems. Comprehensive field and laboratory projects use descriptive geometry, stereographic projection, structural contours, map and cross section construction, air photo interpretation, and seismic reflection data analysis. Required of Geological Engineers. Prerequisite: GEGN101, GEGN203, GEGN204, GEGN205 and GEGN206 or GPGN200. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL310. EARTH MATERIALS. 3.0 Semester Hrs.**
(I) Introduction to Earth Materials, emphasizing the structure, formation, distribution and engineering behavior of minerals and rocks. Structural features and processes are related to stress/strain theory and rock mechanics principles. Laboratories and field exercises emphasize the recognition, description and engineering evaluation of natural materials. Lectures and case study exercises present the knowledge of natural materials and processes necessary for mining engineering careers. Prerequisites: GEGN101. 2 hours lecture; 3 hours lab; 3 semester hours.

**GEOL311. MINING GEOLOGY. 3.0 Semester Hrs.**
(II) Introduction to Mining Geology, emphasizing the formation, distribution, engineering behavior, exploration for and geological aspects of development of ore materials. Laboratories emphasize the recognition, description and engineering evaluation of ores and their hosts. Lectures and case study exercises present the knowledge of ores and ore-forming processes necessary for mining engineering careers. Prerequisites: GEGN101 and GEOL310 or MNGN310. 2 hours lecture; 3 hours lab; 3 semester hours.

**GEOL314. STRATIGRAPHY. 4.0 Semester Hrs.**
(II) Lectures and laboratory and field exercises in concepts of stratigraphy and biostratigraphy, facies associations in various depositional environments, sedimentary rock sequences and geometries in sedimentary basins, and geohistory analysis of sedimentary basins. Prerequisites: GEGN101, GEGN203 or GEGN204, GEGN205. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL315. SEDIMENTOLOGY AND STRATIGRAPHY. 3.0 Semester Hrs.**
(I) Integrated lecture, laboratory and field exercises on the genesis of sedimentary rocks as related to subsurface porosity and permeability development and distribution for non-geology majors. Emphasis is placed on siliciclastic systems of varying degrees of heterogeneity. Topics include diagenesis, facies analysis, correlation techniques, and sequence and seismic stratigraphy. Application to hydrocarbon exploitation stressed throughout the course. Required of all PEGN students. Prerequisite: GEGN101, PEGN308. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEOL321. MINERALOGY AND MINERAL CHARACTERIZATION. 3.0 Semester Hrs.**
(I) Principles of mineralogy and mineral characterization. Crystallography of naturally occurring materials. Principles of crystal chemistry. Interrelationships among mineral structure, external shape, chemical composition, and physical properties. Introduction to mineral stability. Laboratories emphasize analytical methods, including X-ray diffraction, scanning electron microscopy, and optical microscopy. Prerequisite:GEGN101, CHGN122 or CHGN125, GEGN206. 2 hours lecture, 3 hours lab: 3 semester hours.

**GEOL398. 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.

**GEOL399. INDEPENDENT STUDY IN GEOLOGY. 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.

**GEOL410. PLANETARY GEOLOGY. 3.0 Semester Hrs.**
(I) Introduction to the geology of planets, moons, and other bodies within and beyond our solar system. Focusing on topics such as (a) the origin and composition of our solar system and its constituent materials, (b) geologic processes occurring on planetary surfaces (e.g. cratering) and shallow and deep interiors (e.g. volcanism, mantle convection), (c) methods of solar system exploration, and potential for resource discovery and utilization on near-neighbors and asteroids, and (d) comparative planetology (thermal histories, evidence for plate tectonics, origin and retention of atmospheres, exobiology). 2 hours lecture, 3 hours lab; 3 semester hours.

**GEOL443. UNDERGRADUATE FIELD SEMINAR. 1-3 Semester Hr.**
Special advanced classroom and field programs emphasizing detailed study of some aspects of the geology of an area or region. Field studies normally conducted away from the Golden campus. Classroom course content dependent on area of study. Fees assessed for field and living expenses and transportation. 1 to 3 semester hours; may be repeated for credit.

**GEOL444. INVERTEBRATE PALEONTOLOGY. 3.0 Semester Hrs.**
(II) Fossils are the basis for establishing global correlation among Phanerozoic sedimentary rocks, and thus are critical to the reconstruction of the past 550 million years of Earth history. This is a lecture elective course that will aid in rounding out undergraduate Earth science/ engineering geological knowledge. Fossil preservation, taphonomy, evolution, mass extinctions, biostratigraphy, graphic correlation, invertebrate phyla and their geologic history and evolution. Prerequisites: GEGN204, GEGN205, GEGN206. 3 hours lecture; 3 semester hours.

**GEOL470. APPLICATIONS OF SATELLITE REMOTE SENSING. 3.0 Semester Hrs.**
(II) Students are introduced to geoscience applications of satellite remote sensing. Introductory lectures provide background on satellites, sensors, methodology, and diverse applications. One or more areas of application are presented from a systems perspective. Guest lecturers from academia, industry, and government agencies present case studies focusing on applications, which vary from semester to semester. Students do independent term projects, under the supervision of a faculty member or guest lecturer, that are presented both written and orally at the end of the term. Prerequisites: PHGN200 and MATH225. 3 hours lecture; 3 semester hours.

**GEOL498. 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.

**GEOL499. INDEPENDENT STUDY IN GEOLOGY. 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.