Geophysics

Program Description

Founded in 1926, the Department of Geophysics at the Colorado School of Mines is recognized and respected around the world for its programs in applied geophysical research and education. With nearly 20 active faculty and smaller class sizes, students receive individualized attention in a close-knit department. The mission of the geophysical engineering program is to educate undergraduates in the application of geophysics to help meet global needs for energy, water, food, minerals, and the mitigation of natural hazards by exploring and illuminating the dynamic processes of the Earth, oceans, atmosphere and solar system.

Geophysicists study the Earth's interior through physical measurements collected at the Earth's surface, in boreholes, from aircraft, or from satellites. Using a combination of mathematics, physics, geology, chemistry, hydrology, and computer science, both geophysicists and geophysical engineers analyze these measurements to infer properties and processes within the Earth's complex interior. Noninvasive imaging beneath the surface of Earth and other planets by geophysicists is analogous to noninvasive imaging of the interior of the human body by medical specialists.

The Earth supplies all materials needed by our society, serves as the repository for used products, and provides a home to all its inhabitants. Geophysics and geophysical engineering have important roles to play in the solution of challenging problems facing the inhabitants of this planet, such as providing fresh water, food, and energy for Earth's growing population, evaluating sites for underground construction and containment of hazardous waste, monitoring noninvasively the aging infrastructures of developed nations, mitigating the threat of geohazards (earthquakes, volcanoes, landslides, avalanches) to populated areas, contributing to homeland security (including detection and removal of unexploded ordnance and land mines), evaluating changes in climate and managing humankind's response to them, and exploring other planets.

Energy companies and mining firms employ geophysicists to explore for hidden resources around the world. Engineering firms hire geophysical engineers to assess the Earth's near-surface properties when sites are chosen for large construction projects and waste-management operations. Environmental organizations use geophysics to conduct groundwater surveys and to track the flow of contaminants. On the global scale, geophysicists employed by universities and government agencies (such as the United States Geological Survey, NASA, and the National Oceanographic and Atmospheric Administration) try to understand such Earth processes as heat flow, gravitational, magnetic, electric, thermal, and stress fields within the Earth's interior. For the past decade, nearly 100% of CSM's geophysics graduates have found employment in their chosen field, with about 70% choosing to pursue graduate studies.

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

Bachelor of Science Program in Geophysical Engineering

Geophysical Engineering undergraduates who may have an interest in professional registration as engineers are encouraged to take the Engineer in Training (EIT)/Fundamentals of Engineering (FE) exam as seniors. The Geophysical Engineering Program has the following objectives and associated outcomes:

Program Objective 1: Graduates will be competent geophysical engineers who are capable of independent and innovative problem solving.

Program Objective 2: Graduates can design and execute experiments effectively with appropriate treatment of the resulting data.

Program Objective 3: Graduates will be competent in scientific computing.

Program Objective 4: Graduates will be effective communicators, both orally and in writing.

Program Objective 5: Graduates will exhibit good team skills, be able to lead and to follow effectively.

Student Outcomes (from ABET Criterion 3):

a. An ability to apply knowledge of mathematics, science, and engineering.

b. An ability to design and conduct experiments, as well as to analyze and interpret data.

c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health, safety, manufacturability, and sustainability.

d. An ability to function on multidisciplinary teams.

e. An ability to identify, formulate, and solve engineering problems.

f. An understanding of professional and ethical responsibility.

g. An ability to communicate effectively.

h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

i. A recognition of the need for, and an ability to engage in life-long learning.

j. Knowledge of contemporary issues.

k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Program Specific Outcomes

1. Expanded perspective of applied geophysics as a result of participating in employment or research.

2. An ability to analyze, quantitatively, the errors, limitations, and uncertainties in data.

Geophysics Field Camp

Each summer, a base of field operations is set up for four weeks, usually in the mountains of Colorado, for students who have completed their junior year. Students prepare geological maps and cross sections and then use these as the basis for conducting seismic, gravimetric, magnetic, electrical, and electromagnetic surveys. After acquiring these various geophysical data-sets, the students process the data and develop an interpretation that is consistent with all the information. In addition to
the required four-week program, students can also participate in other diverse field experiences. In recent years these have included cruises on seismic ships in the Gulf of Mexico, studies at an archeological site, investigations at an environmental site, a ground-penetrating radar survey on an active volcano in Hawaii, and a well-logging school offered by Baker Hughes.

Study Abroad
The Department of Geophysics encourages its undergraduates to spend one or two semesters studying abroad. At some universities, credits can be earned that substitute for course requirements in the geophysical engineering program at CSM. Information on universities that have established formal exchange programs with CSM can be obtained from either the Department of Geophysics or the Office of International Programs.

Combined BS/MS Program
Undergraduate students in the Geophysical Engineering program who would like to continue directly into the Master of Science program in Geophysics or Geophysical Engineering, are allowed to fulfill part of the requirements of their graduate degree by including up to six hours of specified course credits, which also were used in fulfilling the requirements of their undergraduate degree. Students interested to take advantage of this option should meet with their advisor or department head as early as possible in their undergraduate program to determine which elective courses will be acceptable and advantageous for accelerating them through their combined BS/MS studies.

Summer Jobs in Geophysics
In addition to the summer field camp experience, students are given opportunities every summer throughout their undergraduate career to work as summer interns within the industry, at CSM, or for government agencies such as the U.S. Geological Survey. Students have recently worked outdoors with geophysics crews in various parts of the U.S., South America, and offshore in the Gulf of Mexico.

Undergraduate Research
Students are encouraged to try their hand at research by working on a project with a CSM faculty member, either part-time during the semester, or full-time during the summer. As an alternative to a summer internship, students may wish to participate in a Research Experience for Undergraduates (REU), either at Mines or at another university. REU's are typically sponsored by the National Science Foundation (NSF) and are listed on the NSF website.

The Cecil H. and Ida Green Graduate and Professional Center
The lecture rooms, laboratories, and computer-aided instruction areas of the Department of Geophysics are located in the Green Center. The Department maintains equipment for conducting geophysical field measurements, including magnetometers, gravity meters, ground-penetrating radar, and instruments for recording seismic waves. Students have access to the Department petrophysics laboratory for measuring properties of porous rocks.

Curriculum
Geophysics is an applied and interdisciplinary science; students therefore must have a strong foundation in physics, mathematics, geology and computer sciences. Superimposed on this foundation is a comprehensive body of courses on the theory and practice of geophysical methods. As geophysics and geophysical engineering involve the study and exploration of the entire earth, our graduates have great opportunities to work anywhere on, and even off, the planet. Therefore, the curriculum includes electives in the humanities and social sciences that give students an understanding of international issues and different cultures.

Every student who obtains a Bachelor’s Degree in Geophysical Engineering completes the CSM Core Curriculum plus the courses listed below. We recommend students download the current curriculum flowchart from the Departmental webpage, http://geophysics.mines.edu/GEO-Undergraduate-Program.

Degree Requirements (Geophysical Engineering)

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<td>GPGN229</td>
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EBGN201  PRINCIPLES OF ECONOMICS  3.0
HASS200  GLOBAL STUDIES  3.0
GEGN/GEOL  GEOLOGY ELECTIVE\(^1\)  3.0
PAGN  PHYSICAL ACTIVITY COURSE  0.5

Junior

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Total Semester Hrs: 18.5

Spring

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Total Semester Hrs: 18.0

Summer

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Total Semester Hrs: 4.0

Senior

Fall

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Total Semester Hrs: 15.0

Spring

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Total Semester Hrs: 15.0

Total Semester Hrs: 133.5

1. Students must take at least 3 credits of GEGN or GEOL electives.
2. Within these 9 HASS electives, students must take at least 3 credits at the 400-level.
3. Students must take 12 credits of advanced GPGN elective courses at the 400- or 500-level.

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:

- GPGN100 through GPGN99 inclusive

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

Minor in Geophysics/Geophysical Engineering

Geophysics plays an important role in many aspects of civil engineering, petroleum engineering, mechanical engineering, and mining engineering, as well as mathematics, physics, geology, chemistry, hydrology, and computer science. Given the natural connections between these various fields and geophysics, it may be of interest for students in other majors to consider choosing to minor in geophysics, or to choose geophysics as an area of specialization. The core of courses taken to satisfy the minor requirement typically includes some of the following geophysics methods courses.

- GPGN200  INTRODUCTION TO GEOPHYSICS: GEOPHYSICS AND SOCIETY  3.0
- GPGN404  DIGITAL SIGNAL PROCESSING  3.0
- GPGN409  INVERSION  3.0
- GPGN432  FORMATION EVALUATION  4.0
- GPGN470  APPLICATIONS OF SATELLITE REMOTE SENSING  3.0
- GPGNXXX  Please see department for additional courses for minor requirements.

The remaining hours can be satisfied by a combination of other geophysics courses, as well as courses in geology, mathematics, and computer science depending on the student’s major. Students must consult with the Department of Geophysics to have their sequence of courses approved before embarking on a minor program.

Professors

John H. Bradford, Department Head
Yaoguo Li
Roelof K. Snieder, Keck Foundation Professor of Basic Exploration Science
Ilya D. Tsvankin
Ali Tura

Associate Professors

Thomas M. Boyd, Interim Provost
Brandon Dugan, Baker Hughes Chair in Petrophysics and Borehole Geophysics
Courses

GPGN101. INTRODUCTION TO GEOPHYSICS: GEOPHYSICS AND SOCIETY. 3.0 Semester Hrs.
(I) This is a discovery course designed to introduce freshmen to the science of geophysics in the context of society and humans’ interaction with the Earth. Students will explore geophysical measurements and characterization of earth properties and processes that have the greatest impact on the development of human civilization. Examples include characterizing earthquakes and volcanic eruptions, imaging energy resources deep within the earth, measuring the impacts of climate change on the ice sheets, and evaluation of water resources. 3 hours lecture; 3 semester hours.

GPGN198. 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.

GPGN199. 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.

GPGN200. INTRODUCTION TO GEOPHYSICS. 3.0 Semester Hrs.
(I) (WI) This is a discovery course designed to introduce sophomores to the science of geophysics in the context of the whole-earth system. Students will explore the fundamental observations from which physical and mathematical inferences can be made regarding the Earth’s origin, structure, and processes. Examples of such observations are earthquake records; geodetic and gravitational data, such as those recorded by satellites; magnetic measurements; and greenhouse gases in the atmosphere. Learning will take place through the examination of selected topics that may vary from one semester to the next. Examples of such topics are: earthquake seismology, geomagnetism, geodynamics, and climate change. 3 hours, lecture, 3 semester hours.

GPGN228. INTRODUCTION TO ROCK PHYSICS. 3.0 Semester Hrs.
(I) Introduction to sediment and rock properties, their measurements, and geophysical operations. Course will introduce physical and mathematical framework, quantitative interpretations, and provide framework for multi-physics approaches, data interpretation, and data inversion to help us understand the physical properties of the subsurface. Topics covered will include mineralogy, porosity, density, pore shape/size, pore fluids, permeability, compressibility, stress, and strength and how they can be measured with experiments and approximated with geophysical techniques. 2 hours lecture; 3 hours lab; 3 semester hours.

GPGN229. MATHEMATICAL GEOPHYSICS. 3.0 Semester Hrs.
(I) This course will address how specific mathematical approaches are used to understand and to solve geophysical problems. Topics that will be used in a geophysical context include continuum mechanics, linear algebra, vector calculus, complex variables, Fourier series, partial differential equations, probability, the wave equation, and the heat equation. Prerequisites: MATH111, MATH112, MATH213, PHGN100, PHGN200. Corequisites: MATH225. 3 hours lecture; 3 semester hours.
GPGN268. GEOPHYSICAL DATA ANALYSIS. 3.0 Semester Hrs.  
Equivalent with EPIC268.  
(I, II) Geophysical Data Analysis focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Students work on projects from the geophysical engineering perspective in which they analyze (process, model, visualize) data. In their projects, students encounter limitations and uncertainties in data and learn quantitative means for handling them. They learn how to analyze errors in data, and their effects on data interpretation and decision making. 3 lecture hours; 3 semester hours.

GPGN298. 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.

GPGN299. 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.

GPGN314. APPLIED GEOPHYSICS. 4.0 Semester Hrs.  
(II) Applied Geophysics is an introductory course on the theory and application of gravity, magnetic, electrical, electromagnetic, and seismic methods for imaging the Earth’s subsurface. These tools are employed in various geotechnical and environmental engineering problems, resource exploration and production monitoring, geothermal site characterization, hazards, and humanitarian efforts. Through the combination of three one-hour lectures and one three-hour lab each week, the students are provided with the fundamental theory and hands-on field experiments for each of these techniques including the principles, instrumentation, and procedures of data acquisition, analysis, and interpretation. Prerequisites: MATH213, MATH225, GPGN228, GPGN328, CSCI250. Co-requisite: GPGN329. 3 hours lecture; 3 hours lab; 4 semester hours.

GPGN328. PHYSICS OF THE EARTH - I. 3.0 Semester Hrs.  
(I) This course is the first part of a two-course sequence on Physics of the Earth and will introduce the static fields including the electrostatics, steady state current flow in conductive media, magnetostatics, and gravitational field as used in probing the interior of the Earth and physical processes therein. The spatial context will be earth’s lithosphere and the associated geoscientific problems arise from a wide range of disciplines including environmental problems, hydrology, minerals and energy exploration, hydrology, tectonics, and climate science. The course will discuss static field theory, their interaction with different physical properties of earth materials, and the use of these fields in imaging, characterizing, and monitoring structures and processes in the earth lithosphere and on the interface between atmosphere and crust. Prerequisites: PHGN200, GPGN229. 3 hours lecture; 3 semester hours.

GPGN329. PHYSICS OF THE EARTH - II. 3.0 Semester Hrs.  
(II) The second half of Physics of the Earth will aim to give a global perspective to Earth’s formation and evolution. Starting from conservation laws and continuum mechanics, Earth’s dynamic fields (theory of seismic and electromagnetic wave propagation) will be covered in the context of solid-Earth geophysics and integrated with various geophysical observations & measurements; the Earth seen by the waves, inferring the structure and composition of the interior of planetary bodies from crust to core, physical & thermo-chemical processes in mantle and core shaping Earth’s surface and magnetic field, planetary cooling, ?hot topics? and current challenges in illuminating Earth’s deep structure, modern computational techniques that are used to improve our understanding of Earth’s interior and history. Prerequisites: PHGN200, MATH225, GPGN229, GPGN328. 3 hours lecture; 3 semester hours.

GPGN340. 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 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

GPGN350. SCIENCE AND COMMUNICATION SKILLS. 3.0 Semester Hrs.  
(I) (WI) This class covers the basic skills needed for research and for communicating the results of the research. The class covers hands-on elements of doing research, such as choosing a research topic, generating research questions, making a work plan, dealing with the ambiguity and hurdles of research, research ethics, as well as publishing scientific papers, scientific writing, giving oral communications, and writing research proposals. In addition, the class covers career-oriented topics such as choosing a program for graduate studies, working with an advisor, and applying for a job. Students acquire hands-on experience by choosing a research project, making a work plan, writing a proposal, and presenting that proposal. 3 hours lecture; 3 semester hours.

GPGN398. 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.

GPGN399. 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.

GPGN404. DIGITAL SIGNAL PROCESSING. 3.0 Semester Hrs.  
(I, II) The fundamentals of 1-D digital signal processing as applied to geophysical investigations are studied. Students explore the mathematical background and practical consequences of Fourier series and 1D/2D Fourier transforms, linear time-invariant (LTI) systems, convolution and deconvolution, properties of discrete systems, sampling theorem and signal reconstruction, Z-Transform, discrete-time Fourier transform, discrete Fourier series and discrete Fourier transform, windowing and spectrograms, realization of digital filters, FIR filter design and IIR filter design Emphasis is placed on applying the knowledge gained in lecture to exploring practical signal processing issues. This is done through homework and in-class practicum assignments requiring the programming and testing of algorithms discussed in lecture. Prerequisite: CSCI250. 2 hours lecture; 3 hours lab; 3 semester hours.
GPGN409. INVERSION. 3.0 Semester Hrs.
(I) A study of the fundamentals of inverse problem theory as applied to geophysics. The inversion technology has applicability in all fields of geophysical application, regardless of the physics employed, as well as in non-geophysical data analysis. The course covers fundamental concepts of inversion in the probabilistic and deterministic frameworks, as well as practical methods for solving discrete inverse problems. Topics studied include model discretization, Bayesian inversion, optimization criteria and methods, regularization techniques, error, and resolution analysis. Weekly homework assignments addressing either theoretical or numerical problems through programming assignments illustrate the concepts discussed in class. Knowledge of the Python programming language is assumed. Prerequisites: GPGN229, MATH332, GPGN335, CSCI250. Co-requisite: GPGN435. 3 hours lecture; 3 semester hours.

GPGN411. GRAVITY AND MAGNETIC METHODS. 3.0 Semester Hrs.
Equivalent with GPGN414, (I) Instrumentation for land surface, borehole, sea floor, sea surface, and airborne operations. Reduction of observed gravity and magnetic values. Theory of potential field effects of geologic distributions. Methods and limitations of interpretation. Prerequisite: GPGN314. 3 hours lecture; 3 semester hours.

GPGN419. INTRODUCTION TO FORMATION EVALUATION AND WELL LOGGING. 3.0 Semester Hrs.
(I, II) An introduction to well logging methods, including the relationship between measured properties and reservoir properties. Analysis of log suites for reservoir size and content. Graphical and analytical methods will be developed to allow the student to better visualize the reservoir, its contents, and its potential for production. Use of the computer as a tool to handle data, create graphs and log traces, and make computations of reservoir parameters is required. Prerequisite: GPGN314. 3 hours lecture; 3 semester hours.

GPGN420. ELECTRICAL AND ELECTROMAGNETIC METHODS. 3.0 Semester Hrs.
Equivalent with GPGN422, (II) In-depth study of the application of electrical and electromagnetic methods to crustal studies, minerals exploration, oil and gas exploration, and groundwater. Laboratory work with mathematical models coupled with field work over areas of known geology. Prerequisite: GPGN314. 3 hours lecture; 3 semester hours.

GPGN432. FORMATION EVALUATION. 4.0 Semester Hrs.
(II) The basics of core analysis and the principles of all common borehole instruments are reviewed. The course teaches interpretation methods that combine the measurements of various borehole instruments to determine rock properties such as porosity, permeability, hydrocarbon saturation, water salinity, ore grade and ash content. The impact of these parameters on reserve estimates of hydrocarbon reservoirs and mineral accumulations is demonstrated. Geophysical topics such as vertical seismic profiling, single well and cross-well seismic are emphasized in this course, while formation testing, and cased hole logging are covered in GPGN419/PEGN419 presented in the fall. The laboratory provides on-line course material and hands-on computer log evaluation exercises. Only one of the two courses GPGN432 and GPGN419/ PEGN419 can be taken for credit. Prerequisites: MATH225, MATH348 or PHGN311. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN435. GEOPHYSICAL COMPUTING. 3.0 Semester Hrs.
(I) This course develops the principles of geophysical computing in the context of simulating and validating numerical solutions to the types of partial differential equations commonly found in geophysical investigations (e.g., potential fields, heat flow/diffusion, seismic wave propagation). Students are introduced to architecture of modern computing systems and learn how algorithms can be developed to leverage this architecture to efficiently generate numerical solutions to multidimensional geophysical problems using parallel computing methods. Prerequisite: CSCI250. 2 hours lecture; 3 hours lab; 3 semester hours.

GPGN438. GEOPHYSICS PROJECT DESIGN. 3.0 Semester Hrs.
(II) (WI) Complementary design course for geophysics restricted elective course(s). Application of engineering design principles to geophysics through advanced work, individual in character, leading to an engineering report or senior thesis and oral presentation thereof. Choice of design project is to be arranged between student and individual faculty member who will serve as an advisor, subject to department head approval. Prerequisites: GPGN314, GPGN329, GPGN404. 1 hour lecture; 6 hours lab; 3 semester hours.

GPGN455. EARTHQUAKE SEISMOLOGY. 3.0 Semester Hrs.
Equivalent with GPGN555, (I) Earthquakes are amongst the most significant natural hazards faced by mankind, with millions of fatalities forecast this century. They are also our most accessible source of information on Earth's structure, rheology and tectonics, which are what ultimately govern the distribution of its natural resources. This course provides an overview of how earthquake seismology, complemented by geodesy and tectonic geomorphology, can be used to determine earthquake locations, depths and mechanisms; understand Earth's tectonics and rheology; establish long-term earthquake histories and forecast future recurrence; mitigate against seismic hazards; illuminate large- and fine-scale features of Earth's interior using earthquake data. Students will also cover the recent developments in 3D numerical earthquake source and wave propagation modelling as well as common & modern seismic data formats and processing/visualization tools and techniques used in earthquake seismology. Prerequisites: PHGN200, GPGN461, GPGN229. 3 hours lecture; 3 semester hours.

GPGN458. SEISMIC INTERPRETATION. 3.0 Semester Hrs.
(II) This course will give the participants a unique hands-on experience in seismic interpretation working with several sets of field data and industry standard interpretation software. The course will provide valuable knowledge and information in professional career development. The course involves lectures and labs on seismic interpretation on data sets from a variety of petroleum provinces from around the world. Potential projects for interpretation can be from Gulf of Mexico, North Sea and US land and can have time-lapse and multi-component data types. The class is based on completion and presentation of assignments, exams and final project. Final project will be presentation of the prospect as developed by a group of students. 2 hours lecture; 3 hours lab; 3 semester hours.
GPGN461. SEISMIC DATA PROCESSING. 4.0 Semester Hrs.
Equivalent with GPGN452.
(I) This course covers the basic processing steps required to create images of the earth using 2D and 3D reflection seismic data. Topics include data organization and domains, signal processing to enhance temporal and spatial resolution, identification and suppression of incoherent and coherent noise, velocity analysis, near-surface statics, datuming, normal- and dip-moveout corrections, common-midpoint stacking, principles and methods used for poststack and prestack time and depth imaging, migration velocity analysis and post-imaging enhancement techniques. Realistic synthetic examples and field data sets are extensively used throughout the course. A three-hour lab introduces the student to hands-on data processing using Seismic Unix software package. The final exam consists of processing a 2D seismic line with oral presentation of the results. Prerequisites: GPGN404, GPGN329, GPGN314. 3 hours lecture; 3 hours lab; 4 semester hours.

GPGN470. APPLICATIONS OF SATELLITE REMOTE SENSING. 3.0 Semester Hrs.
(I) An introduction to geoscience applications of satellite remote sensing of the Earth and planets. The lectures provide background on satellites, sensors, methodology, and diverse applications. Topics include visible, near infrared, and thermal infrared passive sensing, active microwave and radio sensing, and geodetic remote sensing. Lectures and labs involve use of data from a variety of instruments, as several applications to problems in the Earth and planetary sciences are presented. Students will complete independent term projects that are presented both written and orally at the end of the term. 3 hours lecture; 3 semester hours.

GPGN471. GEODYNAMICS AND GEOLOGY. 2.0 Semester Hrs.
(I) Earth’s evolving internal dynamics and properties have controlled time-varying crustal geologic processes and their products. All terrestrial planets fractionated synchronously with accretion, but only Earth continued strongly active. Much geology, from ancient granite and greenstone to recently enabled plate-tectonics, will be illustrated in the context of coevolving deep and shallow processes. Integration of geophysics, geology, and planetology will allow evaluation of popular and alternative explanations, but the sum will be contrarian, not conventional. Math and specialist vocabularies will be minimized. PREREQUISITES: CHGN121, PHGN100, PHGN200, and GEGN101. 2 lecture hours, 2 semester hours.

GPGN474. HYDROGEOPHYSICS. 3.0 Semester Hrs.
(II) Application of geophysical methods to problems in hydrology. The course will consider both groundwater and surface water problems from the micro to basin scale. Topics may include characterizing groundwater surface water interaction, critical zone evaluation and weathering processes, snow and ice as a water resource, large scale imaging of aquifer systems, in situ estimation of aquifer parameters, evaluation of groundwater resources, delineation of thermal and chemical pollution of groundwater, and mapping of saltwater intrusion. Readings and discussions will touch on social and political issues surrounding water use and the critical role that physical characterization plays in understanding water resources. Prerequisite: GPGN314. 2 hours lecture; 3 hours lab; 3 semester hours.

GPGN475. PLANETARY GEOPHYSICS. 3.0 Semester Hrs.
(I) Of the solid planets and moons in our Solar System, no two bodies are exactly alike. This class will provide an overview of the observed properties of the planets and moons, cover the basic physical processes that govern their evolution, and then investigate how the planets differ and why. The overarching goals are to develop a quantitative understanding of the processes that drive the evolution of planetary surfaces and interiors, and to develop a deeper understanding of the Earth by placing it in the broader context of the Solar System. Prerequisites: PHGN100, MATH225, and GEGN205 or GEOL410. Senior or graduate standing recommended. 3 hours lecture; 3 semester hours.

GPGN486. GEOPHYSICS FIELD CAMP. 4.0 Semester Hrs.
(S) (WI) Introduction to geological and geophysical field methods. The program includes exercises in geological surveying, stratigraphic section measurements, geological mapping, and interpretation of geological observations. Students conduct geophysical surveys related to the acquisition of seismic, gravity, magnetic, and electrical observations. Students participate in designing the appropriate geophysical surveys, acquiring the observations, reducing the observations, and interpreting these observations in the context of the geological model defined from the geological surveys. Prerequisites: GPGN268, GPGN314, GPGN329, GPGN335, GEGN203 or GEGN204, GEGN205. 12 hours lab; 4 semester hours.

GPGN498. SPECIAL TOPICS IN GEOPHYSICS. 1-6 Semester Hrs.
(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

GPGN499. GEOPHYSICAL INVESTIGATION. 1-6 Semester Hrs.
(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.