

GEOLOGY AND GEOPHYSICS

Graduate work in geology and geophysics is offered at both the master of science (thesis and non-thesis) and doctoral levels. Programs are designed to provide you with an understanding of the fundamentals and principles of geology, geochemistry, and geophysics. Research investigations comprise a significant part of each program, and at the doctoral level an original contribution to the science is required.

Research emphasis of the program is in:

- Low Temperature and Environmental Geochemistry
- Mineralogy/Petrology/Economic Geology
- Geophysics/Tectonics/Remote Sensing
- Sedimentology/Paleontology/Stratigraphy/Petroleum Exploration

In geology and geochemistry, opportunities for research at both the M.S. and Ph.D. levels are available in mining geology, petroleum geology, environmental geochemistry, stratigraphy and sedimentation, clay mineralogy, remote sensing, GIS, palynology, structural geology, igneous and metamorphic petrology, volcanology, and planetary geology.

In geophysics, opportunities for research at both the M.S. and Ph.D. levels are available in the areas of reflection and refraction seismology, theoretical seismology, geophysical data analysis, gravity, magnetics, seismic hazards, and computational geophysics.

The study of the Earth and other planets includes all areas of scientific inquiry. To work effectively in so broad a discipline requires considerable depth and breadth of understanding of physical principles and advanced proficiency in mathematics, particularly for those students contemplating advanced studies in geophysics. A thorough undergraduate training in an earth or physical science is a prerequisite for advanced study in geology or geophysics.

Earth sciences have been an integral part of the university since its founding. The program has a long and proud history of faculty and students who have contributed to the advancement of the science, to mineral and hydrocarbon exploration, and to protecting the environment. The university was formerly the Missouri School of Mines. Because of the school's tradition and location near the Missouri Lead District, the emphasis of the program has been in exploration for mineral and petroleum resources. The program has expanded to include environmental geochemistry, geophysics, soft rock geology, and planetary geology. Our graduates find employment in the mining, petroleum, and environmental industries, as well as with government agencies and academia. The program provides students with diverse educational opportunities to prepare themselves to seek employment in any area of the earth sciences.

The program has a wide variety of equipment for research and exploration in geology, geochemistry, and geophysics. Interaction with mining engineering, geological engineering, petroleum engineering, metallurgy, environmental engineering, biological sciences and various other programs/departments is routine. Our faculty and graduate students commonly participate in collaborative research with other departments on campus as well as universities worldwide. In addition, cooperative research and internship opportunities with the Missouri Geological Survey, the U.S. Geological Survey's National Geospatial Technical Operations Center and the Mark Twain National Forest Service, all located in Rolla, are available. Cooperative programs with local mining companies, petroleum companies, or other industries are also possible.

Thus, your research interests need not fall entirely within the interests of our faculty or within the bounds of the equipment directly available within the program.

A B.S. degree is essential for professional practice in geology or geophysics in industry. Due to the increasing complexity of jobs in the geosciences, the M.S. degree is recognized as the "professional degree" for geoscientists desiring employment in the Petroleum, Minerals, and many other industries. The Ph.D. degree is for those students that want to conduct original research with purpose of adding new knowledge in a specific area of the geosciences. Successful Ph.D. candidates find employment in academia or research centers in government agencies or corporate research labs.

Two M.S. degree options are available: thesis and non-thesis. All Geology and Geophysics MS students are required to take the Professional Geosciences Skills course (GEOLOGY 5100) and either Advanced Physical Geology (GEOLOGY 5111) or Global Tectonics (GEOPHYS 5096). For students whose native language is not English, a minimum score of 79 TOEFL, or a minimum of 53 PTE, or a minimum of 6.5 IELTS is required for admission. GRE scores are not required.

All Geology and Geophysics Ph.D. students are required to take the Professional Geosciences Skills course (GEOLOGY 6100) and either Advanced Physical Geology (GEOLOGY 5111) or Global Tectonics (GEOPHYS 5096). A qualifying examination is required of all Ph.D. students during the third semester of residency.

For students whose native language is not English, a minimum score of 79 TOEFL, or a minimum score of 53 PTE, or a minimum score of 6.5 IELTS is required for admission. GRE scores are not required.

Geoenvironmental Science and Engineering

The graduate certificate in Geoenvironmental Science and Engineering is designed to provide graduate students with the geoscience and engineering backgrounds they will need to be successful in the geoenvironmental consulting or regulatory fields.

The Geoenvironmental Science and Engineering Certificate Program is open to all persons holding a B.S., M.S., or Ph.D. degree in Geology, Geophysics, Geological Engineering, Civil Engineering, or Biology or are currently accepted into a graduate degree program in one of these fields at Missouri S&T. Once admitted to the program, the student must take the four designated courses (provided in the curriculum section). In order to receive a Graduate Certificate, the student must have an average cumulative grade point of 3.0 or better in the certificate courses. Once admitted to the program, a student will be given three years to complete the program.

Students admitted to the Geoenvironmental Science and Engineering Certificate Program will have non-degree graduate status, however, they will earn graduate credit for the courses they complete. If the student completes the four-course sequence with a grade of B or better in each of the courses taken, they, upon application, will be admitted to the non-thesis M.S. degree program in Geology and Geophysics. The certificate credits taken by the students admitted to the M.S. degree program will count towards their master's degree. Students who do not have all of the prerequisite courses necessary to begin the courses in the

Geoenvironmental Science and Engineering Certificate Program will be allowed to take "bridge" courses at either the graduate or undergraduate level to prepare for the formal certificate courses.

One of the following courses is required:

GEOLOGY 4411	Hydrogeology	3
GEO ENG 5331	Subsurface Hydrology	3
GEO ENG 5332	Fundamentals of Groundwater Hydrology	3

Three of the following courses are required:

GEOLOGY 4431	Methods Of Karst Hydrogeology	3
GEOLOGY 4451	Aqueous Geochemistry	3
GEOPHYS 5782	Environmental and Engineering Geophysics	3
GEO ENG 5174	Geological Engineering Field Methods	3
GEO ENG 5233	Risk Assessment In Environmental Studies	3
GEO ENG 5235	Environmental Geological Engineering	3
GEO ENG 5237	Geological Aspects Of Hazardous Waste Management	3
GEO ENG 5381	Intermediate Subsurface Hydrology And Contaminant Transport Mechs	3
GEO ENG 6331	Advanced Subsurface Hydrology	3
BIO SCI 6313	Environmental Microbiology	3
BIO SCI 6363	Advanced Freshwater Ecology	3
BIO SCI 6463	Bioremediation	3
ENV ENG 5605	Environmental Systems Modeling	3
ENV ENG 5635	Phytoremediation and Natural Treatment Systems: Science and Design	3
ENV ENG 6601	Biological Principles In Environmental Engineering Systems	3

Geophysics

The graduate certificate in Geophysics is designed to provide graduate students who want to emphasize this area of research with course guidance and a formal recognition. A certificate in Geophysics will give students an advantage when applying for careers in oil and gas, mining, and other fields.

The Geophysics Certificate Program is open to all persons holding a B.S., M.S., or Ph.D. degree in Geology, Geophysics, Geological Engineering, Petroleum Engineering, or Civil Engineering or are currently accepted into a graduate degree program in one of these fields at Missouri S&T. Once admitted to the program, the student must take the four designated courses (provided in the curriculum section). In order to receive a Graduate Certificate, the student must have an average cumulative grade point of 3.0 or better in the certificate courses. Once admitted to the program, a student will be given three years to complete the program.

Students admitted to the Geophysics Certificate Program will have non-degree graduate status, however, they will earn graduate credit for the courses they complete. If the student completes the four-course sequence with a grade of B or better in each of the courses taken, they, upon application, will be admitted to the non-thesis M.S. degree program in Geology and Geophysics. The certificate credits taken by the students admitted to the M.S. degree program will count towards their master's degree. Students who do not have all of the prerequisite courses necessary to begin the courses in the Geophysics Certificate Program will be allowed to take "bridge" courses at either the graduate or undergraduate level to prepare for the formal certificate courses.

Four of the following courses are required:

GEOPHYS 4231	Seismic Interpretation	3
GEOPHYS 5096	Global Tectonics	3
GEOPHYS 5202	Exploration and Development Seismology	3
GEOPHYS 5211	Seismic Stratigraphy	3
GEOPHYS 5221	Wave Propagation	3
GEOPHYS 5231	Seismic Data Processing	3

GEOPHYS 5241	Advanced Electrical And Electromagnetic Methds In Geophysical Exp	3
GEOPHYS 5261	Computational Geophysics	3
GEOPHYS 5736	Geophysical Field Methods	3
GEOPHYS 5761	Transportation Applications of Geophysics	3
GEOPHYS 5782	Environmental and Engineering Geophysics	3
GEOPHYS 6211	Advanced Seismic Interpretation	3
GEOPHYS 6231	Advanced Seismic Data Processing	3
GEOPHYS 6241	The Theory of Elastic Waves	3
GEOPHYS 6251	Geophysical Inverse Theory	3
GEO ENG 6782	Surface Waves (MASW) and Ground Penetrating Radar (GPR)	3

Petroleum Systems

The graduate certificate in Petroleum Systems is designed to provide graduate students in the geosciences, geological engineering, and petroleum engineering with the key interdisciplinary backgrounds they will need to be successful in the oil and gas industry.

The Petroleum Systems Certificate Program is open to all persons holding a B.S., M.S., or Ph.D. degree in Geology, Geophysics, Geological Engineering, or Petroleum Engineering or are currently accepted into a graduate degree program in one of these fields at Missouri S&T. Once admitted to the program, the student must take the four designated courses (provided in the curriculum section). In order to receive a Graduate Certificate, the student must have an average cumulative grade point of 3.0 or better in the certificate courses. Once admitted to the program, a student will be given three years to complete the program.

Students admitted to the Petroleum Systems Certificate Program will have non-degree graduate status, however, they will earn graduate credit for the courses they complete. If the student completes the four-course sequence with a grade of B or better in each of the courses taken, they, upon application, will be admitted to the non-thesis M.S. degree program in Geology and Geophysics. The certificate credits taken by the students admitted to the M.S. degree program will count towards their master's degree. Students who do not have all of the prerequisite courses necessary to begin the courses in the Petroleum Systems Certificate Program will be allowed to take "bridge" courses at either the graduate or undergraduate level to prepare for the formal certificate courses.

Required Courses:

GEOLOGY 5513	Petroleum Geology	3
One of the following Geophysics courses:		
GEOPHYS 4231	Seismic Interpretation	3
GEOPHYS 5202	Exploration and Development Seismology	3
GEOPHYS 5211	Seismic Stratigraphy	3
GEOPHYS 5231	Seismic Data Processing	3
GEOPHYS 5261	Computational Geophysics	3
One of the following Geology courses:		
GEOLOGY 5311	Depositional Systems	3
GEOLOGY 5511	Applied Petroleum Geology	3
GEOLOGY 5631	Carbonate Petrology	3
GEOLOGY 5661	Advanced Stratigraphy and Basin Evolution	3
GEOLOGY 5671	Clay Mineralogy	3
GEOLOGY 5741	Micropaleontology	3
GEOLOGY 6311	Advanced Structural Geology	3
GEOLOGY 6321	Analytical Structural Geology	3
GEOLOGY 6511	Advanced Petroleum Geology	3
GEOLOGY 6621	Clastic Sedimentary Petrology	3
GEOLOGY 6811	Sedimentary Basin Analysis	3
One of the following Petroleum Engineering courses:		
PET ENG 4111	Fundamental Digital Applications In Petroleum Engineering	3

PET ENG 4210	Drilling and Well Integrity	3
PET ENG 4311	Reservoir Characterization	3
PET ENG 4590	Subsurface Energy Economics	3
PET ENG 4720	Reservoir Geomechanics	3
PET ENG 6711	Geodynamics	3

David M. Borrok, Gulf Oil Foundation Professor and Dean for College of Engineering and Computing
PHD University of Notre Dame
Aqueous geochemistry, petroleum geochemistry, water resources.

Andreas Eckert, Associate Professor
PHD University of Karlsruhe
Mechanical earth modeling, finite element methods in petroleum engineering, petroleum geomechanics and geophysics.

Stephen Shangxing Gao, Professor and Department Chair
PHD University of California-Los Angeles
Seismology, solid earth geophysics, crustal deformation, computational geophysics, plate tectonics.

Kelly Hong Liu, Professor
PHD University of California-Los Angeles
Exploration geophysics, digital signal processing, seismic hazard, earth structure and dynamics.

Jeremy Maurer, Assistant Professor
PHD Stanford University
Geophysics, earthquakes, induced seismicity, remote sensing, big Earth data.

Francisca Oboh Ikuenobe, Professor and Associate Dean for Academic Affairs for College of Engineering & Computing²
PHD Cambridge University
Palynology, biostratigraphy, sedimentology, paleoclimatology.

Jonathan Obrist Farner, Associate Professor
PHD Missouri University of Science and Technology
Sedimentology, stratigraphy, paleolimnology, paleoclimatology.

Wan Yang, Professor
PHD University of Texas at Austin
Sedimentology, sequence stratigraphy, petroleum geology, paleoclimatology.

GEOLOGY 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEOLOGY 5001 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

GEOLOGY 5010 Seminar (LEC 0.50)
Discussion of current topics.

GEOLOGY 5040 Oral Examination (IND 0.0)

After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

GEOLOGY 5085 Internship (IND 3.0)

Students will select, with their committee's advice, problems for investigation and preparation of a graduate research proposal. Problems must provide higher level experiential learning consistent with a graduate degree in geology. Assessment is based upon the quality of written and oral presentations and supervisor's evaluation. Repeatable for credit. Prerequisite: Graduate Standing.

GEOLOGY 5099 Research (IND 0.0-15)

Investigations of an advanced nature leading to the preparation of a thesis or dissertation.

GEOLOGY 5100 Professional Geoscience Skills (LEC 3.0)

Development and communication of complex topics in the geosciences is required for successful post-MS career advancement. Best practices for developing these skills in the geosciences will be critiqued weekly, culminating with poster and oral presentations. Assessment by peer-review and self-evaluation. Topics selected from geosciences careers. Prerequisites: Graduate Standing.

GEOLOGY 5111 Advanced Physical Geology (LEC 3.0)

Examination of topics concerned with the physical properties of earth materials, processes affecting change of the surface and interior of the earth, and the driving forces causing these changes. Weekly critical assessment of literature, and an oral presentation and term paper required. Prerequisite: Consent of instructor.

GEOLOGY 5121 Advanced Historical Geology (LAB 1.0 and LEC 2.0)

Study of the physical and biological history of the Earth beginning with the origin of the solar system up to the present. Emphasis will be placed on processes that shaped the Earth and its ecosystems. Prerequisite: Entrance requirements for the MST program in Earth Science.

GEOLOGY 5311 Depositional Systems (LEC 3.0)

Development of three dimensional depositional models using Walther's Law, Walther's Warning and seismic stratigraphy. Emphasis on overall geometries and internal porosity and permeability characteristics of aquifers and hydrocarbon reservoirs. Includes 3-D models for clastic, carbonate and evaporate sequences. Prerequisites: Geology 1110 or Geo Eng 1150; accompanied or preceded by both Geology 3310 and Geology 3620.

GEOLOGY 5432 Potential Field Theory (LEC 3.0)

The mathematics and physics of gravitational, magnetic, and electrical fields of the earth as derived from potential functions, with applications to practical problems. The theorems of Laplace, Poisson, Gauss, and Green and their applications to geophysics are presented. Prerequisites: Math 5325 (also may be taken as a co-requisite). (Co-listed with Geophys 5432 and Geo Eng 5432).

GEOLOGY 5510 Organic Geochemistry (LEC 3.0)

This course explores the carbon cycle, the history and inventory of organic matter on Earth, the transport of organic matter in aqueous systems, the burial of organic matter, the maturation of organic matter to become petroleum, and organic contaminants in the environment. Prerequisites: Graduate standing or consent of instructor.

GEOLOGY 5511 Applied Petroleum Geology (LAB 2.0 and LEC 1.0)

The principles of petroleum geology are applied in solving hydrocarbon exploration and developmental problems. Geological and economical techniques for evaluating hydrocarbonbearing reservoirs are presented, with methods for decisionmaking under conditions of extreme uncertainty. Prerequisite: Consent of instructor.

GEOLOGY 5513 Petroleum Geology (LAB 1.0 and LEC 2.0)

Principles of origin, migration, and accumulation of oil and gas. The laboratory introduces the procedures used for exploration, and development of hydrocarbon resources. Prerequisites: Geology 1110 or Geo Eng 1150; accompanied or preceded by both Geology 3310 and Geology 3620.

GEOLOGY 5521 Coal Petrology (LEC 3.0)

Formation, composition, and properties of coals. Discussion of the geology of selected coal deposits, the analysis of coal, and the optical identification of coal minerals. Prerequisite: Permission of instructor.

GEOLOGY 5611 Granites And Rhyolites (LAB 1.0 and LEC 3.0)

Processes governing the generation and crystallization of felsic magma will be covered, with specific reference to: 1) crust vs mantle sources, 2) melt migration and emplacement, 3) magma chamber dynamics, 4) the volcanic-plutonic connection, and 5) the relationship to tectonic setting. A field trip at the student's expense is required. Prerequisite: Geology 2620.

GEOLOGY 5631 Carbonate Petrology (LAB 1.0 and LEC 2.0)

Petrology, chemistry and sedimentology of carbonates and other associated chemical sedimentary rocks. Prerequisites: GEOLOGY 2620, 3620 and CHEM 1320 or equivalent; GEOLOGY 3410 recommended.

GEOLOGY 5641 Advanced Igneous Petrology (LAB 1.0 and LEC 2.0)

The genesis of eruptive rocks as evidenced by the physico-chemical conditions of formation of their constituent minerals. A critical examination of various magmatic processes. Use of advanced petrographic techniques. Prerequisites: GEOLOGY 4631.

GEOLOGY 5661 Advanced Stratigraphy and Basin Evolution (LEC 3.0)

Advanced topics in sedimentary geology including: tectonic controls on sedimentary basin development, global sequence stratigraphy, regional facies and diagenetic patterns, basin hydrogeology, thermal evolution of basins and distribution of economic resources. This course should be preceded or accompanied by Geology 3410. Prerequisites: Geology 3620 and Geology 3310.

GEOLOGY 5671 Clay Mineralogy (LAB 1.0 and LEC 2.0)

Mineral structure, geochemical properties, occurrence, environment, and uses of clays. Determination of physical properties, optics, x-ray diffraction, and thermal features of clays. Field trip fee required. Prerequisites: Geology 2610 and 3410, or Chem 2310, or Civ Eng 5715, or Geo Eng 5172.

GEOLOGY 5679 Field and Laboratory Studies in Earth Science (LAB 3.0)

Hands-on laboratory and field experiences in the Earth Sciences. This course is designed to be taught in an intensive three week session during the summer on the S&T campus. Prerequisites: GEOLOGY 2096 or 5121 or equivalents.

GEOLOGY 5681 Lidar Principles and Application (LEC 3.0)

Provides a comprehensive understanding of light detection and ranging (lidar) technology as it has been developed for commercial use; various methods of deploying technology for collection of data for mapping, engineering and science, and application of the data using specialized software for editing and processing point cloud data. Assumes GIS experience. Prerequisite: Senior or graduate standing.

GEOLOGY 5741 Micropaleontology (LAB 1.0 and LEC 2.0)

This course studies the fossil and soft-body characteristics of bacteria, protists, microinvertebrates and organic-walled microfossils (palynomorphs). Focused discussions on systematics, evolutionary histories, paleoecology, and geologic applications of the microfossil groups. Extraction of foraminifera and palynomorphs from rocks in lab. Prerequisite: Geology 4630.

GEOLOGY 6000 Special Problems (IND 0.0-6.0)

Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEOLOGY 6001 Special Topics (LAB 0.0 and LEC 0.0)

This course is designed to give the department an opportunity to test a new course. Variable title.

GEOLOGY 6010 Seminar (IND 0.0-6.0)

Discussion of current topics.

GEOLOGY 6040 Oral Examination (IND 0.0)

After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

GEOLOGY 6050 Continuous Registration (IND 1.0)

Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

GEOLOGY 6085 Internship (IND 3.0)

Students will select, with their committee's advice, problems for investigation and preparation of a graduate research proposal. Problems must provide higher level experiential learning consistent with a graduate degree in geology. Assessment is based upon the quality of written and oral presentations and supervisor's evaluation. Repeatable for credit. Prerequisite: Graduate standing.

GEOLOGY 6097 Advanced Geologic Field Methods (LEC 3.0)

Advanced instruction in planning and implementation of geologic field campaigns, development of an appropriate scientific plan, including logistics, safety, and supervision of field personnel in a manner consistent with professional practices. Emphasis placed upon reflection on projects outcomes supervised with faculty oversight. Field Trip fee required.

GEOLOGY 6098 Advanced Geologic Field Methods (LEC 3.0)

Adv. instruction in theory and practice of qualitative/quantitative description of spatial relationships of rock types in areas exhibiting complex deformation. Emphasis on expl. learning where students plan, implement, and reflect on outcomes for sev. scientific field campaigns in a manner consistent with prof. scientific practices. Field trip fee required.

GEOLOGY 6099 Research (IND 0.0-15)

Investigations of an advanced nature leading to the preparation of a thesis or dissertation.

GEOLOGY 6100 Advanced Professional Geoscience Skills (LEC 3.0)

Communication of complex research topics in the geosciences is required for successful post-doctoral career advancement in both academic and non-academic career paths. Best practices for developing and proposing scientific ideas in the geosciences will be critiqued weekly. Assessment of research proposals presentations includes peer-and self-evaluation. Prerequisites: Doctoral Graduate Standing. (Co-listed with Pet Eng 6100).

GEOLOGY 6211 Geodynamics (LEC 3.0)

The applications of continuum physics to geological and petroleum engineering problems. Topics include plate tectonics, stress and strain in solids, elasticity and flexure, heat transfer, gravity, fluid mechanics, rock rheology, faulting, and flow in porous media. Prerequisites: Math 2222 and Geology 3310. (Co-listed with Pet Eng 6711).

GEOLOGY 6311 Advanced Structural Geology (LAB 1.0 and LEC 2.0)

The course provides theoretical background, analytical techniques, and hands-on experience for analyzing geologic structures at a variety of scales hand sample to global. Prerequisites: Geology 3310, Geophys 4096.

GEOLOGY 6321 Analytical Structural Geology (LAB 1.0 and LEC 2.0)

The course provides theoretical background, analytical techniques, and hands-on experience, for quantifying processes that lead to the formation and evolution of rocks and structures produced as a result of deformation at a variety of scales - hand sample to global. Poster - and oral - presentations, and a research paper required. Prerequisites: Geology 3310, Geophys 4096.

GEOLOGY 6331 Geotectonics (LEC 3.0)

A critical study of the origin, and differentiation of the earth, evolution of the crust, and plate tectonics. Geology of the continents and ocean basins. Regional tectonic analysis of precambrian shields, platforms, orogenic belts, and a review of internal energy sources. Emphasis is on North America. Prerequisite: Geology 3310.

GEOLOGY 6341 Advanced Remote Sensing And Image Processing (LAB 1.0 and LEC 2.0)

Quantitative methods of utilizing remote sensing technology for terrain analysis. Digital image processing of landsat and/or aircraft scanner data for mineral resource studies and geological engineering applications. Prerequisite: Geo Eng 5146. (Co-listed with Geo Eng 6146).

GEOLOGY 6351 Advanced Geochemistry (LEC 3.0)

A study of the absolute and relative abundance of elements and isotopes in the Earth, principles of element transport, formation of the Earth's crust, mineral deposits, and soils. Field trip fee required. Prerequisite: Geology 3410.

GEOLOGY 6411 Advanced Isotope Geochemistry (LAB 1.0 and LEC 2.0)

The use of radiogenic and stable isotopes in geology in the study of the evolution of Earth, crust, mantle, and the Solar System as well as applications to geothermometry, ore petrogenesis, paleontology, and the global climate system. Prerequisites: Geology 2620, 3620, 3410.

GEOLOGY 6421 Environmental Geology (LEC 3.0)

Overview of environmental problems facing humans. Emphasis will be placed on surface and groundwater pollution, geological hazards, and pressures on Earth's ecosystems and natural resources by urbanization and population growth. Prerequisites: GEOLOGY 1110 or 1120 or equivalents.

GEOLOGY 6511 Advanced Petroleum Geology (LAB 2.0 and LEC 1.0)

The principles of petroleum geology are applied in solving hydrocarbon exploration and developmental problems. Various types of oil and gas accumulations are reviewed in detail. Study of criteria useful in evaluating the petroleum potential of undrilled areas. Special investigation assignment is required. Prerequisite: Geology 3310, Geology 5513, Geology 5661, or Geology 6811.

GEOLOGY 6521 Advanced Ore Microscopy (LAB 2.0 and LEC 1.0)

A study of ore suites utilizing various advanced, quantitative ore microscopy techniques including hardness, spectral reflectance, indentation, color, rotation property measurements, fluid inclusion geothermometry, and salinity measurements. Laboratory study includes demonstration and operation of the luminescope and other microbeam techniques. Prerequisite: Geology 4521.

GEOLOGY 6531 Applied Ore Microscopy (LAB 2.0 and LEC 1.0)

Application of ore microscopic and petrographic techniques to problems in ore beneficiation, pelleting, sintering, smelting, refining, refractories, cement, mining, and exploration. Discussions and laboratories are based upon industrial case histories. Prerequisite: Geology 4521.

GEOLOGY 6541 Geology of Natural Resources (LEC 3.0)

The origin and distribution of economically important natural resources including soils, water resources, metals, non-metals, building materials, petroleum, and other energy resources. Prerequisites: GEOLOGY 1110 or 1120 or equivalents.

GEOLOGY 6551 Global Tectonics and Metallogeny (LAB 1.0 and LEC 2.0)

An advanced study of metallic ore deposits. Theories of ore genesis in different tectonic regimes and the effects on exploration. Discussions based on maps, logs, exploration datasets and samples from the world's typical mineral deposits. Prerequisites: Geology 3511 and preceded or accompanied by Geology 4521.

GEOLOGY 6611 Advanced Palynology (LAB 2.0 and LEC 1.0)

Study of organic-walled microfossils, and the processes of sporopollenin preservation, sedimentation and palynofacies. Chronicle of Phanerozoic palynology in lectures. Major emphasis on independent palynostratigraphic research and applications, such as biostratigraphy, paleoclimatology and paleoenvironments. Prerequisite: Geology 4630 or Geology 5741.

GEOLOGY 6621 Clastic Sedimentary Petrology (LAB 1.0 and LEC 2.0)

Petrology and petrography of clastic sedimentary rocks. Emphasis on origin, diagenesis and description of clastic, sedimentary rocks. Prerequisite: Geology 3620.

GEOLOGY 6651 Granite and Rhyolite Petrogenesis (LAB 1.0 and LEC 3.0)

The origin of granites and rhyolites with respect to extreme fractionation, crustal anatexis, magma mixing, and tectonic setting will be explored through critical reading of the literature and examination of hand samples and thin sections from classic geologic terranes. A research paper is required as well as a field trip at the student's expense. Prerequisite: Geology 2620.

GEOLOGY 6711 Advanced Paleoclimatology and Paleoecology (LEC 3.0)

Advanced study of paleoclimatic and paleoecologic processes since the Archean, and the interpretation of Holocene climate changes, including human impacts. Extensive presentations and discussions of current ideas and techniques in paleoclimatic studies. Prerequisite: Geology 3620.

GEOLOGY 6811 Sedimentary Basin Analysis (LEC 3.0)

An advanced study of stratigraphic, diagenetic and tectonic processes in sedimentary basins. Prerequisites: Geology 3310, 3620, 3410 or 4441 or 4451.

GEOLOGY 6917 Applied Petroleum Systems Analysis (LAB 3.0 and LEC 3.0)

Prospective basin evaluation for geoscience graduate students. An industry dataset will be analyzed using geological, geophysical, and engineering methods and software. Students will analyze and interpret well logs, interpret 3D seismic datasets, integrate knowledge from literature, and construct a 3D geomodel for volumetric estimations. Prerequisites: Geology 5513, Geophys 4231, Pet Eng 3330; consent of instructor.

GEOPHYS 5000 Special Problems (IND 0.0-6.0)

Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEOPHYS 5001 Special Topics (LAB 0.0 and LEC 0.0)

This course is designed to give the department an opportunity to test a new course. Variable title.

GEOPHYS 5010 Seminar (LEC 0.50)

Discussion of current topics.

GEOPHYS 5040 Oral Examination (IND 0.0)

After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession.

Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

GEOPHYS 5096 Global Tectonics (LEC 3.0)

An integrated view of the Earth's structure and dynamics with an emphasis on information gained through geophysical methods. Topics include seismology, heat flow, gravity, rheological and compositional structure, plate motions and intermotions, and mantle driving mechanisms for plate tectonics. Prerequisite: Geology 3310.

GEOPHYS 5099 Research (IND 0.0-15)

Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

GEOPHYS 5202 Exploration and Development Seismology (LAB 1.0 and LEC 2.0)

Principles of reflection seismology as applied to the delineation of geologic structures and the determination of stratigraphy and lithology. Emphasis on both the capabilities and limitations of the seismic method. The laboratory utilizes both modeled and actual seismic data. Prerequisites: Math 1208, Math 1211, or Math 1214; Geology 1110 or Geo Eng 1150.

GEOPHYS 5211 Seismic Stratigraphy (LAB 1.0 and LEC 2.0)

A study of the seismic expression of depositional models. Reflection patterns and reflection amplitudes are interpreted to determine bed thicknesses, fluid content, depositional environment, and lithology. Special data acquisition and processing techniques are examined. Prerequisites: Geophys 4521, Geology 3310, 3620.

GEOPHYS 5221 Wave Propagation (LEC 3.0)

A study of Hamilton's principle and energy theorems, fundamentals of plane wave theory, waves in stratified fluids, elastic waves in solids, electromagnetic and hydromagnetic radiation, and Allen's functions and point sources. Prerequisites: Geophys 281, 3221.

GEOPHYS 5231 Seismic Data Processing (LAB 1.0 and LEC 2.0)

Introduction to seismic data processing. Topics to be covered include statics corrections, filtering, velocity analysis, deconvolution, stacking and migration. The course has a field component to record seismic data. If this is offered in the summer, an off-campus trip may be needed. Extra fee may be charged to cover the field expenses. Prerequisites: Geophys 3210 or Geophys 5202.

GEOPHYS 5241 Advanced Electrical And Electromagnetic Methods In Geophysical Exp (LAB 1.0 and LEC 2.0)

Theory of the electrical geophysical methods as applied to subsurface investigations addressing geologic, engineering, groundwater and contaminant transport problems. Course content includes both passive and active methods and recent advances in the application of these methods. Course will include a field component illustrating application of techniques to local problems. Prerequisites: Geophys 3251, Math 2222.

GEOPHYS 5261 Computational Geophysics (LAB 2.0 and LEC 1.0)

Scientific programming in a UNIX/Linux environment, with emphasis on solving geophysical problems such as linear and nonlinear inversion, spectral analysis, seismicity, seismic wave attenuation, shear-wave splitting, and seismic tomography. Prerequisite: Geophys 3210.

GEOPHYS 5432 Potential Field Theory (LEC 3.0)

The mathematics and physics of gravitational, magnetic, and electrical fields of the earth as derived from potential functions, with applications to practical problems. The theorems of Laplace, Poisson, Gauss, and Green and their applications to geophysics are presented. Prerequisites: Math 5325 (also may be taken as a co-requisite). (Co-listed with Geo Eng 5432 and Geology 5432).

GEOPHYS 5736 Geophysical Field Methods (LAB 1.0 and LEC 2.0)

Imaging of selected subsurface features and engineering structures using various geophysical tools. Special emphasis is placed on ground penetrating radar and surface wave techniques. One field trip at student expense required. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 5736).

GEOPHYS 5761 Transportation Applications of Geophysics (LAB 1.0 and LEC 2.0)

Overview of geophysical and non-destructive test methods that are commonly used to investigate transportation structures and their foundations. Emphasis is placed on bridge system substructure, bridge system superstructure, pavement, roadway subsidence, subsurface characterization and vibration measurements. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 5761 and Civ Eng 5750).

GEOPHYS 5782 Environmental and Engineering Geophysics (LAB 1.0 and LEC 2.0)

An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential, induced polarization and electromagnetic methods as applied to the solution of engineering and environmental problems. Prerequisite: Math 2222. (Co-listed with Geo Eng 5782).

GEOPHYS 6000 Special Problems (IND 0.0-6.0)

Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEOPHYS 6001 Special Topics (LAB 0.0 and LEC 0.0)

This course is designed to give the department an opportunity to test a new course. Variable title.

GEOPHYS 6010 Seminar (RSD 0.0-6.0)

Discussion of current topics.

GEOPHYS 6040 Oral Examination (IND 0.0)

After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

GEOPHYS 6050 Continuous Registration (IND 1.0)

Doctoral candidates who have completed all requirements for the degree except the dissertation and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

GEOPHYS 6099 Research (IND 0.0-15)

Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

GEOPHYS 6211 Advanced Seismic Interpretation (LAB 1.0 and LEC 2.0)

The integration of geologic information, well log data and seismic information for interpreting the earth's subsurface using advanced 3-D seismic interpretation software packages. Reservoir identification and evaluation as well as horizon and formation attributes are included. Prerequisites: Geophys 3210 or Geophys 5202.

GEOPHYS 6221 Advanced Geophysical Data Analysis (LEC 3.0)

Applications of advanced time series and spatial series analysis techniques to geophysical data. Topics covered include digitization and aliasing of geophysical signals, frequency and wavenumber spectra, digital filtering and linear systems theory. Hands-on data processing exercises will provide theoretical knowledge as applied to geophysical investigations. Prerequisites: Comp Sci 1970 and Comp Sci 1980 or equivalents.

GEOPHYS 6231 Advanced Seismic Data Processing (LAB 1.0 and LEC 2.0)

Theory and application of seismic data processing. Topics to be covered include convolution, correlation, deconvolution, 2-D filtering, migration and inversion. Prerequisites: Geophys 5202, 5231, Stat 3115.

GEOPHYS 6232 Introduction to Satellite Geodesy (LEC 3.0)

An introduction to satellite geodetic methods, including Global Navigational Satellite Systems (GNSS), satellite gravity, Synthetic Aperture RADAR (SAR) and Interferometric SAR (InSAR), and LiDAR. Geodetic reference frames and various datasets are introduced. Data processing and analysis methods are covered. Students are required to complete a project that utilizes one or more methods covered in the course. Prerequisites: Geo Eng 3148 or graduate standing. (Co-listed with Geo Eng 6232).

GEOPHYS 6241 The Theory of Elastic Waves (LAB 1.0 and LEC 2.0)

A mathematical study of elastic waves in the layered earth. Prerequisites: Geophys 3210.

GEOPHYS 6251 Geophysical Inverse Theory (LAB 1.0 and LEC 2.0)

A study of inverse theory applied to geophysical data, focusing on the relationship between data and model spaces and ways to estimate model parameters via global and local optimization techniques. Prerequisites: Geophys 3210 or Graduate Standing in GGPE.

GEOPHYS 6401 Introduction to Positioning, Navigation, and Timing (LAB 1.0 and LEC 2.0)

This course provides a technical introduction to Global Navigation Satellite Systems (GNSS), covering theory, procedures, and accuracy issues. Fundamental principles of GNSS measurements are covered, including the various sources of error that can affect their accuracy. Practical skills will be emphasized, including the ability to compute positions using both code and phase techniques, and utilize GNSS post-processing software. Quality control and assurance. Surveying techniques. Prerequisites: Geo Eng 3148 or graduate standing. (Co-listed with Elec Eng 6401).

GEOPHYS 6403 Advanced Positioning, Navigation, and Timing (LAB 1.0 and LEC 2.0)

Advanced topics in Global Navigation Satellite Systems (GNSS).

Processing phase and code observations. Data Q/C, accuracy and precision estimates. Kalman filtering and other non-GNSS PNT systems will be explored. Practical applications and technology advancements will be emphasized. Prerequisites: Geophys 6401. (Co-listed with Elec Eng 6403).
