Department of Geosciences

Faculty

Professors: Carlos L. V. Aiken, David E. Dunn (emeritus),William I. Manton, George A. McMechan, Dean C. Presnall (emeritus), Robert H. Rutford (emeritus), Robert J. Stern
Associate Professors: Thomas H. Brikowski, John F. Ferguson

Objectives

The basic objective of the Department of Geosciences Graduate Program is to provide students with a broad fundamental background in geosciences as well as an in-depth emphasis in a particular specialty.

The Master of Science degree (thesis option) is designed for students desiring research experience in a specific area of the geosciences. This degree will prepare the student for professional employment in the energy, mining, or environmental industries or government, as well as those seeking a doctoral degree. The Master of Science degrees (non-thesis options) are designed for students who seek employment in the environmental industry, and the industrial application of Geospatial Information Sciences (GIS).

The Doctor of Philosophy degree in Geosciences emphasizes basic research in one of the specialties in geosciences and is designed to prepare students for advanced positions in the energy, environmental or mining professions in industry or government, or for positions in academia.

The Doctor of Philosophy degree in Geospatial Information Sciences (GIS) is supported by the Department of Geosciences, the School of Social Sciences, and the School of Engineering and Computer Science. The degree reflects geospatial information science origins at the confluence of work in multiple disciplines. The degree focuses on advancement of the technology, its associated theory, and the enhancement of its applications. Graduates of this program will be well suited to advanced positions in the geospatial technology industry and academic positions.

Facilities

Research facilities include: JEOL JSM-T300 scanning electron microscope, petrographic microscopes, rock preparation facilities, and machine shop. Network access to a variety of LINUX workstations, Macintosh and PC computers is available. Parallel processing is done on two state of the art LINUX clusters with 10 64-bit processors, 42 32-bit processors, and 3 terabytes of disk.

Hydrology Laboratory

Field equipment for measuring ground and surface water flow and chemistry, including borehole bailers, electric water level meter, FlowProbe hand-held flow meter, Hach DREL 2010 Basic Water Quality Lab (field spectrophotometer, pH and salinity meters), and YSI-85 DO/salinity/conductivity meter. Software for modeling water flow and transport, including general interfaces GMS and ArgusOne, Hydrus-2D (unsaturated flow and transport), TOUGH2 and Tetrad (2-3D multiphase flow and transport), and many public-domain models. Hardware and software for visualizing model results, including SGI O2 and Linux workstations, GoCAD and IBM DataExplorer software.

Geochemical Laboratories

The Geochemical labs house sample preparation and analytical facilities. The sample prep lab uses multi-acid digestion and metaborate-tetraborate fusion techniques to take rock samples into solution for analysis. The analytical lab hosts the following instruments: 1) A Perkin-Elmer Optima 3300 DV inductively coupled plasma optical emission spectrometer (ICP-OES) instrument, with both radial and axial determination modes, which permits rapid determination of major and trace elements in rocks and water samples; 2) A Perkin-Elmer Sciex Elan 6100 DRC inductively coupled plasma mass spectrometer (ICP-MS), used for trace and rare earth element determinations to low parts per trillion levels. The DRC (dynamic reaction cell) removes interfering Ar species in the plasma and allows trace determinations of several critical elements such as Fe, As, and Se. This machine is also used for Se isotope determinations; 3) A Dionex DX-600 ion chromatograph, used to determine anions and cations in waters, Cl, F, and Br in rocks, in addition to As and Se speciation; and, 4) Titration station, for alkalinity determinations.

Thermal Ionization Mass Spectrometry Laboratories

The principal mass spectrometer is a Finnigan MAT 261 equipped with 9 collectors and a secondary electron multiplier. Also available are an updated NBS 12 inch instrument that is used principally for Rb isotope dilution measurements, and a fixed multicollector, donated by Mobil Oil Corp., that is used for studies of Sr in carbonates. The mass spectrometers are supported by Class 100 clean room facilities with sub-boiling acid distillation apparatus, micro- and semi-microbalances, and vessels for pressure decomposition of refractory silicates. Studies focus on using the evolution of Sr, Nd and Pb as indexes of petrogenetic processes, geochronology, environmental Pb, use of Pb as an index of bone mineral resorption, and evolution of marine Sr. A large inventory of spikes allows precise isotopic dilution analyses of elements of geological (U, Th, REE), environmental (Ag, Cd), or metabolic interest (Ca, Cu, Fe, Mg, Zn).

Remote Sensing Laboratory

Remote sensing research is carried out using 12 PCs and 3 Sun Ultra workstations, color and black-and-white printers, and an HP 2500CP Plotter. A wide range of remote sensing data sets are processed and interpreted, including orbital radar (SIR-C/X-SAR) and

optical (Landsat TM and ETM+, SPOT, and ASTER) imagery. We have extensive GIS (Geographic Information Systems) facilities including an ESRI site license with ARC/INFO, ARC/VIEW, ARC/GIS and MAPINFO. We have a GeoWall stereo projection system and 3D visualization and analysis packages such as GoCad, AutoCad, and 3D Studio Max.

Geophysics Facilities

Geophysical research is supported by two Scintrex CG-3M Gravimeters; a variety of surveying instruments including Nikon theodolite and data collector, a TOPCON GPT 2008 Total Station electronic distance meter and theodolite, two Laser Atlanta Advantage CI reflectorless laser rangefinders, two dual frequency 18 channel Leica 530 RTK GPS systems, a Trimble GeoXT GPS system and GPS post-processing software including Leica SKI, Spectra Precision GeoGenius, Trimble GPSurvey and Trimble Pathfinder Office. Seismic and radar equipment include a Bison 9048 48-channel floating point seismic acquisition system with Betsy, hammer, and explosive sources for shallow to deep exploration;and pulse EKKO IV and 1000 ground penetrating radars.

Admission Requirements

The University's general admission requirements are discussed here.

Applicants are expected to take the GRE General Test (Verbal, Quantitative, and Analytical Writing). A combined score of no less than 1000 on the Verbal and Quantitative portions of the exam is advisable based on our experience with student success in the program. In addition, students should complete and submit a Supplemental Geosciences Application Form which can be obtained from the Geosciences Department Office by mail (FO21, University of Texas at Dallas, Box 830688, Richardson, TX, 75083-0688, USA), telephone (972-883-2401), or e-mail (geosci@utdallas.edu).

Entering students are expected to have completed the equivalent of the University's B.S. degree in Geosciences, as well as a 3-hour scientific programming course. Students whose undergraduate training is in a science other than geology or geophysics are admitted to the program when their previous course work complements or supports their intended research interests. All entering students with non-geoscience degrees such as physics, math, chemistry or biology should have completed the following undergraduate courses: physical geology, rocks and minerals, structural geology, and sedimentology. All students are expected to have completed a faculty approved field course. Students may be admitted with some deficiencies but these must be completed during the first 18 graduate hours. It is understood that the minimum course requirements for the intended degree, as specified below, apply to well-prepared students.

Degree Requirements

The University's general degree requirements are discussed here. Additional requirements are specified below for each degree.

Graduate Certificate in Remote Sensing

The Remote Sensing Certificate is supported by both the Department of Geosciences and the School of Social Sciences. Faculty involved are Certificate Coordinator Mohamed G. Abdelsalam, Ronald Briggs, Fang Qiu, and Robert Stern.

The American Society for Photogrammetry and Remote Sensing (1997) defined remote sensing as the art, science, and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring and interpreting imagery and digital representation of energy patterns derived from non-contact sensor systems.

Remote sensing is a powerful set of software and hardware, computer-based techniques for extraction and presentation of information represented by raster and vector spatial data acquired via non-contact sensors. It provides reliable and cost-effective means of studying the environment for protection, natural resources management and urban planning. Government and non-government organizations continuously seek qualified professionals to use remote sensing for a wide range of applications.

Pre-requisites and Admission

- B.S. or B.A. Degree. Competence in personal computers, especially Windows-based, is expected.
- Application for admission to UTD Graduate School as "non-degree or degree seeking"
- Only B.S. or B.A. transcripts are needed. No GRE score, or reference letters are needed for non-degree seeking students.
- On-line registration is at: www.utdallas.edu/student/admission/grad-admission.html

Course Requirements

The Graduate Certificate in Remote Sensing is obtained by completing 15 hours of courses. Students must complete the following courses: GEOS 5325 Introduction to Remote Sensing, GISC 6381 Introduction to GIS, GEOS 5326 or GISC 7365 Remote Sensing Digital Image Processing, and GEOS 7327 or GISC 7367 Remote Sensing Workshop. In addition, students can choose one of the following courses: GISC 7366 Applied Remote Sensing or GEOS 5328 Radar Remote Sensing.

Master of Science in Geosciences

Thesis Option

All students seeking the Master of Science degree (thesis option) must satisfactorily complete the following requirements (minimum of 35 graduate semester hours):

- GEOS 5304 (or acceptable equivalent) and GEOS 6205.
- A minimum of four courses (minimum of 12 semester hours) in a chosen specialization related to the student's major area of study. Specialty areas are: geochemistry, geophysics, hydrogeology-environmental geosciences, mineral resources-petrology, sedimentology, seismology, remote sensing-geospatial science, and structural geology-tectonics.
- A minimum of three courses (minimum nine semester hours) in at least two specialties other than the chosen specialization.
- A minimum of nine semester hours of thesis research including GEOS 8398 and submit an acceptable thesis.

In addition to the above requirements, students seeking the M.S. degree must submit, no later than the second semester of enrollment, an acceptable research proposal to the supervising committee. Upon completion of the thesis research, the M.S. degree candidate will publicly defend the thesis.

Non-Thesis Option

All students seeking the Master of Science degree (non-thesis option) must satisfactorily complete a minimum of 36 graduate semester hours of a specified curriculum in the general area of environmental geosciences.

- **Core**: Complete 24 semester hours including GEOS 5310, GEOS 5325, GEOS 5407.
- GEOS 5357, GEOS 5358, GEOS 5483, GEOS 5484.
- **Electives**: 9 hours of elective courses selected in consultation with the graduate advisor.
- **Research**: An 8000 level, 3-hour research course.

Master of Science in Geographic Information Sciences

The Master of Science in Geographic Information Sciences is a professional program that is offered jointly by the School of Social Sciences and the School of Natural Sciences and Mathematics. The program focuses on the use of Geographic Information Systems (GIS) and associated technologies such as remote sensing and global positioning systems for managing spatially referenced information. Students are provided with the concepts underlying GIS, the skills for implementing GIS projects in public and private sector organizations, and the ability to use GIS in pure or applied research in substantive areas.

Prospective students should apply using established procedures to either Geosciences or Social Sciences depending on their background.

For the Master's degree in Geographic Information Sciences, beginning students are expected to have completed college Mathematics through Calculus and at least one programming or computer applications course or possess equivalent knowledge. Students must have the equivalent of GISC 6381 Geographic Information Systems Fundamentals and GISC 6382 Applied GIS, or they must take these courses at UTD in addition to the 30 credit hours required for the MGIS. Additional details of the curriculum can be found under "Master of Science in Geographic Information Sciences," in the School of Social Sciences section of the catalog.

Doctor of Philosophy in Geosciences

All students seeking a Doctor of Philosophy degree in Geosciences must satisfactorily complete the following requirements (90 graduate hours minimum).

- GEOS 5304 (or acceptable equivalent) and GEOS 6205.
- A minimum of five courses (minimum 15 semester hours) in a chosen specialization, related to the student's major area of study, selected from the specialties listed under the Master of Science requirements.
- A minimum of five courses (minimum 15 semester hours) in at least three specialties other than the chosen specialization.

In addition to the above course requirements, students seeking the Ph.D. degree must submit an acceptable research proposal describing the intended project to be completed for the dissertation. Students entering with a Master's should complete this proposal in the third semester; students entering without a Master's have until the fourth semester. An oral qualifying examination covering the broad background and detailed knowledge relating to the student's specialization and research proposal will be held in the same semester that the proposal is submitted. After satisfactory performance on the Qualifying Examination, the student will complete and publicly defend the dissertation.

Also, see the University's general degree requirements. Please note that more detailed instructions for Geosciences Graduate students are given in the "Guideline for Graduate Students - Geosciences" that is available in the office of the Department Head.

Doctor of Philosophy in Geospatial Information Sciences

The Doctor of Philosophy in Geospatial Information Sciences is an advanced degree offered jointly by the School of Natural Sciences and Mathematics, the School of Social Sciences and the Eric Jonsson School of Engineering and Computer Science. Geospatial information is a unifying theme across a wide range of disciplines and the unique organization of this program permits a diverse range of expertise to the prospective student. The Ph. D. in GIS is intended to go beyond the M.S. in GIS degree in terms of analysis, the creation of new technology and the novel application of geospatial

information technology. This program will prepare students for leadership positions in academy, industry or government.
Individual students can concentrate in particular discipline areas. The Geosciences component focuses on remote sensing and mapping technologies, including global positioning satellite and three-dimensional laser ranging based data capture as well as other imaging technologies. In particular, these methodologies are applied to geological, hydrological and environmental problems associated with the physical Earth.
It is expected that students will enter this program with diverse educational backgrounds. Applicants may have Bachelors, Masters or other advanced degrees in any relevant field including computer science, economics, engineering, geography, geology, information system management, resource management, geographical information science and possibly others. At least a Bachelors degree from an accredited (or equivalent) institution with an undergraduate/graduate grade point average of 3.25 or better is required. A GRE score of 1150 or higher is desirable. Fluency in written and spoken English is required. (Please see detailed degree requirements under "Doctor of Philosophy in Geospatial Information Sciences," listed in the School of Social Sciences section of the catalog.)

Geosciences Course Descriptions

General Courses

GEOS 5300 Cooperative Geosciences (3 semester hours) An industrial internship in which a student gains real-world industry experience through temporary employment at a geoscience company or government agency. The activity may be in any area of geosciences, and must have a faculty monitor to receive UTD credit. The topic must be approved in advance by the faculty monitor. The student is required to provide regular updates on progress and a final project report for evaluation. Grading is P/F. Designed as an Individual Instruction Course. May be repeated for credit. (3-0) R
GEOS 5301 Geology of the Metroplex (3 semester hours) Lithologic constituents, stratigraphic history, and geologic environments of the greater Dallas-Fort Worth metropolitan area. Special emphasis is given to the Cretaceous sediments that underlie Tarrant and Dallas Counties, with a secondary focus on the broader geologic environment. Three to four 1-day (Saturday) field trips. (3-0) T
GEOS 5302 Ocean Science (3 semester hours) Overview of geological, chemical, physical and biological aspects of oceanography, marine resources and environmental concerns. This course is for students seeking the M.A.T. degree. This course cannot be used to satisfy degree requirements of geosciences majors. (3-0) R
GEOS 5303 Computing for Geoscientists (3 semester hours) Application of computer techniques in solving geological problems. Includes instruction in the MATLAB ® software, plotting facilities, introductory matrix theory, and statistics. Students will examine problems in basic statistical analysis, graphics, and mapping of geological and geophysical data. Development of programming skills in areas directly related to thesis and dissertation research is encouraged. Serves as introduction to UNIX and the U.T. Dallas computing facility. Laboratory sessions are included. (2-3) Y
GEOS 5304 Geosciences Field Trip (3 semester hours) A study of the geology of a selected region within North America and the Caribbean followed by a field trip to the

selected region in order to study the relationships of geologic features within that region. This course can only be used to partially satisfy the field experience requirement and breadth requirement for geosciences majors. Field trip course. (May be repeated for credit.) (3-0) Y

GEOS 5305 Petroleum Geosciences (3 semester hours) Survey of geological and geophysical methods used to find and produce oil and gas, and to perform economic and risk analyses that are crucial in reserve estimates and prospect evaluation. The course is designed to provide the student with the necessary knowledge to become an effective contributor in the oil and gas industry. Students are expected to have the equivalent of a BS or BA degree in Geosciences. (3-0) R

GEOS 5306 Data Analysis for Geoscientists (3 semester hours) Advanced statistical techniques with important applications in Earth science, beyond the level of GEOS 5303. Topics include robust statistics, exploratory data analysis, surface modeling and contouring, Kriging, analysis of point patterns and directional data. Factor, cluster and time series analysis may also be considered. Emphasis will be on application and theoretical understanding. Prerequisite: GEOS 5303 or equivalent. (3-0) R

GEOS 5307 Well Log Interpretation (3 semester hours) The principles and operational limitations of spontaneous potential (SP), normal (16'' and 64''), lateral microcaliper, resistivity, induction, gamma-ray, neutron, density, sonic, dipmeter, and temperature logs will be discussed. Geologic examples will be used to explain the application of these logging tools. The effects of porosity, permeability, mineral, and fluid content to log response in various types of reservoirs will be developed. (3-0) R

GEOS 5319 Principles of Environmental Health (3 semester hour) Introduction to epidemiology and biostatistics. U.S. regulatory agencies. Ethics, risk assessment and public policy. Diseases spread by food and water. Lung diseases associated with particles and fibers. Health significance of exposures to arsenic, cadmium, chromium, lead and mercury compounds and to chemical substances — solvents, PCBs, PBBs, dioxins, and dibenzofurans. Ionizing radiation. Health implications of global warming (3-0) T

GEOS 5400 Earth Science (4 semester hours) A review of Earth processes as a whole: time and geology; igneous and sedimentary processes and products; metamorphism; structure; evolution of continents and oceans. This course is open only to those students whose major undergraduate study was in subjects other than geology. Laboratory and field trip course. (3-3) R

GEOS 5407 Instrumental Techniques in Geosciences (4 semester hours) An introduction to modern instrumental techniques, including inductively coupled plasma spectrophotometry, scanning electron microscopy, x-ray diffraction, electron microprobe techniques, stable isotope mass spectrometry, and thermal ionization mass spectrometry. Sample preparation, mineral separation, and lab safety. Laboratory course. (2-6) R

GEOS 5V08 Special Topics in Geosciences (1-4 semester hours) Courses dealing with a variety of topics including new techniques and specific problems in rapidly developing areas of the science. Hours vary depending on course requirements. ([1-3]-[0-3]) R

GEOS 5409 M.A.T. Field Trip (4 semester hours) Designed for students in the M.A.T. program to gain relevant field geological experience. (May be repeated for credit.) (4-0) R

GEOS 6205 Geoscience Presentations (2 semester hours) Students prepare oral and written presentations based on literature review or research interests and on critiquing

oral presentations. Required of all Geosciences graduate students. (2-0) S
GEOS 7V00 Research and Literature Seminar (1 or 2 semester hours) Presentations and critical analysis of independent work and of the recent literature. (May be repeated for credit.) ([1-2]-0) Y

Hydrogeology-Environmental Geosciences Courses

GEOS 5310 Hydrogeology (3 semester hours) Introduction to the principles and practice of ground- and surface-water hydrology. Study of the principles of occurrence and geologic controls of groundwater, physical flow, and geochemistry of waters. Design and use of procedures for typical hydrologic investigations. (3-0) Y
GEOS 5311 Applied Groundwater Modeling (3 semester hours) This course is designed to provide students with hands-on experience using the most commonly-applied groundwater flow and transport models (e.g. modflow/modpath, MT3D/RT3D, GMS). Practical application of the models and design of modeling studies is emphasized, modeling theory and mathematics is de-emphasized.(3-0) Y
GEOS 5312 Contaminant Transport (3 semester hours) A study of physical and chemical processes of contaminant transport in ground-and surface-water, and approaches toward observing, monitoring and modeling these processes. Current site remediation practices are also reviewed. Prerequisites: GEOS 5310 or instructor's permission. (3-0) T
GEOS 5313 Applied Surface Water Modeling (3 semester hours) The development and application of watershed models emphasizing runoff, stormflow and stormwater management design. This class combines aspects of GIS, remote sensing and surface water hydrology from an applied modeling perspective, using commonly applied computer models (e.g. Rational Method, TR-20, HEC-1) to address drainage problems related to urbanization and land-use changes. (3-0) T
GEOS 7110 Workshop in Environmental Geosciences (1 semester hour) Discussion of current topics in environmental geoscience, including student and faculty research, scientific literature, and advanced techniques in environmental geosciences. (1-0) R
GEOS 8V10 Research in Hydrogeology-Environmental Geosciences (1-9 semester hours) May repeat for credit. ([1-9]-0) S

Remote Sensing, GIS, and GPS Courses

GEOS 5325 Introduction to Remote Sensing (3 semester hours) Application of airborne and satellite remote sensing for understanding the surface of the earth. Focus on interpretation of images obtained by passive and active imaging systems using electromagnetic radiation, especially visible, infra-red, and radar. Laboratory course. (2-3) T
GEOS 5326 (GISC 7365) Remote Sensing Digital Image Processing (3 semester hours) Techniques of digital image processing for a variety of remote sensing data sets and their applications for environmental and geoscientific issues. Extraction of statistical data from remote sensing imagery, radiometric and geometric correction, image enhancement and classification, and techniques for utilizing digital remote sensing data for change detection of the earth's surface. Use of different image processing software to

manipulate digital remote sensing data and extract thematic information. Introduction to Remote Sensing (GEOS 5325) is a prerequisite for this course. Laboratory course. (2-3) T

GEOS 5328 Radar Remote Sensing (3 semester hours) Principles and applications of orbital and airborne radar remote sensing, including real and synthetic aperture radar systems. Principles of Radargrammetry, and single-path and repeat-path interferometry. Applications of radar remote sensing in geosciences, land use and land cover mapping, forestry and agriculture, urban analysis. Laboratory course. Prerequisite: Principles of Remote Sensing (GEOS 5325) (2-3) T

GEOS 5329 (GISC 7366) Applied Remote Sensing (3 semester hours) Methods for using optical and radar remote sensing data and techniques for study of issues related to physical and social sciences, including geological, environmental, and geomorphological studies, forestry, agriculture, and issues related to urban development and planning. Use of a variety of remote sensing data and software to address societal and scientific problems. Laboratory course. Prerequisite: Principles of Remote Sensing (GEOS 5325). (2-3) T

GEOS 5422 GPS (Global Positioning System) Satellite Surveying Techniques (4 semester hours) The theory and application of satellite positioning utilizing the Global Positioning System Code and phase methodology in field observations, data processing and analysis of Differential GPS, high accuracy static and other rapid measurements, in real time and with post-processing. (3-3) Y

GEOS 5423 GIS (Geographic Information Systems) Applications to Geosciences (4 semester hours) The application of GIS to geologic, geophysical and environmental problems. Emphasis on hands-on digital geologic mapping and analysis with Arc/Info software package. Laboratory course. (3-3) T

GEOS 5324 3D Data Capture and Ground Lidar (3 semester hours) The theory and applications of 3D data acquisition in the field for geosciences and non-geosciences studies. The basics and applications of field digital mapping with emphasis on RTK GPS, laser range finder, and terrestrial scanners (ground lidar). 3D digital photorealistic modeling with field photogrammetry and digital cameras. (3-3) T

GEOS 7327 (GISC 7367) Remote Sensing Workshop (3 semester hours) An independent project designed and conducted by the student. The project develops and demonstrates student's competence in using remote sensing techniques in a substantive application to his/her field of interest. Projects may be developed in coordination with a local government, utility, business or other entity which uses remote sensing in operations and research. Formal presentation and a project report are required. Prerequisites: GISC 6381 and GISC 7365(3-0) Y

GEOS 8V21 Research in Remote Sensing, GIS and GPS (1-9 semester hours) May repeat for credit. ([1-9]-0) S

Sedimentology Courses

GEOS 5347 Sequence Stratigraphy (3 semester hours) Origin of stratigraphic sequences and systems tracts, especially tectonic versus eustatic controls. Topics include lithostratigraphy, seismic stratigraphy, chronostratigraphy, and allostratigraphy, with an emphasis on high resolution subsurface sequence stratigraphic methods. Prerequisite:

GEOS 3421 or equivalent. (3-0) Y

GEOS 5441 Stratigraphy and Sedimentology (4 semester hours) Origin and classification of sedimentary rocks, reconstruction of ancient environments, and basic principles of modern stratigraphic nomenclature. Concepts of space and time in the rock record and methods of stratigraphic correlation. Integrated stratigraphic techniques. Study of sedimentary rocks in hand specimen and outcrop. Laboratory course. Field trips. Course is directed to graduate students not majoring in geology and is meant to provide a practical overview of sedimentary geology. Permission of instructor is required to take this course. (3-3) Y

GEOS 5443 Carbonate Sedimentary Environments (4 semester hours) Description and classification of carbonate sediments and carbonate rocks. Aspects of carbonate geochemistry will be covered. The course will emphasize recent carbonate depositional environments and facies models for use as analogs for interpreting ancient sequences. Laboratory will stress identification and classification of carbonate sediments and rocks in hand sample and thin-section. Laboratory and field trip course. Prerequisite: GEOS 3421. (3-3) T or R

Geochemistry Courses

GEOS 5352 Geochemistry of Igneous Rocks (3 semester hours) Chemical composition of igneous rocks and the major processes that control the distribution of the elements in silicate melts. Topics to be covered include the composition of the earth, the structure of silicate melts, trace element partitioning between crystals and melts, and the use of major and trace elements in deciphering the formation and evolution of silicate melts. (3-0) T

GEOS 5355 Low Temperature Geochemistry (3 semester hours) Low-temperature geochemistry including sedimentary systems, weathering, and aqueous geochemistry. Course will include discussion of thermodynamics of aqueous reactions, elemental speciation, activity diagrams, the carbonate system, water-rock reactions and stable isotopes. Lab work will include hands-on use of inductively-coupled plasma instrumentation and use of computer aqueous speciation/modeling software (The Geochemists Workbench, PHREEQC). Prerequisites: One year of chemistry (CHEM 1311 and 1312) or instructor's permission. (2-3) R

GEOS 5356 Isotope Geochemistry (3 semester hours) Synthesis of the elements in stars and chronologies for the galaxy. Isotope systematics in meteorites, abundance anomalies, cosmogenic nuclides, and solar system chronologies. The development of the modern multi-collector mass spectrometer. Mass fractionation laws, double spiking techniques, and high precision isotope ratio measurements. Isotope geochemistry of noble gases and radiogenic nuclides as pertaining to the composition and history of the mantle and crust. Application of stable isotopes to studies of diagenesis and water-rock interaction, groundwater management, paleoceanography and secular variations in the isotopic composition of seawater. High-temperature and, where applicable, low-temperature water-rock interactions pertaining to the origin of igneous rocks. The evolution of radiogenic Sr in sea water. Radiometric age dating as applied to the solution of geologic problems. (3-0) R

GEOS 5359 Aqueous Geochemistry Modeling (3 semester hours). Quantitative modeling of water-water and water-rock chemical interactions using standard computer

programs (e.g. PHREEQC, NETPATH, The Geochemists Workbench). Modeling of isotopic indicators of water-rock interaction and hydrologic processes; surface water chemistry. Prerequisites: One year of chemistry or instructor's permission. (3-0) T
GEOS 5361 Low Temperature Isotopic Tracers (3 semester hours) Stable isotopes in low temperature systems. Oxygen, hydrogen, carbon, sulfur and nitrogen isotopes in aqueous systems. Isotopic fractionation. Stable isotopes in marine sediments. New areas of isotopic research including Li, B, Se, and Sr isotopes in aqueous and sedimentary environments. Prerequisites: One year of chemistry or instructor's permission (3-0) T
GEOS 6455 Geochemical Exploration (4 semester hours) Origin, movement, and fate of elements in the natural environments. Geochemical methods in mineral and petroleum exploration including analytical techniques and studies of weathering, soil formation, primary and secondary dispersion patterns and anomalies. Case studies including environmental applications. Laboratory and field trip course. (3-3) T
GEOS 8V50 Research in Geochemistry (1-9 semester hours) (May repeat for credit.) ([1-9]-0) S

Mineral Resources-Petrology Courses

GEOS 5462 Rocks and Minerals (4 semester hours) Crystallography; identification of common rocks and minerals; origins and occurrences of rocks and minerals. Laboratory course. This course cannot be used to satisfy degree requirements for geosciences majors. (2-6) R
GEOS 5464 Mineral Resources (4 semester hours) Principles and relationships of economics and politics to the utilization of mineral and industrial deposits; ore mineralogy; classification of commercial Earth materials; geochemical cycle of various elements; geology, distribution, characteristics, formation, enrichment and localization of various economic mineral and industrial deposits. Relationship of mineral and industrial deposits to global tectonics. Laboratory and field trip course. (3-3) T
GEOS 5465 Ore Petrology (4 semester hours) Essentials of reflected light microscopy; mineralogy, textural relationships, paragenesis, phase chemistry, and origin of major ore minerals; detailed study of selected ore bodies. Laboratory course. Prerequisite: GEOS 5464 or consent of instructor. (2-6) T
GEOS 6462 Hydrothermal Ore Deposits (4 semester hours) Physical, chemical, and isotopic characteristics of hydrothermal ore deposits and enclosing rocks; properties of ore-forming solutions; solubilities of ore and non-ore minerals; characteristics of geothermal systems; mass transfer; isotopes; and thermal aspects of ore deposition. Laboratory and field trip course. Prerequisite: GEOS 5465 or consent of instructor. (3-3) T
GEOS 8V60 Research in Petrology (1-9 semester hours) (May repeat for credit.) ([1-9]-0) S

Structural Geology-Tectonics Courses

GEOS 5373 Physical Properties of Rocks (3 semester hours) This course provides an understanding of the physical phenomena and processes that determine properties of rocks and soils. Topics include porosity and permeability; surface energy, roughness, and

absorption; percolation, fractures and heterogeneous media; problems of scale; mechanical behavior of dry and fluid saturated rocks; elasticity; viscoelasticity, and plasticity; acoustic, electric, dielectric, thermal, and magnetic properties. The approach is practical, with emphasis on understanding why rocks behave as they do, and how simple physical principles can be used to predict rock and soil properties under various conditions. Suitable for graduate students in any branch of geosciences who wish to obtain a broad introduction to physical properties as they pertain to lab and field measurements, and are applied to reservoir, engineering, and environmental problems. (3-0) R

GEOS 5375 Tectonics (3 semester hours) Study of the earth's present tectonic environments, including geochemistry, sedimentology, and structure; application of present tectonic environments towards the reconstruction of ancient crustal events; consideration of temporal aspects of crustal evolution. Oral and written presentations required. Prerequisite: GEOS 3470 (Structural geology). (3-0) T

GEOS 5470 Structural Geology (4 semester hours) Examination of stress and strain, failure criteria, fault analysis, rheologic properties of geologic materials, fold analysis, and a survey of major structural provinces in North America, with supplemental readings. Laboratory includes map interpretation, standard graphical techniques, and use of stereographic projections, oral presentations, and problem sets. Laboratory and field trip course. Prerequisite: PHYS 1301 or equivalent. (3-3) Y

GEOS 6476 Analysis of Geologic Structures (4 semester hours) Study of strain analysis and the origin of tectonic fabrics, including use of stereonet and petrographic microscope to outline deformational and metamorphic history. Laboratory and field trip course. Prerequisite: GEOS 3470 (Structural geology and petrology), with GEOS 3421 (sedimentology) and MATH 2418 (linear algebra) recommended. (3-3) R

GEOS 7170 Workshop in Structure/Tectonics (1 semester hour) Presentation and discussion of current research with emphasis on problems, techniques, and recent literature. (May be repeated for credit.) (1-0) Y

GEOS 8V70 Research in Structural Geology-Tectonics (1-9 semester hours) May be repeated for credit. ([1-9]-0) S

General Geophysics Courses

GEOS 5380 Seismic Interpretation (3 semester hours) Seismic reflection profiling as it is used to map the distribution of sedimentary layers and faults in the subsurface. Special emphasis is given to applications in hydrocarbon exploration. Extensive use is made of software processing packages. (3-0) T

GEOS 5389 Exploration Gravity (3 semester hours) The gravity method is studied in detail with regard to its application to exploration for hydrocarbons, minerals, geothermal sources, groundwater, and geotechnical studies, including surveying, processing, analysis, and modeling of gravity data. Prerequisite: Consent of instructor.(3-0) T

GEOS 5481 Digital Geophysical Signal Processing (4 semester hours) Principles of the analysis of geophysical signals in both time and space. Includes integral transforms, spectral analysis, linear filter theory and deconvolution techniques. Computer applications are emphasized. Laboratory course. Prerequisite: GEOS 5303 or equivalent, may be taken concurrently. (3-3) R

GEOS 5483 Geophysical Techniques I (4 semester hours) Part one of a two-part course on the theoretical basis and practical aspects of geophysical data collection, processing and interpretation. The planning and execution of small scale surveys, of the type employed in engineering, groundwater and environmental site evaluations, is featured. Techniques include conventional and satellite (Global Positioning System) positioning and the potential field geophysical methods, including gravity, magnetic, and electric (resistivity and electromagnetic). The integrated interpretation of different data types is emphasized. A background in calculus (MATH 2417) and general physics (PHYS 1301) is required. (3-3) T

GEOS 5484 Geophysical Techniques II (4 semester hours) Part two of a two-part course on the theoretical and practical aspects of geophysical data collection. The planning and execution of small scale surveys, of the type employed in engineering, groundwater and environmental site evaluations, is featured. Techniques covered include both refraction and reflection seismology and both low and high frequency, single and multi-channel ground-penetrating radar. Advantage is taken of both the similarities and complimentary behaviors of seismic and radar waves. An integration, of both seismic and radar data, as well as data from the methods covered in Geophysical Techniques I (GEOS 5483), is emphasized in interpretation. A background in calculus (MATH 2417) and general physics (PHYS 1301) is required. Permission of instructor is required. (3-3) T

GEOS 6382 Geophysical Inversion Theory (3 semester hours) Theoretical and practical aspects of fitting mathematical models to data in geophysics. Topics covered include the inversion of both discrete systems and integral equations, for linear and non-linear relationships between data and parameters. Particular attention is paid to assessment of model accuracy and uniqueness. Prerequisites: Advanced calculus and linear algebra or equivalent. (3-0) R

GEOS 8V80 Research in Geophysics (1-9 semester hours) May be repeated for credit. ([1-9]-0) S

Seismology Courses

GEOS 5392 Foundations of Seismology (3 semester hours) Introduction to the theory and mathematical methods of seismology. Tensor analysis of elasticity, and wave equation in terms of rays, waves and modal vibrations are covered. Analytical solutions of the elastic wave equation for layered media will be studied by a variety of methods. (3-0) R

GEOS 6391 Earthquake Seismology (3 semester hours) Near and far field representations of earthquake sources, engineering (strong motion) seismology, characteristics and interpretation of earthquake phases, use of earthquakes in determining Earth structure, risk and prediction, instrumentation. Includes a case study of a recent large earthquake. (3-0) R

GEOS 6392 Reflection Seismology (3 semester hours) Theoretical and practical aspects of seismic reflection data acquisition and processing. Includes the wave equation, the convolutional model, coded sources, the array response, velocity estimation, statics, filtering, pre- and post-stack migration, and direct and indirect detection of hydrocarbons, VSPs, AVO and 3-D processing. Prerequisites: GEOS 5481, and GEOS 5392 or equivalent. (3-0) R

GEOS 6393 Computational Seismology (3 semester hours) Principles of parallel computing with applications to seismology. Includes overviews of Intel and Sun E6000 architectures, writing and debugging parallel code, characterization of machine performance, fast Fourier transforms, Radon transforms, solution of matrix and wave equations. Laboratory course. Prerequisites: GEOS5303, GEOS5481, and any numerical analysis course. (2-3) R

GEOS 6395 Seismic Modeling (3 semester hours) Theory and application of the major techniques for computation of synthetic seismograms. Topics include asymptotic ray theory, spectral and slowness methods, finite differences, finite elements, Kirchhoff, and boundary integral methods. Readings will be drawn from the literature. Prerequisite: GEOS 5392 and any two graduate seismology courses. (3-0) R

GEOS 6396 Seismic Inversion (3 semester hours) Theory and application of the major techniques for inversion of seismic data. Topics include linear and nonlinear matrix methods, Wiechert-Herglotz integration, extremal inversion, migration, wavefield imaging of body and surface waves, and tomography, imaging of VSPs, and Born inversion. Readings will be drawn from the literature. Prerequisite: Any two graduate seismology courses. (3-0) R

GEOS 7190 Workshop in Seismology (1 semester hour) Informal presentation and discussion of current research of graduate students and faculty, of new computing equipment and software, and of current research literature. (Pass/Fail grading only. May be repeated for credit.) (1-0) S

GEOS 8V90 Research in Seismology (1-9 semester hours) May repeat for credit. ([1-9]-0) S

Thesis And Dissertation Courses

GEOS 8398 Thesis (3 semester hours) May repeat for credit. (3-0) S

GEOS 8399 Dissertation (3 semester hours) May repeat for credit. (3-0) S