

# Geosciences (GEOS)

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Department of Geosciences Website (<http://fulbright.uark.edu/departments/geosciences>)

## Degrees Conferred:

M.S. in Geography (GEOG)  
 M.S. in Geology (GEOL)  
 Ph.D. in Geosciences (GEOS)

## Graduate Certificates Offered (non-degree):

Geospatial Technologies (GIST)

## Geography (GEOG) (M.S.)

**Areas of Study:** Human geography, physical geography, GIS, cartography, space and planetary sciences.

**Program Description:** The Department of Geosciences offers a Master of Science (M.S.) degree in geography. This program draws on a variety of faculty expertise in physical, environmental, human, and regional studies in geography as well as in cartography, remote sensing, photogrammetry, and computational aspects of geographic information science (GIS) or geoinformatics.

## Geology (GEOL) (M.S.)

**Areas of Study:** General geology, space and planetary sciences

**Program Description:** Instruction in geology at the graduate level focuses on preparation of students to become practicing professional geologists in industry or to pursue, without deficiencies, doctorates at established programs. Students intending to enter the industrial workforce are encouraged to maintain a broad perspective with an emphasis in an area of geology that has a demonstrated record of past employment, such as petroleum geology or environmental geology. The greatest strength of the program in geology at the University of Arkansas is instruction in practical geologic interpretation, with emphasis on field relationships. This instructional strength includes all levels of teaching and supports an active research program that serves to strengthen the research and

communication skills of the students through writing assignments, oral presentations, and participation in professional societies.

## Geosciences (GEOS) (Ph.D.)

### Primary Areas of Faculty Research:

1. Basin evolution and analysis (including multiple aspects of petroleum geology that incorporate sedimentation, structural geology, stratigraphy and geophysics),
2. Crustal and mantle composition and tectonic evolution,
3. Neotectonics and dynamic geomorphology,
4. Geoinformatics (including GIS, remote sensing, GPS geodesy, and geospatial analysis),
5. Groundwater dynamics, karst hydrology and limnology, and
6. Paleoclimatology.

The Department of Geosciences focuses on research and education dealing with the nature, genesis, and history of the Earth and the global environment, the evolution of landscapes and biota at the Earth's surface, and the advance of geospatial technologies. The Doctor of Philosophy degree is designed for students who are committed to scholarship in the geosciences and who wish to prepare for professional employment within the academic community, industry, or government. Geosciences research requires rigorous observation, quantitative analysis, and modeling in order to yield scientific results that are acceptable for publication in first-rate, internationally-ranked journals. Given the interdisciplinary nature of Geosciences, the Department of Geosciences encourages research including elements of space and planetary sciences, biological sciences, environmental sciences, physics and chemistry to address relevant problems at the boundaries of geoscience and other disciplines.

Applicants for the doctoral program must have completed the baccalaureate degree with a major in geosciences or an allied discipline. Students with academic preparation at the undergraduate or masters level in other disciplines of physical science, engineering, and mathematics are also encouraged to apply. All applicants must submit their scores on the Graduate Record Examination directly to the University of Arkansas Graduate School, provide three letters of recommendation from individuals qualified to assess the applicant's academic potential, a personal curriculum vita, and a statement of academic and research interests.

Qualified students with a bachelor's degree or a master's degree may be accepted into the Ph.D. program. Academic requirements for admission to the program are listed in the table below. In addition, prospective applicants are encouraged to contact Department of Geosciences faculty with similar research interests to initiate dialogue regarding availability for mentoring, potential research topics, and research funding opportunities.

## M.S. in Geography

**Admissions to Degree Program:** Applicants must be admitted to the Graduate School and meet the following requirements: 1) satisfactory undergraduate preparation in geography, 2) three letters from persons competent to judge the applicant's potential for graduate studies, 3) satisfactory GRE scores, and 4) adequate mathematical preparation at the undergraduate level, including statistics, algebra, and/or calculus.

Students who do not meet these requirements may be admitted conditionally. Students with course deficiencies may enroll concurrently in graduate courses. Students speaking English as a foreign language are encouraged to take the TOEFL with results reported to the department.

**Degree Requirements:** Requires a total of 30 semester hours. A minimum of 24 semester hours of course work (including a 7-hour core and 6 hours of quantitative or computational electives as approved by the master's advisory committee), six semester hours of thesis, and a comprehensive examination (defense of thesis) conducted by the candidate's thesis committee are required for all students who obtain an MS in Geography.

#### Core

GEOS 5093	History and Philosophy of Geography	3
GEOS 5333	Research Methods and Materials in Geography (This should now be GEOS 5612 Research Methods in Geosciences which is on the last step of the workflow (PeopleSoft))	3
GEOS 5011	Colloquium	1
<b>Quantitative and Computational Electives</b>		6
Courses as approved by the student's MS Geography master's advisory committee.		
GEOS 600V	Master's Thesis	6

Students should also be aware of Graduate School requirements with regard to master's degrees (<http://catalog.uark.edu/graduatecatalog/degreerequirements/#mastersdegreestext>).

### M.S. in Geology

**Admission to Degree Program:** Students admitted to graduate study should have completed an undergraduate geology program similar to that required for the B.S. degree at the University of Arkansas. Applicants lacking an appropriate background may satisfy deficiencies while enrolled in Graduate School. Prospective students should submit application forms, three letters of recommendation, and a statement of their graduate and professional goals before February 15 for the fall semester and October 15 for the spring semester to assure their consideration. These dates are also deadlines for receipt of application for financial assistance.

**Requirements for the Master of Science Degree:** The program in Geology requires 30 graduate course credit hours, six of which will be derived from a thesis reporting the results of an original laboratory or field research problem. All course work, a thesis topic, and the final thesis must be approved by the student's thesis committee. This committee is selected by the student and the student's thesis director and will consist of a minimum of three members. At least two of the committee members will be chosen from geology faculty whose areas of expertise coincide with the research interests of the student.

Each student will complete a core curriculum consisting of a minimum of 12 hours selected from the following courses:

Select four of the following:		12
GEOS 5253	Geomorphology (formerly GEOS 4053)	
GEOS 5273	Principles of Geochemistry (formerly GEOS 4063) or GEOS 5853 Environmental Isotope Geochemistry	
GEOS 5433	Geophysics (formerly GEOS 4433)	
GEOS 5123	Stratigraphic Principles and Practice	
GEOS 5223	Sedimentary Petrology	

Each student must complete a minimum of 18 credit hours in geology courses, including one credit hour of GEOS 5011 Colloquium, in addition to the six credit hours for the thesis.

Students who have completed some or all of these core courses as part of their undergraduate program must substitute additional elective courses, as approved by their thesis committee, to fulfill the minimum required 24 credit hours of course work.

To complete the requirements for the degree, the candidate must complete all course work with a grade-point average of 3.00, submit an acceptable thesis, and pass a comprehensive examination based primarily on a defense of the student's thesis.

Students should also be aware of Graduate School requirements with regard to master's degrees (<http://catalog.uark.edu/graduatecatalog/degreerequirements/#mastersdegreestext>).

### Ph.D. in Geosciences

#### Requirements for Admission to the Doctor of Philosophy Degree in Geosciences:

- Minimum Undergraduate GPA: 2.85 on a 4.0 system
- Minimum Graduate GPA: 3.20 on a 4.0 system
- Minimum GRE Verbal: 153
- Minimum GRE Quantitative: 144
- Minimum GRE combined Verbal and Quantitative: 297
- Minimum GRE writing: 4
- International students only: a minimum score of 6.5 on the International English Language Testing System (IELTS), 79 on the Internet-based Test of English as a Foreign Language (TOEFL), or a 58 on the Pearson Test of English - Academic (PTE-A), taken within the preceding two years
- M.S./M.A. requirements: 24 units graduate courses, 6 hours thesis
- Recommendations: Three (3) letters of recommendation from individuals qualified to assess the applicant's academic potential
- Ph.D. course requirements: 24 units graduate courses; 18 hours dissertation; completed original dissertation research.
- No course with a grade of less than a C (graduate or undergraduate) will be accepted as fulfilling prerequisites.
- Acceptance by an adviser
- Other: Current Curriculum Vita; Statement of academic and research interests
- Submit application by Jan. 15 deadline for fall semester to assure consideration

#### Course Requirements for the Doctor of Philosophy Degree:

- 24 course hours beyond the U of A M.S./M.A. degree or equivalent.
- GEOS 5023 Technical and Proposal Writing for the Geosciences
- It is strongly recommended that two courses be taken outside of the department that are supplementary to the student's interests and dissertation topic. These may be 3000-level undergraduate courses, if approved by the Advisory Committee and the Graduate School.
- No more than 3 hours of Special Problems or Independent Research
- Dissertation – 18 hours to be taken after admission to candidacy.

**Candidacy Exams:** The comprehensive examinations consist of two rigorous examinations:

1. A written comprehensive examination and
2. An oral defense of the dissertation proposal.

Students will take a comprehensive examination after they have completed the Graduate School residency requirement and have

completed the required departmental core courses. The exam will be taken during the fall or spring semester when classes are in session, but not during final exams. At the time of the exam, the student must have a grade point average of 3.25 on 12 or more hours of course work taken beyond the master's degree. This exam must be taken at least one year prior to completing all requirements for the degree.

The second written work to be assessed by the Comprehensive Examination Committee will be a research proposal composed by the student in the format typical of a National Science Foundation grant proposal. It is expected that the document will conform to all proposal formatting described in the Department of Geosciences Graduate Student Handbook requirements.

**Oral Dissertation Proposal:** Upon admission to candidacy (passing the written comprehensive exam), the student will present to his/her Dissertation Committee a written and oral proposal of the dissertation topic for comment, suggestions, and approval. The dissertation adviser will chair the committee, unless prohibited by Graduate School conflict of interest rules.

Successful completion of the proposal defense requires the positive vote of the committee. Normally this proposal will be completed by the third or fourth semester after matriculation and can only be delayed with the approval of the dissertation committee and the appropriate departmental Graduate Adviser.

Any waivers to these requirements must be appealed to the Advisory or Dissertation committee and the departmental Graduate Adviser.

Students should also be aware of Graduate School requirements with regard to doctoral degrees ([http://catalog.uark.edu/graduatecatalog/degree\\_requirements/#phdandeddgreestext](http://catalog.uark.edu/graduatecatalog/degree_requirements/#phdandeddgreestext)).

The student must maintain a 3.0 GPA in course work taken for the Ph.D. degree.

The Doctor of Philosophy degree is primarily a research degree, but communication of that research is critical for professional development and required for most professional pursuits. To promote development of the communication skills, each student is required to teach labs and/or a course for at least one semester and to present scientific results at one or more national or international professional meetings.

## Graduate Certificate in Geospatial Technologies

The Department of Geosciences offers an online Geospatial Technologies Graduate Certificate through University of Arkansas Global Campus (<http://globalcampus.uark.edu/>). This certificate is designed for working professionals who wish to develop technical skills in the emerging field of geospatial technologies. The certificate provides the technical instruction needed to be employed in the geosciences and collateral disciplines as one of the American Society of Photogrammetry and Remote Sensing's "Mapping Scientist" and as a "Certified Geographic Information Systems Professional" (GISP).

### Requirements for a Geospatial Technologies Graduate Certificate

Requirements for admission: Graduate status; there are no disciplinary requirements.

A total of 12-18 hours are required for the certificate:

GEOS 5043	Foundations of Geospatial Data Analysis	3
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GEOS 5073	Geospatial Technologies Computational Toolkit	3
GEOS 5083	Geospatial Data Mining	3
GEOS 5543	Geospatial Applications and Information Science	3
GEOS 5553	Spatial Analysis Using ArcGIS	3
GEOS 5593	Introduction to Geodatabases	3

It is possible to waive 3 to 6 hours of required coursework for GEOS 5043 and GEOS 5073 through successful completion of proficiency exams.

## Graduate Faculty

**Aly, Mohamed H.**, Ph.D. (Texas A&M), M.S., B.S. (Zagazig University), Assistant Professor, 2013.

**Boss, Steve K.**, Ph.D. (University of North Carolina at Chapel Hill), M.S. (Utah State University), B.S. (Bemidji State University), Professor, 1996.

**Cothren, Jackson David**, Ph.D., M.S. (The Ohio State University), B.S. (United States Air Force Academy), Associate Professor, 2002.

**Covington, Matthew D.**, Ph.D. (University of California-Santa Cruz), B.S. (University of Arkansas), Assistant Professor, 2012.

**Davidson, Fiona M.**, Ph.D., M.A. (University of Nebraska-Lincoln), B.A. (Newcastle Upon Tyne Polytechnic), Associate Professor, 1992.

**Davis, Ralph K.**, Ph.D., M.S., B.S. (University of Nebraska, Lincoln), Professor, 1994.

**Dumond, Gregory**, Ph.D. (University of Massachusetts), M.S. (Texas Tech University), B.S. (University of Texas El Paso), Assistant Professor, 2010.

**Feng, Song**, Ph.D., M.S. (Chinese Academy of Sciences), B.S. (Yunnan University), Assistant Professor, 2013.

**Hays, Phil**, Ph.D., M.S. (Texas A&M University), B.S. (University of Arkansas), Associate Professor, 2000.

**Holland, Edward C.**, Ph.D., M.A. (University of Colorado, Boulder), B.A. (Princeton University), Assistant Professor, 2016.

**Limp, Fred**, Ph.D., M.A., B.A. (Indiana University at Bloomington), University Professor, 1979.

**Liner, Christopher L.**, Ph.D. (Colorado School of Mines), M.S. (University of Tulsa), B.S. (University of Arkansas), Professor, 2012.

**Paradise, Thomas R.**, Ph.D. (Arizona State University), M.A. (Georgia State University), F.G.A., G.G. (Gemological Institute of America), B.S. (University of Nevada), University Professor, 2000.

**Potra, Adriana**, Ph.D. (Florida International University), M.S., B.S. (University of Babes-Bolyai, Romania), Assistant Professor, 2012.

**Shaw, John B.**, Ph.D. (University of Texas at Austin), B.A. (Oberlin College), Assistant Professor, 2014.

**Shi, Xuan**, Ph.D. (West Virginia University), M.S. (Indiana University of Pennsylvania), B.S. (Hubei University), Assistant Professor, 2012.

**Stahle, David William**, Ph.D. (Arizona State University), M.A. (University of Arkansas), B.A. (University of Arizona), Distinguished Professor, 1982.

**Suarez, Celina A.**, Ph.D. (University of Kansas), M.S. (Temple University), B.S. (Trinity University), Assistant Professor, 2012.

**Tullis, Jason A.**, Ph.D., M.S. (University of South Carolina at Columbia), B.S. (Brigham Young University), Associate Professor, 2004.

## Courses

### GEOS 5003. Seminar in Geography. 3 Hours.

Selected topics, the nature of which varies with the need. Prerequisite: Graduate standing. May be repeated for up to 3 hours of degree credit.

### GEOS 5011. Colloquium. 1 Hour.

Weekly meetings of faculty, graduates, advanced students and guests to discuss research and trends in the field of geography. May be repeated for up to 2 hours of degree credit.

**GEOS 5023. Technical and Proposal Writing for the Geosciences. 3 Hours.**

Preparation of technical reports, research proposals, and manuscripts for publication in the area of geosciences.

**GEOS 5033. Advanced Vector Geographic Information Systems. 3 Hours.**

Advanced vector operations and analysis. Topics will include topological analysis, network analysis, geocoding, conflation, implications of source and product map scale, map generation, error mapping, and cartographic production. Prerequisite: ((ANTH 4563 or ANTH 5563 (formerly ANTH 4563)) or ((GEOS 4583 or GEOS 5583 (formerly GEOS 4583)) or equivalent.

This course is cross-listed with ANTH 5043.

**GEOS 5043. Foundations of Geospatial Data Analysis. 3 Hours.**

Basic mathematical tools applied in geospatial technology, including trigonometry in mapping, linear algebra in remote sensing, optimization in spatial decision support, and graph theory in routing. Course develops the framework for spatial data analysis and decision support. Pre- or Corequisite: GEOS 5543.

**GEOS 5053. Quaternary Environments. 3 Hours.**

An interdisciplinary study of the Quaternary Period, including dating methods, deposits, soils, climates, tectonics, and human adaptation. Lecture 2 hours, laboratory 2 hours per week. Prerequisite: Graduate standing.

This course is cross-listed with ANTH 5053, ENDY 5053.

**GEOS 5073. Geospatial Technologies Computational Toolkit. 3 Hours.**

Basic computational tools and processes applied in geospatial software, related computer hardware components, systems and applications software, and spatial database fundamentals. Python, including SciPy and NumPy, geospatial implementations will be emphasized. No programming experience is required. Pre- or Corequisite: GEOS 5543.

**GEOS 5083. Geospatial Data Mining. 3 Hours.**

Basic tools for analyzing, summarizing and visualizing geospatial data. Exploratory data and spatial data analysis, probability distributions and application, single and multivariate analysis and hypothesis testing, and spatial smoothing and interpolation. Emphasis will be on problem solving in geospatial settings using the R statistical language. Prerequisite: GEOS 5043 and GEOS 5073 or equivalent.

**GEOS 5093. History and Philosophy of Geography. 3 Hours.**

This course familiarizes students with the history of geography, the contributions of geographers to scientific thought and theory, and research techniques that are used in geography. Emphasis is given to the integration of statistical and spatial analysis, and their applications in field research. The course includes short field-based projects in and around Northwest Arkansas.

**GEOS 510V. Special Problems in Physical Geosciences. 1-6 Hour.**

Special problems in Geosciences. Prerequisite: Graduate standing. May be repeated for up to 6 hours of degree credit.

**GEOS 5113. Global Change. 3 Hours.**

Examines central issues of global change including natural and human induced climate change, air pollution, deforestation, desertification, wetland loss urbanization, and the biodiversity crisis. The U.S. Global Change Research Program is also examined.

This course is cross-listed with ENDY 5113.

**GEOS 5123. Stratigraphic Principles and Practice. 3 Hours.**

Physical and biological characteristics of sedimentary environments and their correlation in time with emphasis on the local geologic section. Corequisite: Lab component. Prerequisite: GEOS 4223 or GEOS 5323 (formerly GEOS 4223).

**GEOS 5133. Radar Remote Sensing. 3 Hours.**

Introduction to radar remote sensing and its applications in geology, geography, archeology, engineering, and agriculture. Focuses on Synthetic Aperture Radar (SAR) and advanced techniques including radar stereo, polarimetry, and interferometry. Covers Interferometric SAR (InSAR) for mapping topography and modeling Earth's surface motions due to earthquakes, volcanic eruptions, landslides, and subsidence. Prerequisite: GEOS 3023 or equivalent.

**GEOS 5143. 3D Seismic Exploration. 3 Hours.**

(Formerly GEOS 4463.) Interpretation of 3D seismic data for geological structure, stratigraphy, and pore fluid variations with emphasis on hydrocarbon exploration. Credit will not be given for both GEOS 4463 and GEOS 5143. Prerequisite: GEOS 4433 or GEOS 5433 (formerly GEOS 4433).

**GEOS 5153. Environmental Site Assessment. 3 Hours.**

Principles, problems, and methods related to conducting an environmental site assessment. An applied course covering field site assessment, regulatory documentation, and report preparation. Prerequisite: GEOS 4033 or GEOS 5263 (formerly GEOS 4033).

This course is cross-listed with ENDY 5153.

**GEOS 5163. Hydrogeologic Modeling. 3 Hours.**

Topics include numerical simulation of ground water flow, solute transport, aqueous geochemistry, theoretical development of equations, hypothesis testing of conceptual models, limitations of specific methods, and error analysis. Emphasis on practical applications and problem solving. Prerequisite: GEOS 4033 or GEOS 5263 (formerly GEOS 4033) and computer literacy.

**GEOS 5173. Urban Geography. 3 Hours.**

(Formerly GEOS 4073.) Areal patterns of modern urban regions and the focus shaping these patterns. Emphasis is placed on American urban areas and their evolution and functional areas. Field work. Graduate degree credit will not be given for both GEOS 4073 and GEOS 5173.

**GEOS 5183. Geography of the Middle East. 3 Hours.**

(Formerly GEOS 4043.) Physical and cultural landscapes, natural and cultural resources, art and architecture, land use, political history, OPEC, and current problems of North Africa and the Middle East region west of Afghanistan are discussed. Class participation, discussions, slides and films, and student presentations will round out the class. Graduate degree credit will not be given for both GEOS 4043 and GEOS 5183.

**GEOS 5196. Advanced Field Methods of Applied Hydrogeology. 6 Hours.**

Applied field course emphasizing collection and interpretation of ground water data. Three hours may be applied toward an M.S. degree in geology. Prerequisite: GEOS 4033 or GEOS 5263 (formerly GEOS 4033).

**GEOS 520V. Special Problems in Human Geography. 1-6 Hour.**

Special problems in human geography. Prerequisite: Graduate standing. May be repeated for up to 6 hours of degree credit.

**GEOS 5213. Principles of Remote Sensing. 3 Hours.**

Fundamental concepts of remote sensing of the environment. Optical, infrared, microwave, LIDAR, and in situ sensor systems are introduced. Remote sensing of vegetation, water, urban landscapes, soils, minerals, and geomorphology is discussed. The course includes laboratory exercises in GIS software and field spectroscopy.

**GEOS 5223. Sedimentary Petrology. 3 Hours.**

Sediments and sedimentary rocks. Lecture 2 hours, laboratory 2 hours per week. Corequisite: Lab component. Prerequisite: GEOS 4223 or GEOS 5323 (formerly GEOS 4223).

**GEOS 5233. Geography of Religion & Sacrality. 3 Hours.**

Explores the spatial nature of the World's major faiths and religious institutions, focusing on the distribution and origins of these religions. Examines the religious beliefs, rituals, architecture, demographics, and art in different societies, cultures, and countries. Considers the tenets and practices of what is sacred and/or spiritual, held in common by a group or community. Prerequisite: Graduate standing.

**GEOS 5243. Political Geography. 3 Hours.**

(Formerly GEOS 4243.) Contemporary world political problems in their geographic context. Development of the principles of political geography with emphasis upon the problems of Eastern Europe, Africa, and Southeast Asia. Graduate degree credit will not be given for both GEOS 4243 and GEOS 5243.



**GEOS 5253. Geomorphology. 3 Hours.**

(Formerly GEOS 4053.) Mechanics of landform development. Lecture 2 hours, laboratory 3 hours per week. Several local field trips are required during the semester. Graduate degree credit will not be given for both GEOS 4053 and GEOS 5253.

**GEOS 5263. Hydrogeology. 3 Hours.**

(Formerly GEOS 4033.) Occurrence, movement, and interaction of water with geologic and cultural features. Lecture 3 hours per week. Graduate degree credit will not be given for both GEOS 4033 and GEOS 5263. Corequisite: Lab component. Prerequisite: MATH 2043 or MATH 2554, and GEOS 3514.

**GEOS 5273. Principles of Geochemistry. 3 Hours.**

(Formerly GEOS 4063.) Introduction to fundamental principles of geochemistry from historic development to modern concepts. Graduate degree credit will not be given for both GEOS 4063 and GEOS 5273. Corequisite: Lab component. Prerequisite: CHEM 1121L, CHEM 1123 and GEOS 2313.

**GEOS 5283. Economic Geology. 3 Hours.**

(Formerly GEOS 4083.) Introduction to mineral deposits used as economic resources. Covers basic geology and geochemistry of mineral deposit formations and the formation of major classes of deposits. Examines the relationship between the distribution of ores, oil, gas, coal, and Plate Tectonics. Explores environmental issues associated with the extraction of earth resources. Graduate degree credit will not be given for both GEOS 4083 and GEOS 5283. Prerequisite: GEOS 2313.

**GEOS 5293. Introduction to Global Positioning Systems and Global Navigation Satellite Systems. 3 Hours.**

(Formerly GEOS 4593.) Fundamentals of navigation, mapping, and high-precision positioning using the Navstar Global Positioning System. Topics include datum definition and transformation, map projections, autonomous and differential positioning using both code and carrier processing, and analysis of errors. Graduate degree credit will not be given for both GEOS 4593 and GEOS 5293. This course is cross-listed with ANTH 5593.

**GEOS 530V. Special Problems in Regional Geography. 1-6 Hour.**

Special problems in regional geography. Prerequisite: Graduate standing.

**GEOS 5313. Planetary Atmospheres. 3 Hours.**

Origins of planetary atmospheres, structures of atmospheres, climate evolution, dynamics of atmospheres, levels in the atmosphere, the upper atmosphere, escape of atmospheres, comparative planetology of atmospheres.

**GEOS 5323. Stratigraphy and Sedimentation. 3 Hours.**

(Formerly GEOS 4223.) Introductory investigation of stratigraphic and sedimentologic factors important to the study of sedimentary rocks. Lecture 2 hours, laboratory 3 hours per week. A required weekend, two-day field trip will be conducted during the semester. Graduate degree credit will not be given for both GEOS 4223 and GEOS 5323. Corequisite: Lab component. Prerequisite: GEOS 3413.

**GEOS 5333. Research Methods and Materials in Geography. 3 Hours.**

Geographical research and the preparation of research papers. Prerequisite: Graduate standing.

**GEOS 534V. Internship in Physical Geography. 3-6 Hour.**

(Formerly GEOS 430V.) Supervised experience in municipal, county, state or private natural resource management agency, or any other such organization approved by instructor. Graduate degree credit will not be given for both GEOS 430V and GEOS 534V.

**GEOS 5353. Meteorology. 3 Hours.**

(Formerly GEOS 4353.) Examination of the atmospheric processes that result in multifarious weather systems. Offered as physical science. Graduate degree credit will not be given for both GEOS 4353 and GEOS 5353.

**GEOS 5363. Climatology. 3 Hours.**

(Formerly GEOS 4363.) Fundamentals of topical climatology followed by a study of regional climatology. Offered as physical science. Graduate degree credit will not be given for both GEOS 4363 and GEOS 5363.

**GEOS 537V. Geology Field Trip. 1-2 Hour.**

(Formerly GEOS 437V.) Camping field trip to areas of geologic interest, usually conducted during Spring Break. Graduate degree credit will not be given for both GEOS 437V and GEOS 537V. Prerequisite: GEOS 3313. May be repeated for up to 4 hours of degree credit.

**GEOS 5383. Hazard & Disaster Assessment, Mitigation, Risk & Policy. 3 Hours.**

(Formerly GEOS 4383.) Comprehensive introduction to interdisciplinary approaches to natural and environmental hazards and risk. Hazards and disaster assessment, mitigation, and policy are the focus of the class. Graduate degree credit will not be given for both GEOS 4383 and GEOS 5383. May be repeated for up to 6 hours of degree credit.

**GEOS 5393. Mathematical Modeling of Geological Processes. 3 Hours.**

This course explores a variety of topics in applied mathematics and computational methods within the context of studying geological processes and from the perspective of a modeling practitioner. Programming is conducted in Python. Knowledge of Calculus II is necessary.

**GEOS 5403. American Public Lands and Policy. 3 Hours.**

The course examines the role of American federal public lands in 19th-21st century geography, history, policy, and art. It investigates the growth of conservation, preservation, and management movements in the US by looking at America's national parks, forests, dams, wildlife refuges, wilderness areas, managed and agricultural lands. Prerequisite: Graduate standing.

**GEOS 5413. Planetary Geology. 3 Hours.**

Exploration of the solar system, geology and stratigraphy, meteorite impacts, planetary surfaces, planetary crusts, basaltic volcanism, planetary interiors, chemical composition of the planets, origin and evolution of the Moon and planets.

**GEOS 5423. Remote Sensing of Natural Resources. 3 Hours.**

Introductory digital image processing of remotely sensed data. Topics include data collection, laboratory design, scientific visualization, radiometric and geometric correction, enhancement, pattern recognition, artificial intelligence, and change detection in natural resource remote sensing. GIS-based exercises and a course project are included. Prerequisite: GEOS 4413 or GEOS 5213.

**GEOS 5433. Geophysics. 3 Hours.**

(Formerly GEOS 4433.) Derivation from physical principles, of the geophysical methods for mapping the Earth. Computational methods of converting gravity, magnetic, radiometric, electrical, and seismic data into geologic information. Lecture 3 hours, laboratory 2 hours per week. Graduate degree credit will not be given for both GEOS 4433 and GEOS 5433. Corequisite: Lab component. Prerequisite: MATH 2564 and PHYS 2033 and PHYS 2031L and GEOS 3514.

**GEOS 5443. The Solid Earth. 3 Hours.**

Modern views for the origin of the solid Earth and its structure, composition, and evolution through geologic time. Topics will include examination of relevant geophysical and geochemical constraints used to develop global models for the Earth. Prerequisite: GEOS 3313, MATH 2564, CHEM 1123, PHYS 2074 or instructor consent.

**GEOS 5453. Introduction to Raster GIS. 3 Hours.**

(Formerly GEOS 4553.) Theory, data structure, algorithms, and techniques behind raster-based geographical information systems. Through laboratory exercises and lectures multidisciplinary applications are examined in database creation, remotely sensed data handling, elevation models, and resource models using boolean, map algebra, and other methods. Graduate degree credit will not be given for both GEOS 4553 and GEOS 5453.

This course is cross-listed with ANTH 5553.

**GEOS 5463. Microtectonics. 3 Hours.**

Focuses on the microstructural evolution of tectonite rocks and the constraints that can be gleaned from optical microscopic evaluation of rocks in petrographic thin-sections and hand samples. Results are evaluated in the context of plate tectonic theory and geodynamics. Knowledge of mineralogy and petrology equivalent to GEOS 2313 is required. Pre- or Corequisite: GEOS 5563. Corequisite: Lab component.

**GEOS 5473. Applied Climatology. 3 Hours.**

Applied climatology involves the use of climatic data to solve a variety of social, economic and environmental problems, such as for clients in agriculture, water and energy management. The basic purpose of applied climatology is to help society, at all scales and levels, to achieve a better adjustment to the climatic environment.

**GEOS 5483. Severe Weather. 3 Hours.**

(Formerly GEOS 4483.) Focuses on the formation and impact of weather phenomena such as blizzards, floods, tornadoes, thunderstorms, hurricanes and droughts. Covers the mechanisms and physics that control severe weather, advanced terminology, physical concepts and scientific methods used in meteorology, and the analysis and interpretation of meteorological data. Graduate degree credit will not be given for both GEOS 4483 and GEOS 5483.

**GEOS 550V. Internship in GIS & Cartography. 3-6 Hour.**

(Formerly GEOS 440V.) Supervised experience in GIS and/or cartographic applications with municipal, county, state, or private enterprises. Graduate degree credit will not be given for both GEOS 440V and GEOS 550V. May be repeated for up to 6 hours of degree credit.

**GEOS 5513. Introduction to GIS Programming. 3 Hours.**

This course introduces fundamentals of GIS software engineering and offers hands-on tutorials in customized applications using Arc GIS through programming ArcObjects in VBA/VA.net environment. Topics covered include ArcObjects, different programming syntax and styles, and fundamental routines and functions in ArcGIS. After completing the course, students will have the capability develop customized ArcGIS applications.

**GEOS 5523. Cartographic Design & Production. 3 Hours.**

(Formerly GEOS 4523.) This course addresses advanced cartographic concepts (i.e. visual hierarchy, aesthetics, image cognition) and production techniques as they relate to computer-assisted mapping. Students produce a variety of maps using Adobe Illustrator (CS 4-6) software to build a map portfolio. Field trips may be required. Graduate degree credit will not be given for both GEOS 4523 and GEOS 5523.

**GEOS 5533. Introduction to Petroleum Geophysics. 3 Hours.**

(Formerly GEOS 4533.) Introduction to seismic wave propagation and petroleum seismology with particular emphasis on seismic events, elastic waves, and seismic survey design. Credit will not be given for both GEOS 4533 and GEOS 5533. Prerequisite: MATH 2564, PHYS 2033, and GEOL 3514 or consent of instructor.

**GEOS 5543. Geospatial Applications and Information Science. 3 Hours.**

An introduction to the methods and theory underlying the full range of geographic information science and collateral areas - including GNSS, remote sensing, cadastral, spatial demographics and others.

**GEOS 5553. Spatial Analysis Using ArcGIS. 3 Hours.**

Applications of analysis of spatial data using ArcGIS tools in map design, on-line mapping, creating geodatabases, accessing geospatial data, geo-processing, digitizing, geocoding, spatial analysis including basic spatial statistics, analysis of spatial distributions and patterning and 3D application using ArcGIS 3D Analyst. Prerequisite: GEOS 3543 or GEOS 5543.

**GEOS 5563. Tectonics. 3 Hours.**

Development of ramifications of the plate tectonics theory. Analysis of the evolution of mountain belts. Lecture 3 hours per week. Prerequisite: GEOS 3514.

**GEOS 5573. Advanced Cartographic Techniques & Production. 3 Hours.**

Covers advanced production and techniques in cartography, including animation, geospatial visualization, pochade, and advanced visualization. Emphasizes client relationships in creating and producing cartographic materials. Prerequisite: GEOS 4523 or GEOS 5523.

**GEOS 5583. Vector GIS. 3 Hours.**

(Formerly GEOS 4583.) Introduction to geographic information systems (GIS) applications in marketing, transportation, real estate, demographics, urban and regional planning, and related areas. Lectures focus on development of principles, paralleled by workstation-based laboratory exercises using mainstream GIS software and relational databases. Graduate degree credit will not be given for both GEOS 4583 and GEOS 5583.

This course is cross-listed with ANTH 5563.

**GEOS 5593. Introduction to Geodatabases. 3 Hours.**

Fundamental concepts and applications of geospatial databases. Schema development and spatial data models for geodata. Spatial and attribute query and optimization, properties and structures of relational and object-oriented geodatabases. Spatial extensions of SQL, spatial indexing, measurement, and geometry. Course will use PostGIS, ESRI File Geodatabases, and MS-SQL. Prerequisite: GEOS 3543 and GEOS 3103 or equivalent.

**GEOS 560V. Graduate Special Problems. 2-6 Hour.**

Library, laboratory, or field research in different phases of geology. May be repeated for up to 4 hours of degree credit.

**GEOS 5612. Research Methods in Geosciences. 2 Hours.**

Survey of research methodologies used in both geology and geography, with an emphasis on quantitative analysis. Preparation of research proposals and presentations in the field of geosciences. Prerequisite: Graduate standing.

**GEOS 5643. Introduction to Internet GIS. 3 Hours.**

This course introduces Internet computing and Web GIS and offers hands-on tutorials in customized applications using ArcGIS Server JavaScript API. Topics covered include Internet protocols and Web standards, Web services, and fundamental routines and functions in Arc GIS server development. Students will have the capability to develop customized ArcGIS server applications. Prerequisite: GEOS 5513 or equivalent.

**GEOS 5653. GIS Analysis and Modeling. 3 Hours.**

(Formerly GEOS 4653.) Unlike conventional GIS courses that focus on studying "where", this course will teach students to address beyond "where" using various GIS analysis and modeling techniques to explore "why" and "how". The course will provide theoretical and methodological reviews of the principles of cartographic modeling and multi-criteria decision-making. Graduate degree credit will not be given for both GEOS 4653 and GEOS 5653.

This course is cross-listed with ANTH 5653, ENDY 5043.

**GEOS 5663. Low-Temperature Geochemistry of Natural Waters. 3 Hours.**

(Formerly GEOS 4663.) Covers the low-temperature geochemistry of waters and their associated minerals at Earth's surface. Examines the controls on the chemical composition of natural waters and the minerals precipitated from them. Topics covered will include water-rock interactions, pH, redox, the carbonate-water system, clay minerals and exchange, heavy metals, and a brief introduction to stable isotopes and geomicrobiology. Credit will not be given for both GEOS 4663 and GEOS 5663. Prerequisite: CHEM 1121L, CHEM 1123, GEOS 1113, and GEOS 1111L.

**GEOS 5673. Volcanology. 3 Hours.**

A broad introduction to volcanic processes and their associated hazards. Emphasis will be placed on applying basic physical and chemical principles to understanding volcanic systems. Prerequisite: GEOS 2313.

**GEOS 5693. Environmental Justice. 3 Hours.**

(Formerly GEOS 4693.) This course deals with the ethical, environmental, legal, economic, and social implications of society's treatment of the poor, the disenfranchised, and minorities who live in the less desirable, deteriorating neighborhoods, communities, and niches of our country. The class integrates science with philosophy, politics, economics, policy, and law, drawing on award-winning films, current news, and case studies. Credit will not be given for both GEOS 4693 and GEOS 5693.

**GEOS 5713. Geology of Our National Parks. 3 Hours.**

(Formerly GEOS 4563.) This course examines the underlying geology responsible for selected parks, and explores the interplay of geology, biology, climate, topography, and humans to evaluate the value of the parks, and to anticipate the problems they will face in the near and long-term. Credit will not be given for both GEOS 4563 and GEOS 5713. Prerequisite: GEOS 1113.

**GEOS 5743. Petroleum Geology. 3 Hours.**

(Formerly GEOS 4253.) Distribution and origin of petroleum. Lecture 2 hours, laboratory 2 hours per week. Graduate degree credit will not be given for both GEOS 4253 and GEOS 5743. Corequisite: Lab component. Prerequisite: Admission to the Geology graduate program.

**GEOS 5753. Karst Hydrogeology. 3 Hours.**

(Formerly GEOS 4153.) Assessment of ground water resources in carbonate rock terrains; relation of ground water and surface water hydrology to karst; quantification of extreme variability in karst environments; data collection rationale. Field trips required. Graduate degree credit will not be given for both GEOS 4153 and GEOS 5753. Prerequisite: GEOS 4033 or GEOS 5263 (formerly GEOS 4033).

**GEOS 5783. Geography of Europe. 3 Hours.**

(Formerly GEOS 4783.) Geographic regions of the area with emphasis on their present development. Graduate degree credit will not be given for both GEOS 4783 and GEOS 5783.

**GEOS 5793. Geospatial Unmanned Aircraft Systems. 3 Hours.**

Geospatial unmanned aircraft systems (UAS) are becoming key technologies in a number of disciplines. This course will introduce safe and legal operation of UAS in aerial photography, multispectral, thermal and LIDAR applications, geodetic control, photogrammetric and computer vision processing, and the creation of accurate 2D and 3D digital information products. Pre- or Corequisite: (GEOS 4413 or GEOS 5213 (formerly GEOS 4413)) and (GEOS 4593 or GEOS 5293 (formerly GEOS 4593)) or equivalent.

**GEOS 5853. Environmental Isotope Geochemistry. 3 Hours.**

Introduction to principles of isotope fractionation and distribution in geologic environments, isotopic analytical methods, and extraction of isotope samples; application of isotopes in characterization of geologic processes and interaction with hydrologic, surficial, and biologic attenuation, paleothermometry soil, and biogeochemical processes. May be repeated for up to 3 hours of degree credit. This course is cross-listed with ENDY 5853.

**GEOS 5863. Quantitative Techniques in Geosciences. 3 Hours.**

(Formerly GEOS 4863.) An introduction to the application of standard quantitative and spatial statistical techniques to geoscientific analysis. Students will use both micro and large system computers in the course. Graduate degree credit will not be given for both GEOS 4863 and GEOS 5863. This course is cross-listed with ANTH 5863.

**GEOS 5873. Geological Data Analysis. 3 Hours.**

(Formerly GEOS 4873.) Quantitative methods and techniques for analysis and interpretation of geological data. Credit will not be given for both GEOS 4873 and GEOS 5873. Corequisite: Lab component. Prerequisite: MATH 2564 and GEOS 3514.

**GEOS 5924. Earth System History (ACTS Equivalency = PHSC 1104). 4 Hours.**

(Formerly GEOS 4924.) Physical and biological events that form the history of the earth from its formation to the beginning of the historical era. Credit will not be given for both GEOS 4924 and GEOS 5924. Graduate enrollment only with departmental permission. Corequisite: Lab component. Prerequisite: GEOS 3514.

**GEOS 5933. Ancient Forest Science and Sustainability. 3 Hours.**

Ancient forests preserve beautiful habitat with high ecological integrity. This course will examine the development, spatial distribution, and ongoing destruction of ancient forests worldwide, and how science can contribute to the understanding and sustainable management of these valuable resources.

**GEOS 5993. Dynamics of Sediment Transport. 3 Hours.**

The course will give aspiring geologists and civil engineers tools for solving sedimentological problems in their fields. Starting from a grounding in fluid mechanics, we will learn how sediment is transported and stratigraphy accumulated. This will be applied to problems in sedimentology at all scales.

**GEOS 600V. Master's Thesis. 1-6 Hour.**

Master's thesis. Prerequisite: Graduate standing. May be repeated for degree credit.

**GEOS 6013. Seminar in Geoinformatics. 3 Hours.**

Geographic information science and technology research topics of particular interest to the graduate student class. May be repeated for up to 9 hours of degree credit.

**GEOS 700V. Doctoral Dissertation. 1-9 Hour.**

Dissertation research. Prerequisite: Graduate standing and Ph.D. candidacy May be repeated for degree credit.