

Earth Science (ERSC)

Fulbright College offers a major in earth science leading to the Bachelor of Science degree. Prospective secondary teachers may plan a program, in cooperation with the College of Education, which will satisfy the teacher licensure requirements. Students interested in environmental problems, teaching earth science in public schools, or wishing to pursue graduate work in either geography or geology will obtain much of the necessary foundation through this degree. Because the program outlined below lists only minimum science requirements, it is expected that most students will use some of their elective credit hours to strengthen their mathematics and science backgrounds in areas other than geography and geology. These areas of additional study will be determined through consultation between the student and the adviser. Students interested in this major should contact either Professor Ralph Davis or Professor J.C. Dixon.

Requirements for the B.S. Degree with a Major in Earth

Science: In addition to the University Core (<http://catalog.uark.edu/undergraduatecatalog/academicregulations/universitycore>) requirements and the Fulbright College of Arts and Sciences Graduation Requirements (<http://catalog.uark.edu/undergraduatecatalog/collegesandschools/jwilliamfulbrightcollegeofartsandsciences>), the following course requirements must be met. Bolded courses from the list below may be applied to portions of the University/state minimum core requirements.

Basic Courses

Biology		8
Chemistry or Physics		8
GEOS 1113	General Geology (ACTS Equivalency = GEOL 1114 Lecture) (Sp, Su, Fa)	4
& GEOS 1111L	and General Geology Laboratory (ACTS Equivalency = GEOL 1114 Lab) (Sp, Su, Fa)	
GEOS 1133	Earth Science (ACTS Equivalency = GEOL 1124 Lecture) (Sp, Fa)	4
& GEOS 1131L	and Earth Science Laboratory (ACTS Equivalency = GEOL 1124 Lab) (Sp, Fa)	
Select one of the following:		3-4
MATH 2043	Survey of Calculus (ACTS Equivalency = MATH 2203) (Sp, Su, Fa)	
MATH 2053	Finite Mathematics (Sp, Su, Fa)	
MATH 2183	Mathematical Reasoning in a Quantitative World (Sp, Fa)	
MATH 2554	Calculus I (ACTS Equivalency = MATH 2405) (Sp, Su, Fa)	
6 hours in a single world language at the 1013 Elementary II level or higher ¹		6
ASTR 2003	Survey of the Universe (ACTS Equivalency = PHSC 1204 Lecture) (Sp, Su, Fa)	4
& ASTR 2001L	and Survey of the Universe Laboratory (ACTS Equivalency = PHSC 1204 Lab) (Sp, Su, Fa)	

Advanced Courses

GEOS 3023	Introduction to Cartography (Fa)	3
GEOS 3043	Sustaining Earth (Sp, Su, Fa)	3
GEOS 4353	Meteorology (Fa)	3
or GEOS 4363	Climatology (Sp)	
GEOS 2313	Mineralogy and Petrology (Fa)	3
GEOS 3413	Sedimentary Rocks & Fossils (Sp)	3

GEOS 4033	Hydrogeology (Sp)	3
GEOS 4924	Earth System History (ACTS Equivalency = PHSC 1104) (Sp)	4
At least 6 additional hours, at the 3000 level or above, in GEOS.		6
Total Hours		65-66

¹ World language courses taken are dependent on placement level in sequence.

Writing Requirement: The college writing requirement is to be met by completion of a term paper deemed satisfactory by the student's adviser and instructor of an upper-level geoscience course. The college writing requirement may also be met by the completion of an honors thesis.

Earth Science B.S. Eight-Semester Degree Program

Students wishing to follow the eight-semester degree plan should see the Eight-Semester Degree Policy (<http://catalog.uark.edu/undergraduatecatalog/academicregulations/eightsemesterdegreecompletionpolicy>) for university requirements of the program. Core requirement hours may vary by individual, based on placement and previous credit granted. Once all core requirements are met, students may substitute a three-hour (or more) general elective in place of a core area.

First Year	Units	
	Fall	Spring
ENGL 1013 Composition I (ACTS Equivalency = ENGL 1013) (Sp, Su, Fa)	3	
Select one of the following:	3-4	
MATH 1203 College Algebra (ACTS Equivalency = MATH 1103) (Sp, Su, Fa)		
MATH 2043 Survey of Calculus (ACTS Equivalency = MATH 2203) (Sp, Su, Fa) ¹		
MATH 2053 Finite Mathematics (Sp, Su, Fa) ¹		
MATH 2183 Mathematical Reasoning in a Quantitative World (Sp, Fa) ¹		
MATH 2554 Calculus I (ACTS Equivalency = MATH 2405) (Sp, Su, Fa) ¹		
GEOS 1113 General Geology (ACTS Equivalency = GEOL 1114 Lecture) (Sp, Su, Fa)	4	
& GEOS 1111L General Geology Laboratory (ACTS Equivalency = GEOL 1114 Lab) (Sp, Su, Fa)		
1013 Elementary II World Language Course (or higher level)	3	
University/State Core US History requirement	3	
ENGL 1023 Composition II (ACTS Equivalency = ENGL 1023) (Sp, Su, Fa)		3
Select one of the following MATH if still needed, else General Elective:		3-4
MATH 2043 Survey of Calculus (ACTS Equivalency = MATH 2203) (Sp, Su, Fa) ¹		
MATH 2053 Finite Mathematics (Sp, Su, Fa) ¹		
MATH 2183 Mathematical Reasoning in a Quantitative World (Sp, Fa) ¹		
MATH 2554 Calculus I (ACTS Equivalency = MATH 2405) (Sp, Su, Fa) ¹		

General Elective		
GEOS 1133 Earth Science (ACTS Equivalency = GEOL 1124 Lecture) (Sp, Fa) & GEOS 1131L Earth Science Laboratory (ACTS Equivalency = GEOL 1124 Lab) (Sp, Fa)	4	
2003 Intermediate I World Language Course (or higher level)	3	
University/State Core Fine Arts or Humanities Course requirement	3	
Year Total:	16	16

Second Year	Units	
	Fall	Spring
GEOS 2313 Mineralogy and Petrology (Fa)	3	
CHEM or PHYS Course (as needed)	4	
University/State Core Humanities or Fine Arts Course requirement (as needed)	3	
University/State Core Social Science requirement	3	
General Elective	3	
ASTR 2003 Survey of the Universe (ACTS Equivalency = PHSC 1204 Lecture) (Sp, Su, Fa) & ASTR 2001L Survey of the Universe Laboratory (ACTS Equivalency = PHSC 1204 Lab) (Sp, Su, Fa)		4
GEOS 3413 Sedimentary Rocks & Fossils (Sp)		3
CHEM or PHYS Course (as needed)		4
University/State Core Social Science requirement		3
Year Total:	16	14

Third Year	Units	
	Fall	Spring
BIOL Course (as needed)	4	
GEOS 3023 Introduction to Cartography (Fa) ^{1,2}	3	
University/State Core Social Science requirement	3	
Advanced Level Elective ¹	3	
Advanced Level Elective ¹	3	
GEOS 3043 Sustaining Earth (Sp, Su, Fa)		3
BIOL Course (as needed)		4
Advanced Level Elective ¹		3
GEOS 4033 Hydrogeology (Sp)		3
General Elective		1
Year Total:	16	14

Fourth Year	Units	
	Fall	Spring
Select one of the following:	3	
GEOS 4353 Meteorology (Fa) (as needed) ^{1,2} or Advanced Level Elective ¹		
Upper Level GEOS Course ^{1,2}	3	
3000-plus Level Elective ¹	3	
General Electives	6	
GEOS 4924 Earth System History (ACTS Equivalency = PHSC 1104) (Sp)		4
Select one of the following		3

GEOS 4363 Climatology (Sp) or Advanced Level Elective ¹		
Upper Level GEOS Course ^{1,2}		3
3000-plus Level Elective ¹		3
Year Total:	15	13

Total Units in Sequence: 120

¹ Meets 40-hour advanced credit hour requirement. See College Academic Regulations (<http://catalog.uark.edu/undergraduatecatalog/collegesandschools/jwilliamfulbrightcollegeofartsandsciences>).

² Meets 24-hour rule (24 hours of 3000-4000 level courses in Fulbright College), in addition to meeting the 40-hour rule. See College Academic Regulations (<http://catalog.uark.edu/undergraduatecatalog/collegesandschools/jwilliamfulbrightcollegeofartsandsciences>).

Earth Science (B.S.) Teacher Licensure in Life/Earth Science or Physical/Earth Science Requirements: Students wanting to teach science in middle or secondary school should consult with an adviser in the College of Education and Health Professions.

Courses

GEOS 1111L. General Geology Laboratory (ACTS Equivalency = GEOL 1114 Lab) (Sp, Su, Fa). 1 Hour.

Laboratory exercises concerning the identification of rocks and minerals, use of aerial photographs and topographic maps, and several field trips. Pre- or Corequisite: GEOS 1113.

This course is equivalent to GEOL 1111L.

GEOS 1111M. Honors General Geology Laboratory (Fa). 1 Hour.

Survey of geological processes and products and their relationships to landforms, natural resources, living environments, and human beings. Lecture 3 hours, laboratory 2 hours per week. Corequisite: GEOS 1113H.

This course is equivalent to GEOL 1111L.

GEOS 1113. General Geology (ACTS Equivalency = GEOL 1114 Lecture) (Sp, Su, Fa). 3 Hours.

Survey of geological processes and products, and their relationships to landforms, natural resources, living environments and human beings. Lecture 3 hours per week. GEOS 1111L is recommended as a corequisite.

This course is equivalent to GEOL 1113.

GEOS 1113H. Honors General Geology (Irregular). 3 Hours.

Survey of geological processes and products and their relationships to landforms, natural resources, living environments, and human beings. Lecture 3 hours, laboratory 2 hours per week. Corequisite: GEOS 1111M.

This course is equivalent to GEOL 1113.

GEOS 1123. Human Geography (ACTS Equivalency = GEOG 1113) (Sp, Su, Fa). 3 Hours.

Basic course in human geography stressing the interrelationships between the natural factors of the environment and man's activities, especially the role of geography in the understanding of social problems and economic and political activities.

GEOS 1131L. Earth Science Laboratory (ACTS Equivalency = GEOL 1124 Lab) (Sp, Fa). 1 Hour.

Laboratory exercises concerning human interactions with the physical environment including the study of earthquakes, volcanoes, flooding, erosion, mass wasting, water supply and contamination, and waste disposal.

GEOS 1133. Earth Science (ACTS Equivalency = GEOL 1124 Lecture) (Sp, Fa). 3 Hours.

The application of earth science principles and knowledge of problems created by human occupancy and exploitation of the physical environment.

GEOS 2003. World Regional Geography (ACTS Equivalency = GEOG 2103) (Sp, Fa). 3 Hours.

Survey of problems, development potential, and physical and human resources of the developing and developed world.

GEOS 2003H. Honors World Regional Geography (Sp, Fa). 3 Hours.

Survey of problems, development potential, and physical and human resources of the developing and developed world. Prerequisite: Honors candidacy.

This course is equivalent to GEOS 2003.

GEOS 2313. Mineralogy and Petrology (Fa). 3 Hours.

General principles of mineralogy and petrology, study and identification of common minerals, igneous & metamorphic rocks using hand samples. Corequisite: Lab component. Prerequisite: GEOS 1113 and CHEM 1103.

GEOS 3013. Foundations of Geospatial Data Analysis (Sp, Fa). 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. Students may receive credit for the course through testing. Prerequisite: GEOS 3543.

GEOS 3023. Introduction to Cartography (Fa). 3 Hours.

Students learn basic principles of map design, cartographic theory and field surveying to produce a variety of computer-generated maps. An introductory course designed for students in a variety of different disciplines using AutoCad software and various new technologies. Field trips may be required.

GEOS 3033. Building Materials Field Studies (Irregular). 3 Hours.

Study of durable building materials, their availability, strength, deterioration, limitation and utility. Historic construction techniques, identification of architectural materials, architectural elements assessment, causes and mechanisms of deterioration, conservation and treatment of architectural materials, preservation philosophies and standards and creation of a practical field identification kit will also be covered. Corequisite: Lab component.

GEOS 3043. Sustaining Earth (Sp, Su, Fa). 3 Hours.

Theory and growth of conservation and sustainability, the wise use of the major natural resources of the United States. This course meets the requirement in conservation and sustainability for teachers. Prerequisite: Junior standing. This course is cross-listed with GEOS 3043H.

GEOS 3043H. Honors Sustaining Earth (Sp, Su, Fa). 3 Hours.

Theory and growth of conservation and the wise use of the major natural resources of the United States. This course meets the requirement in conservation for teachers. Prerequisite: Junior standing.

This course is cross-listed with GEOS 3043.

GEOS 3052. Geology for Engineers (Fa). 2 Hours.

Geologic principles involved in construction, reservoir location, etc. Lecture 2 hours, laboratory 2 hours per week. Corequisite: Lab component.

GEOS 3062. Geology of Arkansas (Sp). 2 Hours.

A survey of the distribution, genesis, and age of the rocks, fossils, structures, landforms and geological processes of Arkansas. Equivalent to two hours of lecture per week. Field trips required. Prerequisite: GEOS 1113 or GEOS 1113H.

GEOS 3103. Geospatial Technologies Computational Toolkit (Sp, Fa). 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. Students may receive credit for the course through testing. Prerequisite: GEOS 3543.

GEOS 3114. Invertebrate Paleontology (Sp). 4 Hours.

Survey of the invertebrate phyla commonly preserved as fossils emphasizing their physical and biological characteristics. Lecture 3 hours, laboratory 2 hours per week. Corequisite: Lab component. Prerequisite: GEOL 1133 or (BIOL 1543 and BIOL 1541L) or equivalent.

GEOS 3313. Igneous and Metamorphic Rocks (Sp). 3 Hours.

Megascopic study and classification of igneous and metamorphic rocks. Lecture 2 hours, laboratory 2 hours per week. Corequisite: Lab component. Prerequisite: GEOS 2313.

GEOS 3333. Oceanography (Even years, Sp). 3 Hours.

The sea, its landforms; its winds and currents as related to the atmosphere, world climates, and world trade; its basin as avenues for continental drift; its waters as habitat for plant and animal life; its marine and submarine resources as presently and potentially useful to man. Offered as physical science. Prerequisite: Junior standing.

GEOS 3383. Principles of Landscape Evolution (Fa). 3 Hours.

Examines the role of waves, rivers, wind, and tectonics in shaping and modifying the surface of the earth. Considers the way in which an understanding of landscape processes is essential to the effective solution of environmental problems. Lecture 3 hours. May be repeated for up to 3 hours of degree credit.

GEOS 3413. Sedimentary Rocks & Fossils (Sp). 3 Hours.

An introductory study of sedimentary rocks and fossils from the standpoint of classification, field and laboratory description, genesis, and preservation. Lecture 2 hours, laboratory 2 hours per week. Corequisite: Lab component. Prerequisite: GEOS 2313.

GEOS 3514. Structural Geology (Sp). 4 Hours.

Survey of deformational features and their geological significance in the crust of the earth. Lecture 3 hours per week. Corequisite: Lab component. Prerequisite: GEOS 1113 or GEOS 3052.

GEOS 3543. Geospatial Applications and Information Science (Sp, Fa). 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.

This course is cross-listed with ANTH 3543.

GEOS 3553. Spatial Analysis Using ArcGIS (Sp, Fa). 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.

GEOS 3563. Geospatial Data Mining (Sp, Fa). 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 3003 and GEOS 3103 or equivalent.

GEOS 3593. Introduction to Geodatabases (Sp, Fa). 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. Prerequisite: GEOS 3543, GEOS 3003 and GEOS 3103.

GEOS 360V. Undergraduate Special Problems (Sp, Su, Fa). 1-6 Hour.

Library, laboratory, or field research in different phases of geology. May be repeated for up to 6 hours of degree credit.

GEOS 3901. Junior Honors Course (Sp, Su, Fa). 1 Hour.

Special honors research in geology. One hour credit each semester. Prerequisite: Junior standing.

GEOS 3911. Junior Honors Course (Sp, Su, Fa). 1 Hour.

Special honors research in geology. One hour credit each semester. Prerequisite: Junior standing.

GEOS 3923H. Honors Colloquium (Irregular). 3 Hours.

Covers a special topic or issue, offered as part of the honors program. Prerequisite: Honors candidacy (not restricted to candidacy in geology or geography). May be repeated for degree credit.

GEOS 399VH. Honors Course (Irregular). 1-6 Hour.

Honors course. Prerequisite: Junior standing. May be repeated for up to 6 hours of degree credit.

GEOS 4033. Hydrogeology (Sp). 3 Hours.

Occurrence, movement, and interaction of water with geologic and cultural features. Lecture 3 hours per week. Corequisite: Lab component. Prerequisite: MATH 2043 or MATH 2554, and GEOS 3514.

GEOS 4043. Geography of the Middle East (Fa). 3 Hours.

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. Prerequisite: Junior standing.

GEOS 4043H. Honors Geography of the Middle East (Irregular). 3 Hours.

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. Prerequisite: Junior standing.

This course is equivalent to GEOS 4043.

GEOS 4053. Geomorphology (Sp). 3 Hours.

Mechanics of landform development. Lecture 2 hours, laboratory 3 hours per week. Several local field trips are required during the semester. Corequisite: Lab component. Prerequisite: GEOS 1113 or GEOS 3052.

GEOS 4063. Principles of Geochemistry (Fa). 3 Hours.

Introduction to fundamental principles of geochemistry from historic development to modern concepts. Corequisite: Lab component. Prerequisite: CHEM 1121L, CHEM 1123 and GEOS 2313.

GEOS 4073. Urban Geography (Sp). 3 Hours.

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. Prerequisite: Junior standing.

GEOS 4083. Economic Geology (Irregular). 3 Hours.

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. Prerequisite: GEOS 2313.

GEOS 4093. History and Philosophy of Geography (Even years, Sp). 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 410V. Special Problems in Geosciences (Fa). 1-6 Hour.

Designed to meet the needs of students who wish to study one particular geographic topic in some detail. Prerequisite: Junior standing. May be repeated for up to 6 hours of degree credit.

GEOS 410VH. Honors Special Problems in Geosciences (Fa). 1-6 Hour.

Designed to meet the needs of students who wish to study one particular geographic topic in some detail. Prerequisite: Junior standing. May be repeated for up to 6 hours of degree credit.

This course is equivalent to GEOS 410V.

GEOS 4133. Radar Remote Sensing (Sp). 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 4153. Karst Hydrogeology (Irregular). 3 Hours.

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. Prerequisite: GEOS 4033.

GEOS 4223. Stratigraphy and Sedimentation (Fa). 3 Hours.

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. Corequisite: Lab component. Prerequisite: GEOS 3413.

GEOS 4233. Geography of Religion & Sacrality (Irregular). 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: Junior or senior standing.

GEOS 4243. Political Geography (Odd years, Fa). 3 Hours.

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. Prerequisite: Junior standing.

GEOS 4253. Petroleum Geology (Fa). 3 Hours.

Distribution and origin of petroleum. Lecture 2 hours, laboratory 2 hours per week. Corequisite: Lab component. Prerequisite: Geology major and senior standing.

GEOS 430V. Internship in Physical Geography (Sp, Su, Fa). 3-6 Hour.

Supervised experience in municipal, county, state or private natural resource management agency, or any other such organization approved by instructor.

GEOS 4353. Meteorology (Fa). 3 Hours.

Examination of the atmospheric processes that result in multifarious weather systems. Offered as physical science. Prerequisite: Junior standing.

GEOS 4363. Climatology (Sp). 3 Hours.

Fundamentals of topical climatology followed by a study of regional climatology. Offered as physical science. Prerequisite: GEOS 1133 or GEOS 4353.

GEOS 437V. Geology Field Trip (Sp). 1-2 Hour.

Camping field trip to areas of geologic interest, usually conducted during Spring Break. Prerequisite: GEOS 3313. May be repeated for up to 4 hours of degree credit.

GEOS 4383. Hazard & Disaster Assessment, Mitigation, Risk & Policy (Sp). 3 Hours.

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. Prerequisite: Junior or senior standing. May be repeated for up to 6 hours of degree credit.

GEOS 4383H. Honors Hazard & Disaster Assessment, Mitigation, Risk & Policy (Sp). 3 Hours.

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. Prerequisite: Junior or senior standing. This course is equivalent to GEOS 4383.

GEOS 4393. American Public Lands & Policy (Irregular). 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: Junior or senior standing.

GEOS 4393H. Honors American Public Lands & Policy (Irregular). 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: Honors standing and Junior or senior standing. This course is equivalent to GEOS 4393.

GEOS 440V. Internship in GIS & Cartography (Sp, Su, Fa). 3-6 Hour.

Supervised experience in GIS and/or cartographic applications with municipal, county, state, or private enterprises. May be repeated for up to 6 hours of degree credit.

GEOS 4413. Principles of Remote Sensing (Fa). 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. Prerequisite: GEOS 3023 or GEOS 3543.

GEOS 4433. Geophysics (Irregular). 3 Hours.

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. Corequisite: Lab component. Prerequisite: MATH 2564 and PHYS 2033 and PHYS 2031L and GEOS 3514.

GEOS 4443. The Solid Earth: Structure, Composition and Evolution (Irregular). 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: CHEM 1123, GEOS 3313, MATH 2564, PHYS 2074 or instructor consent.

This course is cross-listed with GEOS 5443.

GEOS 4463. 3D Seismic Exploration (Sp). 3 Hours.

Interpretation of the spatial component of three-dimensional seismic data in geologic structure and stratigraphy with emphasis on hydrocarbon exploration. Prerequisite: GEOS 3514 or instructor consent.

GEOS 4473. Applied Climatology (Fa). 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 4473H. Honors Applied Climatology (Fa). 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. This course is equivalent to GEOS 4473.

GEOS 4483. Severe Weather (Sp). 3 Hours.

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. Prerequisite: GEOL 1133 and GEOL 1131L.

GEOS 4503. Advanced Cartographic Techniques & Production (Irregular). 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.

GEOS 4513. Introduction to GIS Programming (Fa). 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 to develop customized ArcGIS applications.

GEOS 4523. Cartographic Design and Production (Sp). 3 Hours.

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. Prerequisite: GEOS 3023.

GEOS 4533. Introduction to Petroleum Geophysics (Fa). 3 Hours.

Introduction to seismic wave propagation and petroleum seismology with particular emphasis on seismic events, elastic waves, and seismic survey design. Prerequisite: MATH 2564, PHYS 2033, and GEOL 3514 or consent of instructor.

GEOS 4553. Introduction to Raster GIS (Fa). 3 Hours.

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. Prerequisite: GEOS 3543 or ANTH 3543. This course is cross-listed with ANTH 4553.

GEOS 4563. Geology of Our National Parks (Fa). 3 Hours.

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. Prerequisite: GEOL 1113.

GEOS 4563H. Honors Geology of Our National Parks (Fa). 3 Hours.

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. Prerequisite: GEOL 1113.

This course is equivalent to GEOS 4563.

GEOS 4583. Vector GIS (Sp). 3 Hours.

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.

Prerequisite: GEOS 3023 or GEOS 3543.

This course is cross-listed with ANTH 4563.

GEOS 4593. Introduction to Global Positioning Systems and Global Navigation Satellite Systems (Fa). 3 Hours.

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. Prerequisite: GEOS 3543 or GEOS 5543.

This course is cross-listed with ANTH 4593.

GEOS 4643. Introduction to Internet GIS (Sp). 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 ArcGIS server development. Students will have the capability to develop customized ArcGIS server applications. Prerequisite: GEOS 3543 or equivalent.

GEOS 4653. GIS Analysis and Modeling (Sp). 3 Hours.

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.

This course is cross-listed with ANTH 4653.

GEOS 4653H. Honors GIS Analysis and Modeling (Sp). 3 Hours.

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.

This course is cross-listed with GEOS 4653, ANTH 4653.

GEOS 4663. Low-Temperature Geochemistry of Natural Waters (Fa). 3 Hours.

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. Prerequisite: CHEM 1121L, CHEM 1123, GEOS 1113, and GEOS 1111L.

GEOS 4673. Volcanology (Irregular). 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.

This course is cross-listed with GEOS 5673.

GEOS 4686. Geology Field Camp (Su). 6 Hours.

A professional course taught off campus emphasizing occurrence, description, mapping, and interpretation of major rock types. May not be taken for graduate credit. Prerequisite: GEOS 3413 and GEOS 3514.

GEOS 4693. Environmental Justice (Sp). 3 Hours.

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. This course is cross-listed with GEOS 4693H, SUST 4693.

GEOS 4693H. Honors Environmental Justice (Sp). 3 Hours.

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. This course is cross-listed with GEOS 4693, SUST 4693.

GEOS 4783. Geography of Europe (Irregular). 3 Hours.

Geographic regions of the area with emphasis on their present development.

Prerequisite: Junior standing.

GEOS 4793. Geospatial Unmanned Aircraft Systems (Fa). 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 and GEOS 4593 or equivalent.

GEOS 4793H. Honors Geospatial Unmanned Aircraft Systems (Fa). 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: Honors standing, GEOS 4413 and GEOS 4593 or equivalent.

This course is equivalent to GEOS 4793.

GEOS 481V. Cooperative Education Program (Sp, Su, Fa). 1-6 Hour.

Credit for off-campus, compensated work experience related to geology arranged through the Cooperative Education Office and Department of Geology. May be repeated for degree credit.

GEOS 4863. Quantitative Techniques in Geosciences (Sp). 3 Hours.

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.

This course is cross-listed with ANTH 4863.

GEOS 4873. Geological Data Analysis (Sp). 3 Hours.

Quantitative methods and techniques for analysis and interpretation of geological data. Corequisite: Lab component. Prerequisite: MATH 2564 and GEOS 3514.

GEOS 4924. Earth System History (ACTS Equivalency = PHSC 1104) (Sp). 4 Hours.

Physical and biological events that form the history of the earth from its formation to the beginning of the historical era. Graduate enrollment only with departmental permission. Corequisite: Lab component. Prerequisite: GEOL 3514.

This course is equivalent to GEOL 4924.

GEOS 4933. Ancient Forest Science and Sustainability (Sp). 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 4972H. Senior Honors Course I (Sp, Su, Fa). 2 Hours.

Special honors research in geology. Two hours of credit each semester.

Prerequisite: Junior honors.

GEOS 4982H. Senior Honors Course II (Sp, Su, Fa). 2 Hours.

Special honors research in geology. Two hours of credit each semester.

Prerequisite: Junior honors.