DEPARTMENT OF EARTH AND ENVIRONMENTAL SCIENCE

Department of Earth and Environmental Science
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Department Chair:
Interim Chair: Michael B. Kruger

Professors:
Wei Ji (graduate Geography adviser and GIS Certificate Program Director), Tina M. Niemi (principal undergraduate Geology adviser)

Associate Professors:
Jimmy O. Adegoke (undergraduate Geography advisor; Director of CAER), Caroline P. Davies (undergraduate Environmental Science advisor; Director, Environmental Studies program), Jejung Lee

Professors Emeriti:
Raymond M. Coveney, Jr., Steven L. Driever, Richard J. Gentile, Syed E. Hasan, Daniel P. Hopkins, James B. Murowchick

Department Description
The Department of Geosciences offers programs of study leading to bachelor of science degrees in Environmental Science, Geography, and Geology and bachelor of arts degrees in Environmental Studies, Geography and Geology. The department offers a master of science degree in Environmental and Urban Geosciences and participates in the Interdisciplinary Ph.D. program. The department also offers an undergraduate and graduate certificate in Geographic Information Systems (GIS). Students who designate Geosciences (Environmental Studies, Geology or Geography focus) on their application for admission to the doctoral program must meet admission and other requirements available from the department. See the School of Graduate Studies section in the Graduate Catalog for more information about doctoral programs. The department takes a leading role in the undergraduate interdisciplinary Environmental Studies program. Courses offered by the department can be used to fulfill the requirements of the Missouri Department of Education for earth science, science-math, and social science teaching specialties.

Students majoring in Environmental Studies, Environmental Science, Geography, or Geology obtain a broad liberal arts education during their undergraduate career and at the same time receive sound fundamental training in the geosciences. Departmental faculty members are committed to educating non-majors about the earth and environmental sciences as well as those students who plan to pursue careers in the geosciences.

All undergraduate majors in the Department of Geosciences (including Environmental Studies) must maintain a minimum grade point average above 2.0 in all courses taken to fulfill departmental degree requirements. This minimum GPA also applies to all credit hours transferred from other institutions.

Students in the geosciences address earth-related questions and problems facing society today. Environmental studies focuses on environmental processes and policy. Geography deals with place and the relationships between people and the environment. Geology explores the materials and processes of the earth and its evolution and history.

We offer unique university experiences such as field courses and excursions. The Geosciences' faculty and students have conducted research in many countries such as Jordan, Mexico, Chad, China, Korea, Cameroon, the Bahamas, Denmark, Spain, India and Turkey.

Special Resources and Services
Geosciences Museum
The Geosciences Museum, founded by Richard L. Sutton, M.D., is located in Room 271, R.H. Flarsheim Hall. It contains relief models and interactive displays, along with a full range of 2,500 spectacular mineral and fossil specimens from all over the world. Hours of operation are 8:30 a.m. to 4:30 p.m. Monday through Friday. Admission is free.

Center for Applied Environmental Research (CAER)
The Center for Applied Environmental Research http://cas.umkc.edu/caer is administered by the Geosciences Department and directed by Professor Jimmy O. Adegoke. The center is a resource for governmental agencies, private firms, and the general public in matters of the environment. Its programs address such matters as environmental geophysics, geochemistry, underground space, foundation stability, waste management, geologic hazards, environmental justice, natural resource assessment, and land-use planning.
Undergraduate Admission Requirements

Prospective students desiring to major in the Geosciences programs should enroll in as much work as possible in mathematics, English composition and sciences during their high school years.

Students transferring from other colleges or universities should have taken required non-departmental 100- and 200-level courses listed under degree programs in this catalog prior to arriving at UMKC. For example, geology students should take mineralogy during their first fall semester after transferring and should have already completed the chemistry prerequisite by that time. In addition, it would be desirable for B.S. majors to have completed a semester of calculus. To assure that students transferring from other institutions of higher education can continue in an uninterrupted plan of study in the fields of geology, geography or environmental studies, it is advisable that they acquaint themselves with the departmental degree requirements listed in this catalog as well as the two-year timetable of course offerings available from the department advisors, prior to registration.

Science and Math Division of CAS Degree Requirements

The following geosciences courses count toward the Science and Math requirements of the College of Arts and Sciences:

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td>ENV-SCI 110L</td>
<td>Understanding the Earth Laboratory</td>
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<td>ENV-SCI 110R</td>
<td>Understanding the Earth: Introduction to Environmental Science and Laboratory</td>
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<td>GEOG 203</td>
<td>Introduction to Geographic Information Systems</td>
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<td>GEOG 314</td>
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<td>GEOG 317</td>
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<td>GEOG 335</td>
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<td>GEOG 360</td>
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<td>GEOG 401</td>
<td>Advanced Geographic Information Science</td>
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<td>GEOG 402</td>
<td>Environmental Remote Sensing and Digital Image Analysis</td>
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<td>GEOG 404</td>
<td>Biogeography and Landscape Ecology</td>
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<td>GEOG 406</td>
<td>Global Environmental Change</td>
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<td>GEOG 435</td>
<td>Geoarchaeology</td>
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<td>GEOG 442</td>
<td>Quaternary Environments</td>
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<td>GEOG 444</td>
<td>Spatial Data Analysis</td>
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<tr>
<td>All Geology courses</td>
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Social and Behavioral Science Division of CAS Degree Requirements

All Geography courses except those listed above count toward the Social and Behavioral Sciences requirements of the College of Arts and Sciences.

Careers for Geography, Geology and Environmental Studies/Science Graduates

**Geography**

Students of geography at UMKC are offered a well-rounded education leading to promising career prospects; the market for geographers is global. Geography is centrally concerned with the whole range of interrelations between human beings and the natural and built environments. Geography graduates find work in commerce; government and public administration; city and regional planning; natural resource management and environmental conservation; historic preservation; landscape design; pollution control; weather-forecasting; climatological and agricultural analysis; statistical analysis; government and commercial map-making; transportation; the travel and tourism industry; market analysis and development; diplomacy; and national and international economic development programs. Experience with geographic information science (GIS) and remote sensing technologies is a great advantage in all these fields. Well-educated geographers are often involved in the crafting of policy and legislation, in the practice of law, in consulting, in publishing and in education.

**Geology**

Geology graduates have numerous employment opportunities, especially in areas relating to the environment, to engineering and to applied geology. Training in urban and environmental geology will prepare graduates to develop and evaluate environmental impacts, deal with waste management issues; model groundwater flow; handle laboratory and field instrumentation; and assess natural hazards. Geologic studies of soils, energy, mineral and water resources, and the environment are essential for private industry, as well as for governmental agencies. Graduates may also join state and federal geological surveys. The petroleum industry was for many years the principal employer of geologists. However, currently the best employment opportunities are in the area of the environment.

**Environmental Studies**

Environmental issues such as climate variation, atmospheric pollutants and non-point-source water pollution are complex issues. The general public is ill-equipped to evaluate these issues and must rely on experts. The need for environmental education and professionals in the field of the environment
has never been greater. Given these needs, employment opportunities are unlimited and are likely to remain so for decades. Specific careers available to those who hold an environmental studies degree lie with companies and agencies that deal with engineering, environmental geology, environmental law, environmental health and safety, emergency response, environmental training, environmental chemistry, politics and social issues.

**Departmental Activities**

**Advising System**
Students who wish to major in Geology, Geography or Environmental Studies should seek advice from the department at the earliest possible time. Transfer students, including those from local community colleges, should see faculty advisors in the department prior to admission to UMKC. All full-time faculty members serve as department advisors, but lead roles are designated to particular faculty for each discipline. Individuals may inquire about advising appointments at any time during the semester by phone at (816) 235-1334 or by email at geosciences@umkc.edu.

**Practicums and Internships**
The nature of the fields of atmospheric science, environmental studies, geology, and geography necessitates practical in-class and laboratory exercises; field trips and fieldwork; working seminars and independent projects of a practical nature. More explanation of specific courses can be found in the individual course descriptions. Internships are available with local organizations.

**Financial Aid and Transportation Costs**
A variety of scholarships and student financial aid alternatives are available to students accepted for regular enrollment. (See the Financial Aid website http://www.umkc.edu/finaid for more information.) Scholarships available solely to Geosciences students include the ASCE-AEG Scholarship Fund, Association of Earth Sciences Clubs Fund, Richard J. Gentile Scholarship, The Geosciences Scholarship, the Truman Stauffer Memorial Scholarship, and the Denis Ward Scholarship. Please note that certain field courses and field trips necessitate that some travel costs are at the expense of the individual student.

**Teacher Certification in Earth Science or Social Science**
Certification as a middle school (grades 5-9) or secondary (grades 9-12) Earth Science teacher in either Kansas or Missouri requires that a student complete specific requirements in Biology, Chemistry, Environmental Studies, Geology, Physics and in the School of Education. Certification as a middle school (grades 5-9) or secondary (grades 9-12) Social Science teacher in either Kansas or Missouri requires that a student complete specific requirements in History, Political Science, Economics, Geography, Behavioral Sciences and in the School of Education. A separate application for teacher education is required. For further information about the program, consult the School of Education (http://catalog.umkc.edu/colleges-schools/education) section of this catalog or contact the Education Student Services Office at (816) 235-2234.

**Faculty**

Jimmy O. Adegoke Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=adegoke); Professor of Geosciences; B.S. (Ahmadu Bello University); M.S. (University of Ibadan); Ph.D. (Pennsylvania State University).

Raymond M. Coveney, Jr. Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=coveney); Professor Emeritus of Geosciences; B.S. (Tufts University); M.S., Ph.D. (University of Michigan).

Caroline P. Davies Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=davies); Associate Professor of Geosciences; B.A. (College of William-Smith); M.S. (University of Maine); Ph.D. (Arizona State University).

Steven L. Driever Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=driever); Professor Emeritus of Geosciences; B.A. (University of Virginia); M.S. (Northwestern University); Ph.D. (University of Georgia).

Richard J. Gentile Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=gentile); Professor Emeritus of Geosciences; B.A., M.A. (University of Missouri-Columbia); Ph.D. (University of Missouri-Rolla).

Syed E. Hasan Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=hasan); Professor Emeritus of Geosciences; B.S. (Patna University); M.S. (Indian Institute of Technology, formerly Roorkee University); Ph.D. (Purdue University).

Daniel P. Hopkins Professor Emeritus of Geosciences; B.A. (Tulane University); Ph.D. (Louisiana State University)

Paul L. Hilpman Professor Emeritus of Geosciences; A.B. (Brown University); M.A., Ph.D. (University of Kansas).

Wei Ji Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=ji); Professor of Geosciences; B.S., M.S. (Peking University); Ph.D. (University of Connecticut).

Jejung Lee Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=lee); Professor of Geosciences; B.S., M.S. (Seoul National University); Ph.D. (Northwestern University).

Tina M. Niemi Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=niemi); Professor of Geosciences; B.A. (College of Wooster); M.S., Ph.D. (Stanford University).
Fengpeng Sun Contact Information (https://cf1.umkc.edu/intapps/lookup/?LastName=sun); Assistant Professor of Geosciences; B.S. (Nanjing University); M.S., Ph.D. (University of California-Irvine).

1. Associate or Adjunct Graduate Faculty
2. Members of UMKC Graduate Faculty
3. Members of UMKC Doctoral Faculty

Environmental Science Courses

ENV-SCI 110L Understanding the Earth Laboratory Credits: 2
Laboratory and field demonstration and exercises in environmental science. Weekly exercises or field trips.
ENV-SCI 110L - MOTR PHYS 110LES: Essent. Physical Sciences w/Lab

ENV-SCI 110R Understanding the Earth: Introduction to Environmental Science and Laboratory Credits: 3
This introductory course surveys the processes that shape our planet. Topics include: plate tectonics and mountain-building, rivers and oceans, atmospheric circulation, weather and climate, and the amazingly complex relationships between life on Earth and the physical environment.
ENV-SCI 110R - MOTR PHYS 110LES: Essent. Physical Sciences w/Lab

ENV-SCI 210 Issues in Environmental Science Credits: 3
Explores important environmental issues such as air and water pollution, water supply, climate change, agriculture and food supply, environmental health, ecosystem disruption, environmental management, environmental ethics, and energy resources. Topics may vary depending on current events.

ENV-SCI 220 Ecosystem Science for Decision Makers Credits: 3
This course addresses the fundamentals of ecosystem science with an emphasis on human-induced change in natural systems. Course content characterizes the biological patterns found in nature emphasizing application of underlying principles. Scientific tools are provided to evaluate ecosystem concerns and make informed decisions.

ENV-SCI 303 Weather and Climate Credits: 4
Overview of weather processes and the main components of the climate system. Emphasis is on the physical basis of daily weather patterns, seasonal climate variability and longer-term climate change at local, regional, and global scales. The theme throughout the course will be the importance of weather and climate as major drivers of environmental change.
Prerequisites: ENV-SCI 110R or GEOLOGY 220.

ENV-SCI 310 Field Experience in Waste Management Credits: 2-3
This course provides an overview of waste management issues, including nature, classification and disposal of various wastes, and U.S. laws governing the management of solid, hazardous, biologic and nuclear waste. Lectures and discussions will be supplemented by visits to waste management facilities to study methods and technologies used for treatment and disposal of wastewater, solid, hazardous, and biologic wastes. This field-intensive course includes travel to neighboring states and includes an overnight out-of-town stay. Final report required.

ENV-SCI 310 Field Experience in Waste Management Credits: 2-3
This course provides an overview of waste management issues, including nature, classification and disposal of various wastes, and U.S. laws governing the management of solid, hazardous, biologic and nuclear waste. Lectures and discussions will be supplemented by visits to waste management facilities to study methods and technologies used for treatment and disposal of wastewater, solid, hazardous, and biologic wastes. This field-intensive course includes travel to neighboring states and includes an overnight out-of-town stay. Final report required.

ENV-SCI 321 Climate Change Impact Assessment and Policy Response Credits: 3
This course introduces how scientists assess observed climate change and predict future climate change. Lectures, discussions, problem sets, and term papers help students explore interactions among climate change, human activities and policy responses. It helps students achieve an appreciation for the role of accurate scientific information as foundation for shaping political agreements and policies on climate change.
Prerequisites: ENV-SCI 110R.

ENV-SCI 332CZ Environmental Sustainability Credits: 3
This course will introduce the concept of sustainability and review how sustainability might work at the individual, neighborhood, state, nation and global scales. Students will participate in some form of community engagement on sustainability as well as reflect upon how their own practices impact the environment.

ENV-SCI 416 Understanding and Living with Volcanoes Credits: 3
This course will examine the distribution, tectonic setting, and morphology of a range of volcano types on Earth and a few examples from other planets. Students will study volcanic processes including explosive and passive processes and how we investigate them. This will involve discussion of volcanic hazards and hazard assessment, risk communication, and the challenges of volcanic crises response. The course will also cover how volcanoes impact the local and global economy and Earth's climate. Recommended preparation: GEOG 314 / GEOLOGY 314 or GEOLOGY 325 or GEOLOGY 342.
Prerequisites: GEOLOGY 220 or ENV-SCI 110R/ENV-SCI 110L, and GEOG 203 or GEOG 402.
ENV-SCI 449 Global Water and Sustainability Credits: 3
This course examines the physical characteristics of water and its role in Earth systems. The challenges facing societies in an era of rapidly-changing climate are explored.

ENV-SCI 496 Environmental Internship Credits: 1-4
Students obtain practical experience working for local engineering and environmental firms, or governmental agencies. Specific duties and application requirements will vary depending on the funding organization’s needs. Junior or senior standing required for undergraduates.

ENV-SCI 5550 Ecotoxicology Credits: 3
This course addresses the fundamentals of ecotoxicology, integrating the sciences of ecology and toxicology. Students will learn the biological basis for pollutant effects on individuals and populations of plants and animals, how pollutant intensity varies as a function of bioavailability, the basics of risk assessment, and how pollutant effects are modified by ecological interactions within communities and ecosystems. The ultimate goal of ecotoxicology is to predict the effects of pollution within an ecological context.
Prerequisites: BIOLOGY 108, CHEM 211, CHEM 212R.

Environmental Studies Courses
ENV-STDY 325 Cultural Perspectives on the Environment Credits: 3
This course explores the history of conservation practices in American agriculture from the 1700s through the present. Additionally, the course examines the past and present legal implications of environmental statutes for minority farmers from a social and environmental justice perspective.

ENV-STDY 334 Gender and the Environment Credits: 3
This course provides a survey of different ways women relate to nature. The objectives of the course are: to understand historical relationships between women and nature in the western world, to understand different theoretical approaches to studying women and nature, to explore the geography of women’s activism on behalf of the environment, and to understand how women’s health is linked to the environment.

ENV-STDY 412 Global Tourism Credits: 3
This course is a regional survey of world tourism. Topics include the uniqueness of place, the marketing of tourist destinations, and the cultural, economic, and environmental impacts on host societies.
Prerequisites: GEOG 105 or GEOG 200 or GEOG 202.

ENV-STDY 430 Soil and Groundwater Remediation Credits: 3
Prerequisites: GEOG 335 (or GEOLOGY 335).

ENV-STDY 450 Ecotoxicology Credits: 3
This course addresses the fundamentals of ecotoxicology, integrating the sciences of ecology and toxicology. Students will learn the biological basis for pollutant effects on individuals and populations of plants and animals, how pollutant intensity varies as a function of bioavailability, the basics of risk assessment, and how pollutant effects are modified by ecological interactions within communities and ecosystems. The ultimate goal of ecotoxicology is to predict the effects of pollution within an ecological context.
Prerequisites: BIOLOGY 108, CHEM 211, CHEM 212R.

ENV-STDY 499WI Environmental Studies Practicum Credits: 3
Students conduct research, participate in discussions, and prepare written reports on selected topics concerning the environment.
Prerequisites: Senior standing, RooWriter.

Geography Courses
GEOG 105 Introduction to the Elements of Geography Credits: 3
A survey of major elements of physical and human geography, with a concise overview of the world’s regions. Emphasis on global relationships and distributions, both environmental and cultural. Climates, natural vegetation, land forms, cultural origins and diffusions, economic patterns.
GEOG 105 - MOTR GEOG 101: World Regional Geography

GEOG 150 Introduction to Physical Geography Credits: 3
This course is an introduction to the study of the natural environmental systems of earth—the atmosphere, the hydrosphere, the biosphere, and the lithosphere. The primary objective of the course is to provide a broad overview of these systems at a global scale. This overview will entail descriptions of natural systems and the variations they exhibit both from place to place and through time. It will also entail explaining how natural systems operate and interact with each other, thereby providing a necessary foundation for understanding the tremendously diverse physical geography of earth. Applies to natural science requirement.
GEOG 150 - MOTR GEOG 100: Physical Geography
GEOG 200 World Geography I Credits: 3
A survey of the physical and human geography of the regions and nations of Europe and the Americas, with Australia and New Zealand. The approach is strongly historical, emphasizing interconnections, shared colonial backgrounds and broader global contexts in the modern world. The course is aimed at non-specialists.

GEOG 202 World Geography II Credits: 3
A survey of the physical and human geography of the regions and nations of Russia and the other former Soviet republics, the Middle East, Africa, South Asia, East Asia Southeast Asia and the Pacific Realm. The approach is strongly historical emphasizing interconnections shared colonial backgrounds, and broader global contexts in the modern world. The course is aimed at non-specialists.

GEOG 203 Introduction to Geographic Information Systems Credits: 4
An introductory course covering the basic principles of geographic information systems focusing on such software programs as ARC-INFO and ARC-VIEW.

GEOG 210 Human Geography Credits: 3
A study of the geographical underpinnings and distribution of the main elements of culture, including population patterns, language, religion, political territorial organization, settlement, and economic livelihood. The environmental settings, geographic origins, diffusion, and geographic interrelationships of these culture traits are emphasized.

GEOG 203 Weather and Climate Credits: 4
Overview of weather processes and the main components of the climate system. Emphasis is on the physical basis of daily weather patterns, seasonal climate variability and longer-term climate change at local, regional, and global scales. The theme throughout the course will be the importance of weather and climate as major drivers of environmental change.

Prerequisites: ENV-SCI 110R or GEOLOGY 220.

GEOG 209 Urban Geography Credits: 3
Historical development, morphology and functions of urban places, including intercity relationships and the relationship between cities and their hinterlands; emphasis on American cities.

GEOG 311 Economic Geography Credits: 3
A systematic study of the modern world economy that includes discussion of the location of production and consumption, the nature and role of multinational enterprises in trade, resource limitations to growth, and cultural responses to globalization.

GEOG 314 Principles of Geomorphology Credits: 4
Explores the processes that shape the earth’s surface. Focuses on the development and description of fluvial, glacial, eolian, and coastal landforms. Studies the influence of tectonic and climatic factors. Field trip.

Prerequisites: ENV-SCI 110R (or GEOLOGY 220).

GEOG 317 Cartography Credits: 4
Design and preparation, by hand and computer, of informative, effective, and attractive maps and other graphics for various geographical purposes, especially term papers, thesis, and public presentations. Lectures, discussion, and laboratory.

GEOG 321 Climate Change Impact Assessment and Policy Response Credits: 3
This course introduces how scientists assess observed climate change and predict future climate change. Lectures, discussions, problem sets, and term papers help students explore interactions among climate change, human activities and policy responses. It helps students achieve an appreciation for the role of accurate scientific information as foundation for shaping political agreements and policies on climate change.

Prerequisites: ENV-SCI 110R.

GEOG 325 Cultural Perspectives on the Environment Credits: 3
This course explores the history of conservation practices in American agriculture from the 1700s through the present. Additionally, the course examines the past and present legal implications of environmental statutes for minority farmers from a social and environmental justice perspective.

GEOG 329 World Political Geography Credits: 3
An analysis of the influence of geographic factors (both physical and human) on the economic and political relationships of the nations of the world. Emphasis will be placed on population size and political viability of states, boundaries and frontiers as limits of national space, problems related to the spatial integration of states, and the independence and interdependence of states within the larger world political system.

GEOG 332 Cultural Geography Credits: 3
A study of the distribution and interpretation of cultural patterns throughout the world. Examined are material and non-material elements of culture such as settlement, land use, technology and belief systems. The geographic origins and diffusion of culture traits are emphasized.

GEOG 333 Geographic Elements of Urban Planning Credits: 3
Analysis of the changing form and structure of urban places from a planning viewpoint. The focus will be on land-use trends on both the intraurban and interurban levels. Covered will be such topics as planning for urban transportation, new towns, land-use planning, urban renewal, and environmental planning.
GEOG 334 Gender and the Environment Credits: 3
This course provides a survey of different ways women relate to nature. The objectives of the course are: to understand historical relationships between women and nature in the western world, to understand different theoretical approaches to studying women and nature, to explore the geography of women’s activism on behalf of the environment, and to understand how women’s health is linked to the environment.

GEOG 335 Introduction to Waste Management Credits: 3
Prerequisites: ENV-SCI 110R, GEOG 150, GEOLOGY 220.

GEOG 336 Principles of Soil Science Credits: 3
Study of genesis, evolution, distribution and classification of soils. Analysis of soil-forming materials and processes. Lecture, discussion and laboratory.
Prerequisites: ENV-SCI 110R, GEOLOGY 220.

GEOG 340 Geography of the United States and Canada Credits: 3
A survey of the physical and human geography of the United States and Canada. The approach is strongly historical emphasizing interconnections, shared colonial backgrounds, and broader international contexts in the Americas and around the globe. This course is aimed at non-specialists.

GEOG 341 Geography of South America Credits: 3
A study of the physical and human geography of South America, with an emphasis on cultural processes and the historical record. Contemporary issues such as economic development, trade, urbanization, and geopolitical conflicts are discussed.

GEOG 342 Geography of Mexico, Central America and the Caribbean Credits: 3
A study of the physical and human geography of Middle America, with an emphasis on cultural processes and the historical record. Contemporary issues such as economic development, trade urbanization, and geopolitical conflicts are discussed.

GEOG 350 Geography of Europe Credits: 3
A survey of the physical and human geography of the regions and nations of Europe. The approach is strongly historical, emphasizing international interconnections and broad global contexts. The course is aimed at non-specialists.

GEOG 351 Regional Geography of the Middle East Credits: 3
A study of human imprint upon the land through settlement patterns, institutions of land organization, and types of economy. Strategies for the economic development of various regions in the Middle East are discussed.

GEOG 360 Principles of Biogeography Credits: 4
This course is an introduction to biogeography that explores the patterns of plant and animal distributions from both ecological and historical perspectives. We examine past geologic and climatic conditions, as well as interactions between organisms and their environment to explain modern distributions of flora and fauna. Human interactions with plants and animals have increasingly profound consequences on distributions of flora and fauna from destruction to management. We explore the increasing importance of issues and strategies in conservation. The laboratory portion of the course builds on core ecological concepts and provides experiences of field observation, data collecting and data analysis.
Prerequisites: ENV-SCI 110R.

GEOG 398 Field Trip Credit: 1
Three-day field trip in March or April (at student’s expense) for department majors. An opportunity to observe and study physical and cultural features and collect materials. Brief descriptive report of trip required. Recommended preparation: 6-9 hours of upper-level geography.

GEOG 401 Advanced Geographic Information Science Credits: 4
This course is designed for the students knowledgeable in the fundamentals of geographic information systems, who wish to gain expertise in advanced topics and applications in geographic information systems, remote sensing, and related environmental informatics. Classes are organized to encourage active learning. Students are encouraged and guided to develop their research projects by integrating related techniques of geographic information science.
Prerequisites: GEOG 203 or GEOG 450.

GEOG 402 Environmental Remote Sensing and Digital Image Analysis Credits: 4
This course will provide students with innovative techniques for landscape-level environmental analysis, geographic and geological studies, earth science research, and environmental resources management using remotely sensed data including satellite images. Students will be taught basic remote sensing concepts and technical skills, including energy radiative transfer processes in remote sensing, sensors and resolutions, computer-based image processing and classification, and remote sensing/GIS integration.
Prerequisites: GEOG 203 or GEOG 450.
GEOG 403WI History and Philosophy of Geoscience Credits: 3
A survey of geoscientific thought since antiquity. The substance of geography, geology, and environmental studies will be sought primarily in scholarly treatise and formal analytical systems including cartography, but the course also addresses geoscientific principles emerging from the history of environment, government, law, economy, religion, literature, and material culture. Readings, lectures, discussions, research, writing. **Prerequisites:** RooWriter.

GEOG 404 Biogeography and Landscape Ecology Credits: 3
Principles and applications of biogeography and landscape ecology, emphasizing distribution of major ecosystems and related plants and animal species on earth, biodiversity, landscape patterns and processes, and physical, biological, and human interactions. The course explores ecosystem and landscape analyses using advanced GIS, remote sensing, and spatial modeling methods for real problem solving in environmental and biological research, ecosystem conservation, and urban planning and studies. **Prerequisites:** GEOG 203, GEOG 402 (or GEOG 5502).

GEOG 406 Global Environmental Change Credits: 3
This course will examine the current rates of global environmental change and potential causes in the context of Earth's natural climate variability. The course will follow a seminar format. Students will read and discuss published articles on current and emerging theories of forcing mechanisms in the Earth's systems.

GEOG 412 Global Tourism Credits: 3
This course is a regional survey of world tourism. Topics include the uniqueness of place, the marketing of tourist destinations, and the cultural, economic, and environmental impacts on host societies. Recommended preparation: GEOG 105 or GEOG 200 or GEOG 202.

GEOG 416 Understanding and Living with Volcanoes Credits: 3
This course will examine the distribution, tectonic setting, and morphology of a range of volcano types on Earth and a few examples from other planets. Students will study volcanic processes including explosive and passive processes and how we investigate them. This will involve discussion of volcanic hazards and hazard assessment, risk communication, and the challenges of volcanic crises response. The course will also cover how volcanoes impact the local and global economy and Earth's climate. **Prerequisites:** GEOLOGY 220 or ENV-SCI 110R/110L, and GEOG 203 or GEOG 402.

GEOG 417 Special Topics Credits: 1-3
Individual research and study of a selected topic in geography, meteorology or earth science.

GEOG 426 Paleoecology. Microfossils and Climate Change Credits: 3
Paleoecology will focus on questions addressing past environments and past climates based on the ecology of microfossils. Micro-organisms are very sensitive to a wide variety of environmental conditions including temperature, precipitation, hydrology, water chemistry, salinity, habitat, and pollution. The fossil remains of these organisms are used as proxy indicators for reconstructing past environmental conditions, climate change, vegetation dynamics, and human impacts. Students will have the opportunity to process microfossils and make interpretations based on analysis data.

GEOG 430 Energy Resources Credits: 3
This course covers the distribution, origin, and utilization of all types of energy. Topics include exploration, production, storage, transportation and conservation of carbon-based fuels, hydrologic, nuclear energy, and alternate energy sources such as solar, wind, geothermal, and hydrogen. **Prerequisites:** ENV-SCI 110R (or GEOLOGY 220).

GEOG 435 Geochronology Credits: 3
This course examines geochronological and archaeological methods used in reconstructing sites, settlement patterns, and paleoenvironments. Explores dating methods, soils, and stratigraphy as tools for studying landscape evolution and human occupation. **Prerequisites:** GEOG 314 (or GEOLOGY 314).

GEOG 437 Population Geography Credits: 3
This course analyzes human populations: how they grow, how their compositions change, and how and why people migrate from one place to another. Students will study basic demographic processes- mortality, fertility, and migration-and underline theory and techniques. Students will also examine relationships between population growth and population planning, immigration, urbanization and cities, and the environment.

GEOG 442 Quaternary Environments Credits: 3
This course reviews earth climatic history and focuses on major mechanisms for global and regional climate change. Methods of paleoclimatic reconstruction are examined, including analysis of proxy data and climate modeling. Application of these methods toward prediction of future climate change is also explored. Recommended preparation: GEOG 314 or GEOLOGY 314.

GEOG 444 Spatial Data Analysis Credits: 4
Quantitative techniques and applications of spatial data analysis. The course will cover basic geospatial analysis techniques including hypothesis testing, kriging, variogram analysis, multivariate analysis and reliability analysis. Emphasis is on practical applications rather than theories. Intended for Geology, Geography, Environmental Studies, and relevant fields. Three hours lecture and one hour computer lab per week.
GEOG 448 Satellite Climatology Credits: 4
Use of satellite observations to study the climate system. Discussions consider the development of satellite climatology, sensors, platforms and methodologies used to estimate climate variables from radiance measurements. Aspects of climate that are emphasized include cloud climatologies, cloud systems, atmospheric moisture, radiation budget, and land-surface conditions. Three hours lecture and one hour lab per week.
Prerequisites: GEOG 303.

GEOG 449 Global Water and Sustainability Credits: 3
This course examines the physical characteristics of water and its role in Earth systems. The challenges facing societies in an era of rapidly changing climate are explored.

GEOG 450 GIS Fundamentals for Research Applications Credits: 4
This course will address the needs of upper level undergraduate and graduate students who desire to learn and apply fundamental Geographic Information Systems concepts and techniques for their research projects. This course will draw on the content of the Introductory GIS course offered by the department but will also be flexible such that the individual needs or interest of students can be met through guided reading and/or tailored laboratory sessions. The Department of Geosciences GIS computer laboratory, with a variety of GIS and Remote Sensing software, will be available for this course. Only for upper-level undergraduate and graduate students.

GEOG 457 North American Prehistory Credits: 3
This class offers instruction in the archaeological survey of prehistoric North America from the Arctic to northern Mexico. The course outlines cultural developments within this region form the peopling of the Americas near the end of the last Ice Age to the arrival of Europeans more than 10,000 years later. The diversification of Native American societies across this time span is examined in relation to social and environmental challenges, including the transformation of hunter-gatherer groups into chiefdoms and complex agricultural societies.

GEOG 460 Transportation Geography Credits: 3
Relation between transportation and spatial organization, selected analytical models dealing with traffic demand, network configuration, and allocation of transport facilities; application to specific problem areas including commuting. Seminar with discussions of briefs and term paper.

GEOG 496 Geography Internship Credits: 1-6
Students obtain directed practical experience working with non-profits, governments, or private enterprises. Duties will vary based on contractual agreement between the student, host organization, and the professor.
Prerequisites: Junior standing or higher.

GEOG 499WI Geography Seminar Credits: 3
Students critique geographic research and prepare a paper and an oral presentation on an approved topic.
Prerequisites: Senior standing, RooWriter.

GEOG 5502 Environmental Remote Sensing and Digital Image Analysis Credits: 4
This course will provide students with innovative techniques for landscape-level environmental analysis, geographic and geological studies, earth science research, and environmental resources management using remotely sensed data including satellite images. Students will be taught basic remote sensing concepts and technical skills, including energy radiative transfer processes, in remote sensing, sensors and resolutions, computer-based image processing and classification, and remote sensing/GIS integration.
Prerequisites: GEOG 203.

GEOG 5503WI History and Philosophy of Geoscience Credits: 3
A survey of geoscientific thought since antiquity. The substance of geography will be sought primarily in scholarly treatises, formal analytical systems, and cartography, but the course also addresses geographical principles emerging from the history of such matters as government, law economy, religion, and material culture. Readings, lectures, discussions, research, writing.
Prerequisites: RooWriter.

GEOG 5504 Biogeography and Landscape Ecology Credits: 3
Principles and applications of biogeography and landscape ecology, emphasizing distribution of major ecosystems and related plants and animal species on earth, biodiversity, landscape patterns and processes, and physical, biological, and human interactions. The course explores ecosystem and landscape analyses using advanced GIS, remote sensing, and spatial modeling methods for real problem solving in environmental and biological research, ecosystem conservation, and urban planning and studies.
Prerequisites: GEOG 203, GEOG 402 (or GEOG 5502).

GEOG 5506 Global Environmental Change Credits: 3
This course will examine the current rates of global environmental change and potential causes in the context of Earth's natural climate variability. The course will follow a seminar format. Students will read and discuss published articles on current and emerging theories of forcing mechanisms in the Earth's systems. Additional in-depth research and written evaluation are required for graduate credit.

GEOG 5507 Advanced Geographic Information Science Credits: 4
Prerequisites: GEOG 203.
GEOG 5508 Archaeological Field Survey Methods Credits: 3
This class offers instruction in the basic skills required to conduct field surveys in archaeology and other geosciences disciplines. In the classroom, students learn about the development of archaeology as a scientific discipline and how to recognize some of the basic field data sought by archaeologists. Students earn about mapping and land navigation techniques. The field phase of instruction includes visits to archaeological sites in the region.

GEOG 5509 Urban Geography Credits: 3
Historical development, morphology and functions of urban places, including intercity relationships and the relationship between cities and their hinterlands; emphasis on American cities. Students will complete a series of reports and a term paper.

GEOG 5510 Landscape, Language, Literature, and Law Credits: 3
An examination of the geographic underpinnings and implications of languages, literatures, and jurisprudence. The course explores languages' historic rootedness in the interactions between human beings and their surroundings; the varying geographic expressiveness and discrimination of languages; the effect and significance of literary evocations of landscapes; and the cultural and environmental geographic content of the language of law. Readings, lectures, discussions, writing.

GEOG 5512 Global Tourism Credits: 3
This course is a regional survey of world tourism. Topics include the uniqueness of place, the marketing of tourist destinations, and the cultural, economic, and environmental impacts on host societies.
**Prerequisites:** GEOG 105 (or GEOG 200, or GEOG 202).

GEOG 5515 History and Philosophy of Cartography Credits: 3
An examination of the techniques, assumptions, psychology, and cultural implications of mapping from the Stone Age to the age of satellites and the computerized Geographic Information System. Readings, lectures, discussions, writing.
**Prerequisites:** Baccalaureate degree.

GEOG 5526 Paleocology: Microfossils and Climate Change Credits: 3
Paleocology will focus on questions addressing past environments and past climates based on the ecology of microfossils. Micro-organisms are very sensitive to a wide variety of environmental conditions including temperature, precipitation, hydrology, water chemistry, salinity, habitat, and pollution. The fossil remains of these organisms are used as proxy indicators for reconstructing past environmental conditions, climate change, vegetation dynamics, and human impacts. Students will have the opportunity to process microfossils and make interpretations based on analysis of data.

GEOG 5530 Location Theory Credits: 3
An analysis and evaluation of the basic theories that have been developed to account for the spatial arrangements of economic activity. Emphasis on urban areas as nodes of economic interaction. Three hours lecture and discussion per week.
**Prerequisites:** GEOG 311, six hours in economics or urban studies.

GEOG 5535 Geoarchaeology Credits: 3
This course examines geomorphological and archaeological methods used in reconstructing sites, settlement patterns, and paleo-environments; evaluating archeological site integrity; and assessing the impact of development, with the emphasis on geomorphological evidence. No archaeological background necessary.
**Prerequisites:** GEOG 150, GEOG 314.

GEOG 5537 Population Geography Credits: 3
An analysis of human population: how they grow, their changing compositions, and how and why people migrate from one place to another. Basic demographic processes-mortality, fertility, and migrate- and theory and techniques for their study are discussed. The relationships between population growth and population planning, immigration, urbanization and cities, and the environment.

GEOG 5542 Quaternary Environments Credits: 3
This course reviews earth climatic history and focuses on major mechanisms for global and regional climate change. Methods of paleoclimatic reconstruction are examined, including analysis of proxy data and climate modeling. Application of these methods toward prediction of future climate change is also explored.
**Prerequisites:** GEOG 314 (or GEOLOGY 314).

GEOG 5544 Advanced Spatial Data Analysis Credits: 4
This course will focus on advanced computation methods for the analysis and modeling of complex and often non-deterministic processes in the spatial and environmental sciences. Students will be introduced to innovative techniques for analyzing large datasets with attribute spaces of very high dimensionality, including hyper-spectral remote sensing data. Three hours lecture and one hour computer lab per week.
**Prerequisites:** GEOG 444, elementary statistics, or permission of instructor.

GEOG 5546 Global Water and Sustainability Credits: 3
This course examines the physical characteristics of water and its role in Earth systems. The challenges facing societies in an era of rapidly changing climate are explored.
GEOG 5548 Satellite Climatology Credits: 4
Use of satellite observations to study the climate system. Discussions consider the development of satellite climatology, sensors, platforms and methodologies used to estimate climate variables from radiance measurements. Aspects of climate that are emphasized include cloud climatologies, cloud systems, atmospheric moisture, radiation budget, and land-surface conditions. Three hours of lecture and one hour of lab per week.

GEOG 5597 Graduate Seminar in Geosciences Credits: 3
This graduate seminar examines emerging and current issues in Environmental and Urban Geosciences. Most environmental issues and their solutions are inherently multidisciplinary and are characterized by significant interactions between oceans, atmosphere, land, and society. In addition to examining these issues, this seminar engages students in the process of critically evaluating Earth and human systems studies. The course provides students with a fundamental background of today's important environmental challenges and experience doing the craft of science through critically reading, thinking, writing, and speaking.

GEOG 5598 Special Topics in Geography Credits: 1-3
Advanced independent research in Cultural or Physical Geography.
Prerequisites: Baccalaureate degree.

GEOG 5598A Special Topics in Cultural Geography Credits: 1-3
Advanced independent research in Cultural Geography.
Prerequisites: Baccalaureate degree.

GEOG 5598B Special Topics in Physical Geography Credits: 1-3
Advanced independent research in Physical Geography.
Prerequisites: Baccalaureate degree.

GEOG 5598D Special Topics in Advanced GIS and Remote Sensing Credits: 1-3
Advanced independent research in geographic information science (GIS) and remote sensing.

GEOG 5598F Special Topics: Geostatistics and Modeling Credits: 1-3
Advanced independent research in geostatistics and modeling techniques.

GEOG 5598K Issues in Waste Management Credit: 1
This course focuses on the critical problems of managing the waste materials generated in our society. The course includes discussion of various types of waste-municipal solid waste, hazardous (industrial) waste, nuclear and medical wastes. Sources, handling, storage, transportation, treatment and disposal of these wastes are reviewed. Experts from government and the waste management industry give guest lectures.

GEOG 5599 Research and Thesis Geography Credits: 1-9
Students will conduct research and writing in support of a thesis topic, which will have been approved in advance by the appropriate graduate advisory committee. Credit load will also be approved in advance by the student's graduate advisor.
Prerequisites: Baccalaureate degree.

GEOG 5690 Special Research Topics Credits: 1-3
Student will produce a major research paper suitable for publication under the direction of their instructor.

GEOG 5699R Research And Dissertation Credits: 1-10
Research for dissertation in partial fulfillment of the Geosciences requirements for the Ph.D. degree.

Geology Courses

GEOLOGY 220 General Geology Credits: 3
Geology is the study of Earth, the materials that make up the Earth, and the forces and processes that build and shape the continents, oceans, and life on Earth. The goal of this course is for students to gain an understanding of the fundamental concepts and scientific principles that underlie the physical, chemical, and biological processes that shape our Earth and to learn to think critically about scientific information and how geologic processes affect us every day.

GEOLOGY 220 - MOTR GEOL 100: Geology

GEOLOGY 220L General Geology Laboratory Credits: 2
Laboratory and field investigations of principles of the geology designed to complement the topics covered in GEOLOGY 220 through the use of inquiry-based investigations in the laboratory and field.
GEOLOGY 250L Field Methods in Earth and Environmental Science Credits: 3
A field-based course covering basic methods used by earth scientists for environmental, geographic, and geologic investigations. Students will collect field data at off-campus sites, conduct periodic monitoring, and analyze samples using departmental and personal instrumentation. Students will work on collaborative projects and will present their results. Class will meet weekly for four hours in the field.
Prerequisites: ENV-SCI 110R (or GEOLOGY 220), ENV-SCI 110L (or GEOLOGY 220L).

GEOLOGY 251L Field Methods in Earth and Environmental Science: Off-Campus Credits: 3
This course will provide students with an introductory, inquiry-based learning experience that focuses on the application of field methods for understanding surface and subsurface earth processes and environmental issues. Students will collect field data at off-campus sites, conduct periodic monitoring, and analyze samples using departmental instrumentation. Students will work on collaborative projects and will present their results. Class will meet at an off campus location during break (added cost) plus have four on campus meetings. Prerequisites: GEOLOGY 220 (or ENV-SCI 110R), GEOLOGY 220L (or ENV-SCI 110L).

GEOLOGY 303 Weather and Climate Credits: 4
Overview of weather processes and the main components of the climate system. Emphasis is on the physical basis of daily weather patterns, seasonal climate variability and longer-term climate change at local, regional, and global scales. The theme throughout the course will be the importance of weather and climate as major drivers of environmental change.
Prerequisites: ENV-SCI 110R or GEOLOGY 220.

GEOLOGY 312 Mineralogy Credits: 4
Introduction to crystallography, mineral chemistry and the systematic classification and identification of minerals. Three hour lecture and discussion with two hours laboratory a week.
Prerequisites: CHEM 212R, GEOLOGY 220.

GEOLOGY 313 Evolution and the Geologic Record Credits: 4
An introduction to the history of life by studying the geologic record. Students will examine major features of the fossil record including: invertebrates, vertebrates, and plants. Students explore what the fossil record tells us about geologic time, evolution, past environments and distributions of organisms. Three hours of lecture and two hours of laboratory a week. The course will include field trips to collect and interpret fossils and paleoenvironments.
Prerequisites: ENV-SCI 110R or GEOLOGY 220.

GEOLOGY 314 Principles of Geomorphology Credits: 4
Explores the processes that shape the earth's surface. Focuses on the development and description of fluvial, glacial, eolian, and coastal landforms. Studies the influence of tectonic and climatic factors. Three hours lecture and two hours lab per week. Field trip.
Prerequisites: ENV-SCI 110R or GEOLOGY 220.

GEOLOGY 321 Climate Change Impact Assessment and Policy Response Credits: 3
This course introduces how scientists assess observed climate change and predict future climate change. Lectures, discussions, problem sets, and term papers help students explore interactions among climate change, human activities and policy responses. It helps students achieve an appreciation for the role of accurate scientific information as foundation for shaping political agreements and policies on climate change.
Prerequisites: ENV-SCI 110R.

GEOLOGY 325 Sedimentology/Stratigraphy Credits: 4
Study of sedimentary rocks with special emphasis given to hand specimen identification based on mineral composition and textural features. Characteristics of sediments, transportation and environment of sediment deposition. Principles of stratigraphy, facies analysis and interpretation. Measurement and description of stratified rocks. Three hours lecture and two hours lab per week. Field trips.
Prerequisites: GEOLOGY 220.

GEOLOGY 326CZ Archaeology of Ancient Disasters Credits: 3
Remarkable human achievements are revealed by archaeological research, but the human past was frequently shaped as well by disasters of natural and human origin. Drawing on case studies that include data from the geosciences, archaeological excavations, and historical sources, this class examines how earth processes, the biosphere, and human cultural behavior were all sources of catastrophe. The study of ancient disasters not only gives us a wider understanding of human history, it may offer lessons for coping with future catastrophes.

GEOLOGY 335 Introduction to Waste Management Credits: 3
Prerequisites: ENV-SCI 110R, GEOG 150, GEOLOGY 220.
GEOLOGY 342 Igneous and Metamorphic Petrology Credits: 4
Introduction to the principles governing the classification, occurrence and origins of igneous and metamorphic rocks. Three hours lecture and discussion with two hours laboratory a week.
Prerequisites: GEOLOGY 312.

GEOLOGY 350 Earth Structures and Tectonics Credits: 4
This course is designed to teach students the basic techniques and approaches for problem solving in structural geology. The course will cover the fundamentals of crustal deformation and discuss joints, faulted and folded rocks in their plate tectonic context. Two hours of lectures and three hours of laboratory a week. Course will include local field trips and one weekend field trip.
Prerequisites: GEOLOGY 220, PHYSICS 210 (or PHYSICS 240).

GEOLOGY 370R Hydrogeology Credits: 3
Geology and hydrologic factors controlling the occurrence, movement, quality, recovery and development of water supply and distribution. Problems relating to urbanization of flood plains.

GEOLOGY 398 Geology Midcontinent Field Trip Credit: 1
A study of a selected area of the midcontinent U.S. with emphasis on locations to be visited during a three-day field trip (at the student's expense). An opportunity to observe and study physical features and collect materials. Several scheduled one-hour meetings in addition to field trip. Lectures, discussion and reading assignments provide a background to place the area covered by the field trip into the overall geologic framework of the Midcontinent U.S. Descriptive report or written examination. Limited enrollment.
Prerequisites: Junior or senior level.

GEOLOGY 407 Archaeological Resources Management Credits: 3
This class examines contemporary issues managing archaeological resources. This class is intended for students seeking work in Cultural Resources Management (CRM), those already working CRM, or student anthropology, environmental studies, geology, geography, public administration and other fields likely to deal with archaeological and historical resources in a research or employment setting. This class does not require a background in archaeology.

GEOLOGY 408 Archaeological Field Survey Methods Credits: 3
This course offers instruction in the basic skills required to conduct field surveys in archaeology and other geosciences disciplines. In the classroom, students learn about the development of archaeology as a scientific discipline and how to recognize some of the basic field data sought by archaeologists. Students learn about mapping and land navigation techniques. The field phase of instruction includes visits to archaeological sites in the region.

GEOLOGY 409 Field School in Archaeology Credits: 1-5
This class offers students an opportunity to attend a field school in archaeology. Students will be taught how to: design archaeological research, set-up excavation, keep a wide range of excavation records, make maps and drawings, take photographs related to excavation problems, identify and receiver a broad spectrum if artifact and faunal remains, collect samples for specialized analysis and use a wide range of excavation tools. This course will also introduce students to recording and analyzing excavated materials in the archaeological laboratory. Class size limited to 20 students.

GEOLOGY 411 Mineral Deposits Credits: 3
Distribution, origin and environmental implications of extractable resources including non-metallic deposits, ores, and selected energy resources.

GEOLOGY 416 Understanding and Living with Volcanoes Credits: 3
This course will examine the distribution, tectonic setting, and morphology of a range of volcano types on Earth and a few examples from other planets. Students will study volcanic processes including explosive and passive processes and how we investigate them. This will involve discussion of volcanic hazards and hazard assessment, risk communication, and the challenges of volcanic crises response. The course will also cover how volcanoes impact the local and global economy and Earth's climate. Recommended preparation: GEOG 314 / GEOLOGY 314 or GEOLOGY 325 or GEOLOGY 342.
Prerequisites: GEOLOGY 220 or ENV-SCI 110R/110L, and GEOG 203 or GEOG 402.

GEOLOGY 434 Hazardous Waste Operations Management Credits: 2
Overview of federal regulations dealing with hazardous waste management, toxicology, hazard communication, site management, air monitoring, operating procedures, and health and safety. The course includes hands-on training on spill control, equipment use and emergency response. Practical training involves physical stress and participants must be in good physical health. This course satisfies OSHA’s 40 hour training requirement for hazardous waste personnel.

GEOLOGY 441 Environmental Geophysics Credits: 3
Fundamental theory and near-surface applications of the geophysical methods; (1) seismic refraction, (2) seismic reflection, (3) gravity, and (4) magnetics. Emphasis will be placed on the use of these methods in environmental and engineering investigations, addressing such issues as water resources, contaminant transport, geotechnical properties and archaeological protection. Course will include a field component illustrating application of selected techniques to local environmental problem.

GEOLOGY 446 Petroleum Geology Credits: 3
Study of the origin, concentration, exploration for and recovery of petroleum.
Prerequisites: GEOLOGY 220.
GEOLOGY 456 Field Methods in 3D Imaging of the Environment Credits: 3
This course is designed to teach students techniques to create high-resolution, 3D images of the environment and detailed topographic maps using digital technologies. The class will include instruction on various aerial systems and hand-held photography and the software required for data acquisition, processing, and interpretation.

GEOLOGY 460 Introduction to Geochemistry Credits: 3
Basic principles governing the origin, distribution and migration of the elements and the geochemical cycles operating in the earth's atmosphere, hydrosphere and lithosphere.
Prerequisites: CHEM 212R, GEOLOGY 312.

GEOLOGY 471 Tectonics Credits: 3
A detailed inquiry into plate tectonics and the geophysical and geological data that define the motion of lithospheric plates. Global examples of divergent, convergent, and transform plate boundaries will be studied through lectures, discussions, problem sets, and term papers.
Prerequisites: GEOLOGY 325, GEOLOGY 350.

GEOLOGY 472 Earthquake Geology Credits: 3
A detailed inquiry into the study of present and past earthquakes as they are preserved in the seismological, geophysical, and geologic record. Global examples of earthquakes will be studied through lectures, discussions, problem sets, term papers, field trips and field projects.

GEOLOGY 490 Geology Field Camp Credits: 6
Study and practical involvement in the methods of geological mapping. The six-week course is conducted during the summer, partially in a field camp away from the Kansas City area. Students pay their own travel expenses to and from the field. Participation in the course involves individual mapping in the field area and field reports.

GEOLOGY 498 Undergraduate Field Research Credits: 1-5
The student will collaborate with fellow students and instructors in collection of original field geologic data at a location remote from campus. Field research will be carried out during semester intersessions or summer semesters.

GEOLOGY 499WI Geology Seminar Credits: 3
Students participate in discussions; present formal talks; and prepare written papers on selected topics.
Prerequisites: Senior standing, RooWriter.

GEOLOGY 507 Archeological Resources Management Credits: 3
This class examines contemporary issues managing archaeological resources. This class is intended for students seeking work in Cultural Resources Management (CRM); those already working CRM, or student anthropology, environmental studies, geology, geography, public administration and other fields likely to deal with archaeological and historical research or employment setting. This class does not require a background in archaeology.

GEOLOGY 508 Archaeological Field Survey Methods Credits: 3
This class offers instruction in the basic skills required to conduct field surveys in archaeology and other geosciences disciplines. In the classroom, students learn about the development of archaeology as a scientific discipline and how to recognize some of the basic field data sought by archaeologists. Students learn about mapping and land navigation techniques. The field phase of instruction includes visits to archaeological sites in the region.

GEOLOGY 509 Field Study in Archaeology Credits: 1-5
This class offers students an opportunity to attend a field school in archaeology. Students will be taught how to: design archaeological research, set-up excavation, keep a wide range of excavation records, make maps and drawings, take photographs related to excavation problems, identify and recover a broad spectrum of artifact and faunal remains, collect samples for specialized analyses and use a wide range of excavation tools. This course will also introduce students to recording and analyzing excavated materials in the archaeological laboratory.

GEOLOGY 512 Geology and Hazardous Waste Management Credits: 3
Nature, sources and characterization of hazardous waste; collection, transportation and disposal of hazardous wastes. Fundamentals of toxicology and risk assessment. Application of geologic principles and methods in the assessments and remediation of abandoned hazardous waste sites and contaminated aquifers. Review of selected case histories. Experts from government and private organizations will be invited to deliver guest lectures. An out-of-town field trip to a hazardous waste site is required. A term paper based on library research or an approved experimental project is required for graduate credit.
Prerequisites: GEOLOGY 325, GEOLOGY 342, GEOLOGY 350.

GEOLOGY 513 Advanced Mineral Deposits Credits: 3
Distribution, origin and environmental implications of extractable resources including non-metallic deposits, ores, and selected energy resources.
Prerequisites: GEOLOGY 312, GEOLOGY 325, graduate standing.

GEOLOGY 516 Understanding and Living with Volcanoes Credits: 3
This course will examine the distribution, tectonic setting, and morphology of a range of volcano types on Earth and a few examples from other planets. Students will study volcanic processes including explosive and passive processes and how we investigate them. This will involve discussion of volcanic hazards and hazard assessment, risk communication, and the challenges of volcanic crises response. The course will also cover how volcanoes impact the local and global economy and Earth's climate.
GEOLOGY 5521 Advanced Methods for Earth and Environmental Science Credits: 3
This course will provide students with an inquiry-based learning experience that focuses on the application of field methods for understanding surface and subsurface earth processes and environmental issues. Students will collect field data at off campus site, conduct periodic monitoring, and analyze samples using departmental instrumentation.
Prerequisites: GEOLOGY 220 (or ENV-SCI 110R), GEOLOGY 220L (or ENV-SCI 110L).

GEOLOGY 5525 Quaternary Geology Credits: 3
The study of Quaternary processes, surficial deposits, and land forms. Course content will cover both the glaciated and nonglaciated portions of the United States as well as the interrelations between Quaternary geology and urbanization. Three hour lecture. Field trips.
Prerequisites: GEOLOGY 314, baccalaureate degree in geology.

GEOLOGY 5531 X-Ray Diffraction and Fluorescence Methods: X-Ray Mthds Geol/Anly Credits: 2
Theory and practical application of x-ray diffraction and fluorescence methods in characterizing geologic materials. Two hours lecture and one 2-hour lab per week for 8 weeks.

GEOLOGY 5532 Icpms Applications in Geology Credits: 2
Theory and practical application of Inductively-Coupled Plasma Mass Spectrometry in the geosciences and environmental sciences. Two hours lecture and discussion, and one 2-hour lab per week for 8 weeks.

GEOLOGY 5534 Hazardous Waste Operation Management Credits: 2
Overview of federal regulations dealing with hazardous waste management, toxicology, hazard communication, site management, air monitoring, operating procedures, and health and safety. The course includes hands-on training on spill control, equipment use and emergency use and emergency response. Practical training involves physical stress and participants must be in good physical health. This course satisfies OSHA's 40 hour training requirement for hazardous waste personnel.
Prerequisites: GEOG 335 (or GEOLOGY 335).

GEOLOGY 5535 Aqueous Geochemistry Credits: 3
This course is directed to two objectives. First it will equip the students with a basic understanding of the geochemical principles and calculations which are directly related to environmental problems and second, it will provide the student with a basic understanding of specific problem areas in environmental geochemistry.
Prerequisites: CHEM 211, CHEM 212R, Baccalaureate degree in geology.

GEOLOGY 5536 Introduction to Scanning Electron Microscopy Methods Credits: 2
Practical introduction to the use of the scanning electron microscope and its accessories, including image production, elemental analysis, and elemental mapping of solid materials. Geological applications will be emphasized, but the methods presented will be useful for microscopic examination of solid materials in any discipline. 2 hours of lecture and lab per week for 8 weeks.
Prerequisites: Permission of the instructor.

GEOLOGY 5541 Environmental Geophysics Credits: 3
Fundamental theory and near-surface applications of the geophysical methods including seismic methods, potential methods, and electrical methods. Emphasis will be placed on the use of these methods in environmental and engineering investigations, addressing such issues as water resources, contaminant transport, geotechnical properties, and archaeological protection. Course will include a field component illustrating application of selected techniques to a local environmental problem.
Prerequisites: Baccalaureate degree in Geology.

GEOLOGY 5542 Electrical Methods in Environmental Geophysics Credits: 3
Fundamental theory and near-surface applications of the electrical geophysical methods; (1) electrical resistivity, (2) electromagnetics, (3) ground penetrating radar, and (4) induced polarization. Emphasis will be placed on the use of these methods in environmental and engineering investigations, addressing such issues as water resources, contaminant transport, geotechnical properties and archaeological protection. Course will include a field component illustrating application of selected techniques to a local environmental problem.
Prerequisites: Baccalaureate degree in Geology.

GEOLOGY 5546 Petroleum Geology Credits: 3
This course addresses the geological habitat of oil and natural gas, the impacts of petroleum on society, subsurface mapping techniques, and the acquisition and interpretation of subsurface and production data.
Prerequisites: GEOLOGY 220, baccalaureate degree in geology.

GEOLOGY 5551 Geotechnics Credits: 4
Integration of the basic principles and concepts from material sciences, rock and soil mechanics, and civil engineering. Mechanical properties, geologic aspects and engineering classifications of earth materials and the effects of physical forces on their engineering behavior will be emphasized. Three hours of lecture and two hours of laboratory each week. Field trips.
Prerequisites: PHYSICS 210, PHYSICS 220, GEOLOGY 350.
GEOLOGY 5555 Environmental Impact Analysis Credits: 3
A systematic analysis of the spectrum of environmental changes related to human use and occupancy in urban settings. Study of the nature of activities such as industrialization, mining, urbanization and transportation, and their effect on the specific site and general region. Methods of measuring aesthetic and economic quality of the urban areas will be explored in an attempt to facilitate writing environmental impact statements. 
Prerequisites: Baccalaureate degree in geology.

GEOLOGY 5559 Inquiry-Based Field Studies for Teachers Credits: 3-6
Inquiry-based studies in environmental science, environmental chemistry and geology involving collaborations between course participants, practicing scientists and professional educators. The course is designed especially for pre- and in-service teachers of all levels and contact areas to enhance critical thinking, problem solving and process skills as defined by state and national standards. Projects will balance field and lab studies with analysis and presentation of results through electronic, oral and written means.

GEOLOGY 5561 Geologic Mapping Credits: 3
Analysis of the stratigraphic section in the greater Kansas City area by field investigation. Compilation of descriptive data and the construction of detailed geologic maps. Practical problems to determine the most beneficial use of the land in an area that is rapidly becoming urbanized. Previous field mapping experience highly recommended.
Prerequisites: Baccalaureate degree in geology.

GEOLOGY 5570 Advanced Hydrogeology Credits: 3
This course will focus on advanced groundwater hydrology with emphasis on flow equations and computational modeling in various geologic settings. Students will be introduced to basic analytical skills to derive dynamics of groundwater flow, comprehensive understanding of aquifer characteristics, and interpretation of field based groundwater data using computational simulations.
Prerequisites: Baccalaureate degree in Geosciences, GEOL 370R, or permission of instructor.

GEOLOGY 5571 Tectonics Credits: 3
A detailed inquiry into plate tectonics and the geophysical and geological data that define the motion of lithospheric plates. Global examples of divergent, convergent, and transform plate boundaries will be studied through lectures, discussions, problem sets, and term papers.
Prerequisites: GEOLOGY 325, GEOLOGY 350.

GEOLOGY 5572 Earthquake Geology Credits: 3
This course is detailed inquiry into the study of present and past earthquakes as they are preserved in the seismological, geophysical, and geological record. Global examples of earthquakes will be studied through lectures, discussions, problem sets, term papers, field trips and field projects.
Prerequisites: GEOLOGY 350.

GEOLOGY 5597 Graduate Seminar in Geosciences Credits: 3
This graduate seminar examines emerging and current issues in Environmental and Urban Geosciences. Most environmental issues and their solutions are inherently multidisciplinary and are characterized by significant interactions between oceans, atmosphere, land, and society. In addition to examining these issues, this seminar engages students in the process of critically evaluating Earth and human systems studies. The course provides students with a fundamental background of today's important environmental challenges and experience doing the craft of science through critically reading, thinking, writing, and speaking.

GEOLOGY 5598 Special Topics in Urban Environmental Geology: Environmental Sci Credits: 1-3
Individual research into practical geoscience problems in the urban environment. Provides opportunity for individual research in applied geology. Topic and method to be established by student and academic supervisor prior to enrollment.

GEOLOGY 5598A Special Topics In Urban Environmental Geology: Petroleum Geology Credits: 1-3

GEOLOGY 5598B Spec Topics In Urban Environmental Geology: Soil/Rock Mechanics Credits: 1-3

GEOLOGY 5598C Sp Topics In Urban Environmental Geol: Stratigraphy/Paleontology Credits: 1-3

GEOLOGY 5598D Spec Topics In Urban Environmental Geology-Environmental Geology Credits: 1-3

GEOLOGY 5598E Special Topics in Energy and Mineral Resources Credits: 1-3
This course provides students an opportunity for advanced independent research in energy and mineral resources.

GEOLOGY 5598H Special Topics in Urban Environmental Geology - Geochemistry and Mineralogy Credits: 1-3
Special Topics In Urban Environmental Geology - Geochemistry and Mineralogy

GEOLOGY 5598I Special Topics In Urban Environmental Geology Credits: 1-3

GEOLOGY 5598J Special Topics In Urban Environmental Geology: Environmental Sci Credits: 1-3

GEOLOGY 5598K Special Topics in Geostatistics and Modeling Credits: 1-3
Advanced independent research in geostatistics and modeling techniques.
GEOLOGY 5599 Research and Thesis: Geology Credits: 1-9
Individual directed research by the student leading to the preparation of a formal written thesis and oral defense.

GEOLOGY 5690 Special Research Topics Credits: 1-3
Student will produce a major research paper suitable for publication under the direction of their instructor.

GEOLOGY 5699R Research And Dissertation Credits: 1-10
Research for dissertation in partial fulfillment of the Geosciences requirements for the Ph.D. degree.

GEOLOGY 5899 Required Graduate Enrollment Credit: 1