GEOG - GEOGRAPHICAL SCIENCES

GEOG100 Introduction to Geography (3 Credits)
An introduction to the broad field of geography as it is applicable to the general education student. The course presents the basic rationale of variations in human occupancy of the earth and stresses geographic concepts relevant to understanding world, regional and local issues.

GEOG110 The World Today: Global Perspectives (3 Credits)
The most critical issue facing the world today is the sustainability of both human and physical systems in the 21st century. This class uses the context of regions of the world to explore the 21st century issues of climate change, development, politics, economy, and demography. Each region will be used to highlight aspects of sustainability.

GEOG130 Development Geography: Environmental & Social Justice (3 Credits)
The geography of economic, social, and environmental well-being and inequality. The course will provide an integrated perspective on the causes, interconnections, and consequences across time and space of, among others, globalization, climate change, poverty, employment, migration and urban growth, agricultural productivity, rural development, policies and international trade. Portraits of selected countries and regions will be developed.

GEOG140 Natural Disasters: Earthquakes, Floods, and Fires (3 Credits)
Catastrophic Environmental Events (CCE) that are becoming more common in this time of global environmental change and it is essential that today's students be equipped with the knowledge and skills to be leaders as we, as a society, understand the upheaval that these CCEs are causing. Students will examine how CEEs shape human society and ecosystem from the interdisciplinary perspective afforded by the field of Geography. Students will use the latest geographic science concepts and techniques in exploring these events. Using satellite imagery they will gain a multi-scale perspective of the ecological and societal aspects of the events.

GEOG156 How NASA Sees the Earth (3 Credits)
The world of Earth science data is complex and can be overwhelming with a wide range of data sources and formats, hefty downloads and the need for complicated analytical tools. To make use of enormous volumes of available data and geoinformation products, one has to know where and how to search and obtain the data, how to analyze the data, and how to extract useful information and knowledge. In this course, you will learn about the state-of-the-art Web-based tools that allow you to efficiently display and analyze a large number of datasets in a way many professionals working in the Earth science domain would. You will learn how to visualize multiple Earth science datasets produced by NASA in a variety of ways directly on the Internet, without the need to download, manage and store them. Students will be introduced to comprehensive functions to analyze the data and generate customized maps, animations, multi-variable correlations, regional subsetting, etc.
Cross-listed with: INST156.
Credit Only Granted for: GEOG156 or INST156.

GEOG158 Special Topics in Study Abroad I (1-6 Credits)
Special topics course taken as part of an approved study abroad program.
Repeatable to: 15 credits if content differs.

GEOG170 Mapping our Digital World (3 Credits)
Introduction to technical methods used in gathering, analyzing, and mapping geospatial information for applications such as urban mobility, environmental monitoring, situational awareness, and disaster management. Topics include Geographic Information Systems (GIS), cartography, map projections, satellite and airborne remote sensing, the global positioning system (GPS), and introductory statistics and probability. The course is a gateway to more advanced technical classes in geospatial science.

GEOG172 Earth From Space (3 Credits)
Earth observations from space enable the mapping and monitoring of our changing planet. This survey course reviews current observational capabilities and examines scientific applications in quantifying global environmental change. Drivers and outcomes of key dynamics will be illustrated and discussed, including sea and continental ice loss, deforestation, ocean warming, urbanization, agricultural expansion and intensification, and vegetation response to climate change.

GEOG198 Selected Topics in Geography (1-3 Credits)
Readings and discussion on selected topics in the field of geography or GIS
Repeatable to: 12 credits if content differs.

GEOG201 Geography of Environmental Systems (3 Credits)
A systematic introduction to the processes and associated forms of the atmosphere and earth's surfaces emphasizing the interaction between climatology, hydrology and geomorphology.

GEOG202 Introduction to Human Geography (3 Credits)
Introduction to what geographers do and how they do it. Systematic study of issues regarding social and cultural systems from a global to a local scale. Looks at the distribution of these variables and answers the question "Why here, and not there"?

GEOG211 Geography of Environmental Systems Laboratory (1 Credit)
A laboratory course to accompany GEOG 201. Analysis of the components of the earth's energy balance using basic instrumentation; weather map interpretation; soil analysis; the application of map and air photo interpretation techniques to landform analysis.
Prerequisite: Must have completed or be concurrently enrolled in GEOL120, GEOL100, or GEOG201.

GEOG212 Career Planning for Geographical Sciences, GIS, and ENSP Majors (1 Credit)
Increase student knowledge of professional development opportunities in Geographical Sciences through classroom activities and invited speakers, and to build awareness of career development tools and strategies.
Restriction: Must be in one of the following programs (Geography; GEOG-GIS & Computer Cartography).

GEOG258 Special Topics in Study Abroad II (1-6 Credits)
Special topics course taken as part of an approved study abroad program.
Repeatable to: 15 credits if content differs.

GEOG272 Introduction to Earth Observation Science (3 Credits)
Concepts and principles of Earth observation and remote sensing in relation to photographic, thermal infrared and radar imaging. Methods of obtaining quantitative information from remotely-sensed images. Interpretation of remotely-sensed images emphasizing the study of spatial and environmental relationships.
Credit Only Granted for: GEOG272 or GEOG372.
Formerly: GEOG372.

GEOG276 Principles of Python Programming and Geocomputing (3 Credits)
Introduces conceptual and practical aspects of scientific computing using the Python programming language. The main focus is on developing proficiency for the basic elements of the development environment, foundational syntax including variables, logical operators, looping, conditional statements, nesting, and common programming patterns for mathematical and textual computing. In addition, essential data structures and functionality for scientific computing, such as arrays, dataframes, and data visualization will be introduced. Throughout the course, students will also become exposed to various applications in the domain of the social and environmental sciences.

GEOG298 Special Topics in Geography (3 Credits)
An introductory course dealing with special topics in geography.
Repeatable to: 6 credits if content differs.

GEOG301 Advanced Geographical Environmental Systems (3 Credits)
This course will provide the students with an overview of the key elements of physical geography, including biogeography (factors and processes that control the geographical distributions of plants and animals, climatology (processes associated with controlling variations in weather and climate), and geomorphology (factors and processes that control changes to the physical structure of the earth surface in relation to geological structures).
Prerequisite: GEOG201 and GEOG211.
Credit Only Granted for: GEOG398B or GEOG301.
Formerly: GEOG398B.

GEOG306 Introduction to Quantitative Methods for the Geographical Environmental Sciences (3 Credits)
Essentials in the quantitative analysis of spatial and other data, with a particular emphasis on statistics and programming. Topics include data display, data description and summary, statistical inference and significance tests, analysis of variance, correlation, regression, and some advanced concepts, such as matrix methods, principal component analysis, and spatial statistics. Students will develop expertise in data analysis using advanced statistical software.

GEOG328 Topics in Regional Geography (3 Credits)
Selected topics in regional geography.
Repeatable to: 6 credits if content differs.

GEOG330 As the World Turns: Society and Sustainability in a Time of Great Change (3 Credits)
Cultural geography course on society and sustainability. Culture is the basic building block that is key to sustainability of societies. Course will cover sustainability of societies on different scales, examining local, regional, and worldwide issues. Sustainability will be examined as a key element of environmental sustainability. How societies adjust to rapid world change will be examined as a positive and/or negative factor in sustainability.
Credit Only Granted for: GEOG330, GEOG360, or GEOG362.
Formerly: GEOG362.

GEOG331 Introduction to Human Dimensions of Global Change (3 Credits)
Introduction to global-scale interrelationship between human beings and the environment. The development of global issues including but not limited to the environment, food, energy, technology, population, and policy.
Prerequisite: ANTH220, ANTH260, GEOG202, or GEOG201; or permission of BSOS-Geography department.
Credit Only Granted for: GEOG331 or GEOG361.
Formerly: GEOG361.

GEOG332 Economic Geography (3 Credits)
Principles of managing scarce resources in a world where everyone faces tradeoffs across both time and space. Focuses on the relationship between globalization processes and changing patterns of locational advantages, production, trade, population, socioeconomic and environmental grace and sustainability.
Credit Only Granted for: GEOG203, GEOG303, or GEOG332.
Formerly: GEOG303.

GEOG333 The Social Geography of Metropolitan Areas in Global Perspective (3 Credits)
A socio-spatial approach to human interaction within the urban environments: ways people perceive, define, behave in, and structure world cities and metropolitan areas. Cultural and social differences define spatial patterns of social activities which further define distinctions in distribution and interaction of people and their social institutions.
Prerequisite: GEOG201 and GEOG202; or permission of BSOS-Geography department.
Credit Only Granted for: GEOG456 or GEOG333.
Formerly: GEOG456.

GEOG340 Geomorphology (3 Credits)
Survey of landform types and role of processes in their generation. Frequency of occurrence and implications for land utilization. Emphasis on coastal, fluvial, and glacial landforms in different environmental settings. Landform regions of Maryland.

GEOG346 Cycles in the Earth System (3 Credits)
The Earth System operates through some fundamental cycles such as water, energy, and the Carbon Cycle. This course will build on GEOL/GEOG/AOSC123 starting with concept of feedbacks within the Earth System, global energy balance and the Greenhouse Effect. A brief introduction to the atmospheric and oceanic circulation will lead to the water cycle connecting the land, ocean, and atmosphere to the Earth System. Introduction to the Global carbon, nitrogen, and sulfur cycles will be followed by the concept of long-term climate regulation and short-term climate variability. The concepts of cycles, feedbacks, forcings, and responses in the Earth System will be applied to Global Warming and Ozone Depletion.
Prerequisite: GEOG123, AOSC123, GEOL123, or MATH140; or permission of CMNS-Geology department.
Recommended: PHYS171, PHYS141, PHYS161, or MATH141. Cross-listed with GEOL346.
Credit Only Granted for: AOSC346, GEOG346, or GEOL346.

GEOG358 Special Topics in Study Abroad III (1-6 Credits)
Special topics course taken as part of an approved study abroad program.
Repeatable to: 15 credits if content differs.

GEOG371 Programming for Image Analysis (3 Credits)
Introduces application programing interface (API) functions and image processing techniques for efficient processing of satellite images. The main programing language of the course is Python. The course will use a Geospatial Data Abstraction Library (GDAL) which provides a unified way of manipulating images incorporating geospatial information. For image processing, the course will use Python-based libraries such as scikit-image and OpenCV.
Prerequisite: GEOG276, GEOG306, and GEOG272.

GEOG373 Geographic Information Systems (3 Credits)
Characteristics and organization of geographic data; creation and use of digital geospatial databases; metadata; spatial data models for thematic mapping and map analysis; use of geographic information system in society, government, and business. Practical training with use of advanced software and geographic databases.

GEOG376 Programming for Geospatial Analysis (3 Credits)
Covers conceptual and practical aspects of geospatial data modeling and analysis techniques using the Python programming language. The main focus is on developing a solid understanding of the programmatic conventions needed to create, manipulate, and process geospatial data types, such as point, line, & polygon vectors, networks, trajectories, and space-time extensions. In addition, students will develop a proficiency in applying these data structures to perform automated geospatial analysis, such as GIS operations, agent-based models, and spatial statistics.
Prerequisite: GEOG276 and GEOG373; Must have completed or be concurrently enrolled in MATH120, MATH130, or MATH140; or must have completed MATH220.
Recommended: GEOG306.

GEOG377 Artificial Intelligence for Spatial Data (3 Credits)
Covers the basics of deep learning and expand to a variety of network architectures widely used for spatio-temporal data including convolutional networks, recurrent networks, transformers, generative adversarial networks, diffusion models, etc. with tasks on classification, segmentation, estimation, forecasting, generation, clustering and more. Covers training strategies, transfer learning, domain adaptation, meta-learning, self-supervised learning, knowledge-guided learning, spatial-aware learning, etc. Recent advances such as large foundation models, with discussions on both general-purpose and geospatial-focused foundation models, and ethics aspects such as fairness. The techniques will be discussed in the context of spatial and spatio-temporal data. The implementation side will be based on Python. Students will do projects based on research topics or interests, with applications (domain-driven) or technically innovative (general methodology-driven).
Credit Only Granted for: GEOG398E or GEOG377.
Formerly: GEOG398E.

GEOG384 Internship in Geography I (3 Credits)
Supervised field training to provide career experience. Introduction to professional level activities, demands, opportunities. Placement at a public agency, non-profit organization, or private firm. Participation requires application to the internship advisor in preceding semester.
Prerequisite: GEOG211, GEOG306, GEOG212, and GEOG201; and (ENGL393 or ENGL390).
Restriction: Must be in Geography program.

GEOG385 Internship in Geography II (3 Credits)
Supervised field training to provide career experience. Introduction to professional-level activities, demands, opportunities. Placement at a public agency, nonprofit organization, or private firm. Participation requires application to the internship advisor in preceding semester.
Prerequisite: GEOG211, GEOG306, GEOG212, and GEOG201; and must have completed a Junior (Professional) English course.
Restriction: Must be in Geography program.

GEOG396 Honors Research (3 Credits)
First course in the departmental honors sequence. Student development of a potential research topic under the guidance of a faculty advisor, culminating in a written and oral presentation of a research proposal.
Restriction: Permission of BSOS-Geography department; and senior standing or higher; and must be in Geography program.
Formerly: GEOG397.

GEOG397 Honors Thesis (3 Credits)
Second course in the departmental honors sequence. Student research under the auspices of a faculty advisor, culminating in a research paper to be defended orally before the geography honors committee.
Prerequisite: GEOG396.
Restriction: Must be in Geography program; and senior standing or higher.
Formerly: GEOG399.

GEOG398 Special Topics in Geography (1-3 Credits)
An introductory course dealing with special topics in geography.
Restriction: Permission of BSOS-Geography department.
Repeatable to: 6 credits if content differs.
Credit Only Granted for: GEOG298 or GEOG398.
Formerly: GEOG298.

GEOG413 Migration: Latin America and the United States (3 Credits)
Develops an understanding of the push and pull factors that have contributed to human mobility (migration) that has transformed the Americas. The class is divided in two parts: immigration and emigration from Latin American and Latin America migration to the United States. We will be interested in studying the migration shifts that have occurred in Latin America and the theories that help explain them. The themes that will be addressed are the history of migration with Latin America and to North America, the impact of this migration on both sending and receiving countries, and the various policy strategies and issues concerning migration.
Prerequisite: GEOG313; or permission of BSOS-Geography department.
Recommended: HIST250; or USLT201; or LASC234.
Credit Only Granted for: GEOG413, or GEOG498M.
Formerly: GEOG498M.

GEOG415 Land Use, Climate Change, and Sustainability (3 Credits)
The issues of climate change and land use change as two interlinked global and regional environmental issues and their implications for society and resource use are explored.
Prerequisite: GEOG306; or permission of BSOS-Geography department.
Recommended: GEOG340; or GEOG342; or GEOG331. Or GEOG201; and GEOG211.
Credit Only Granted for: GEOG415 or GEOG498D.
Formerly: GEOG498D.

GEOG416 Conceptualizing and Modeling Human-Environmental Interactions (3 Credits)
Develops skills to carry out research that integrates environmental and economic aspects of sustainability by introducing extensively used quantitative tools for analyzing human-environmental interactions in the field of ecological economics. These include, e.g., index number calculations and decomposition analysis, Environmental Kuznets Curve (EKC), environmental input-output analysis and life-cycle analysis, and multi-criteria decisions aid (MCDA). Students will need laptops to run models during class.
Prerequisite: Permission of BSOS-Geography department.
Corequisite: MATH130, MATH140, or MATH120; or MATH220.

GEOG417 Land Cover Characterization Using Multi-Spectral Remotely Sensed Data Sets (3 Credits)
Students will be introduced to the image processing steps required for characterizing land cover extent and change. Key components of land cover characterization, including image interpretation, algorithm implementation, feature space selection, thematic output definition, and scripting will be discussed and implemented.
Prerequisite: GEOG272 and GEOG306; or permission of BSOS-Geography department.
Jointly offered with: GEOG617.
Credit Only Granted for: GEOG417 or GEOG617.

GEOG418 Field and Laboratory Techniques in Environmental Science (1-3 Credits)
Lecture and laboratory learning each week. A variable credit course that introduces field and laboratory analyses in environmental science. Individual learning contract are developed with instructor.
Restriction: Permission of BSOS-Geography department.
Credit Only Granted for: GEOG418 or GEOG448.
Formerly: GEOG448.

GEOG421 Changing Geographies of China (3 Credits)
Covers physical geography, history, and economic and political systems of the world's most populous country. The major focus will be on geographical issues in China's contemporary development: agriculture, population, urbanization, resource and energy, and environment.
Prerequisite: Permission of BSOS-Geography department. Or GEOG202; and GEOG201; and (GEOG435, GEOG333, or GEOG332).
Recommended: GEOG130; or GEOG140.
Credit Only Granted for: GEOG328B or GEOG421.
Formerly: GEOG328B.

GEOG422 Changing Geographies of Sub-Saharan Africa (3 Credits)
Students will develop an understanding of the geographic contexts of SubSaharan Africa, including an overview of the physical, bioclimatic, historical, cultural, political, demographic, health and economic geographies of Sub-Saharan Africa. Students will fill in the map of Africa by studying the spatial distribution within each of these geographic domains. In addition to an overview of geography South of the Sahara, the Congo will be taken as a more intensive case study through additional readings, lectures and discussions.
Prerequisite: Permission of BSOS-Geography department. Or GEOG201; and GEOG202; and (GEOG335 or GEOG333).
Recommended: GEOG130 or GEOG110.
Credit Only Granted for: GEOG328C, GEOG422.
Formerly: GEOG328C.

GEOG423 Latin America (3 Credits)
A geography of Latin America and the Caribbean in the contemporary world: political and cultural regions, population and natural resource distribution, economic and social development, poverty, crime, urbanization, migration trends, and natural disasters.
Prerequisite: Permission of BSOS-Geography department. Or GEOG201 and GEOG202; and (GEOG332, GEOG435, or GEOG333).
Recommended: GEOG130 and GEOG110.
Credit Only Granted for: GEOG313 or GEOG423.
Formerly: GEOG313.

GEOG431 Culture and Natural Resource Management (3 Credits)
Basic issues concerning the natural history of humans from the perspective of the geographer. Basic components of selected behavioral and natural systems, their evolution and adaptation, and survival strategies.
Credit Only Granted for: GEOG421 or GEOG431.
Formerly: GEOG421.

GEOG432 Spatial Econometrics (3 Credits)
An introduction to modern econometric techniques in general and spatial econometrics in particular, using the popular open source statistical computer language R. A focus on using statistical computing to produce analytical reports for real-world applications, research papers, and dissertations.
Prerequisite: Permission of BSOS-Geography department.
Jointly offered with: GEOG732.
Credit Only Granted for: GEOG432 or GEOG732.

GEOG438 Seminar in Human Geography (3 Credits)
Selected topics in human geography.
Recommended: GEOG201; or GEOG211.
Restriction: Permission of BSOS-Geography department.
Repeatable to: 6 credits if content differs.

GEOG440 Polar Remote Sensing (3 Credits)
The harsh environment of the vast polar regions makes them some of the most inaccessible places on Earth. With widespread environmental change already underway, satellite remote sensing provides the only means by which to obtain year-round observations of the polar climate system. The objective of this course is to provide students with an overview of polar remote sensing techniques, including the physical principles of active and passive sensors, orbits, electromagnetic radiation, atmospheric transmission, calibration and validation. We will focus on measurements of the polar oceans, sea ice, glaciers, ice sheets, snow and permafrost, and examine the response of the cryosphere to climate change.
Prerequisite: PHYS171 or PHYS161; and AOSC401 or GEOG301; or with permission of instructor.
Cross-listed with: AOSC440.
Jointly offered with: AOSC642.
Credit Only Granted for: AOSC440, GEOG440, AOSC642, or GEOG640.

GEOG441 The Coastal Ocean (3 Credits)
Introduction to coastal oceanography, focusing on the physical, biological, and geological aspects of ocean areqs on the inner continental shelves. Wave, currents, and tidal dynamics of bays, open coast, estuaries, and deltas. Sedimentary environments of major coastal types. Ecology and biogeochemical relationships, including benthic and planktonic characteristics. Coastal evolution with sea level rise. Human impacts: eutrophication, modification of sedimentation. The coastal future: rising sea level, hypoxia, and increased storminess.
Prerequisite: GEOG140; or students who have taken courses with comparable content may contact the department; or permission of BSOS-Geography department.
Credit Only Granted for: GEOG441 or GEOG498C.
Formerly: GEOG498C.

GEOG442 Biogeography and Environmental Change (3 Credits)
Biogeographical topics of global significance, including a consideration of measurement techniques, and both descriptive and mechanistic modeling. Topics may include: scale in biogeography, biodiversity, carbon geography, climate and vegetation, interannual variability in the biosphere, land cover, global biospheric responses to climate change, NASA's Mission to Planet Earth and Earth Observation System. The class focuses on both natural and athropogenic controls, impacts of biography on climate and ecosystem services and different methods in biogeography.
Prerequisite: GEOG301. And GEOG201 and GEOG211; or permission of BSOS-Geography department. Jointly offered with GEOG642.
Credit Only Granted for: GEOG642, GEOG442, GEOG447, or GEOG484.
Formerly: GEOG4 47.

GEOG458 Special Topics in Study Abroad IV (1-6 Credits)
Special topics course taken as part of an approved study abroad program.
Repeatable to: 15 credits if content differs.

GEOG461 Machine Learning for Computational Earth Observation Science (CEOS) (3 Credits)
Provides an introduction to machine learning methods and models with an emphasis on Earth observation. Topics will include supervised (decision trees, random forest, neural networks, support vector machine, Gaussian process and ensemble techniques), and unsupervised techniques (clustering/segmentation, dimension reduction, multi-dimensional data visualization). The course will highlight the state-of-the-art deep learning models; object-based versus pixel-based image classification; how to deal with missing data and non-uniform coverage of data; and large scale land cover land use mapping from heterogenous satellite data. Practical part will include satellite image classification by applying classification models and biophysical parameters retrieval by applying regression models.
Prerequisite: GEOG371.

GEOG470 Algorithms for Geospatial Computing (3 Credits)
An introduction to fundamental geospatial objects and geometric algorithms for spatio-temporal data processing and analysis. Point data representation and analysis: spatial data models and data structures, algorithms for spatial queries, point clustering algorithms. Surface and scalar field modeling, such as terrains: raster and triangle-based models (TINs), algorithms for building and querying TINs. Algorithms for natural and urban terrain analysis: morphology computation and visibility analysis. Applications to processing and analysis of LiDAR (Light Detection And Ranging) data in the context of terrain reconstruction, urban modeling, forest management and bathymetry reconstruction for coastal data management. Road network computation and analysis: algorithms for route computation in road networks, and for road network reconstruction from GPS and satellite data.
Prerequisite: GEOG276; or a minimum grade of C- in CMSC330 and CMSC351; or permission of instructor.
Cross-listed with: CMSC401.
Jointly offered with: GEOG770.
Credit Only Granted for: CMSC498Q, CMSC401, CMSC788I, GEOG470, GEOG498I, GEOG770, or GEOG788I.
Formerly: GEOG498I.

GEOG471 Technologies for Computational Earth Observations (3 Credits)
An introduction and exploration of cutting-edge novel remote sensing datasets and their associated science uses and applications. We present several modules focused on different technologies (multispectral, lidar, radar, thermal), and for each have both hands-on lab assignments, lectures, and applications case studies. Data fusion techniques, and common analysis and processing pitfalls are presented and discussed. Hands-on computer labs allow students to explore each dataset via online tutorials. After all datasets are presented, students download their own datasets in an area of interest to them, and work toward a unique student-driven project for presentation to the class. The sky is literally the limit in this interactive course which provides a research experience opportunity for students in a supportive atmosphere.
Prerequisite: GEOG371 or permission of instructor.

GEOG472 Remote Sensing: Digital Processing and Analysis (3 Credits)
Digital image processing and analysis applied to satellite and aircraft land remote sensing data. Consideration is given to image preprocessing techniques including radiometric calibration, geometric registration as well as atmospheric correction. Analysis methods include digital image exploration, feature extraction, thematic classification, change detection, and biophysical characterization. An application-oriented course project will be completed through the self-guided computer labs.
Prerequisite: GEOG272 and GEOG306; or students who have taken courses with comparable content may contact the department.

GEOG473 Geographic Information Systems and Spatial Analysis (3 Credits)
Analytical uses of geographic information systems; data models for building geographic data bases; types of geographic data and spatial problems; practical experience using advanced software for thematic domains such as terrain analysis, land suitability modeling, demographic analysis, and transportation studies.
Prerequisite: GEOG306 and GEOG373; or students who have taken courses with comparable content may contact the department.
Credit Only Granted for: GEOG473 or GEOG482.
Formerly: GEOG482.

GEOG475 Geographic Visualization and Digital Mapping (3 Credits)
An overview of the basic concepts and techniques that underlie digital map making and the broader field of geographic visualization for intermediate GIS users. This includes the use of color, map symbolization, map layout, and also the contribution to geographic visualization from the fields of scientific visualization, information visualization, and cognition. Fundamentals of dynamic map design and web mapping will be introduced through the use of animated and interactive maps.
Prerequisite: GEOG373 and GEOG306.

GEOG476 Object-Oriented Computer Programming for GIS (3 Credits)
Expands on conceptual and practical aspects of programming for geographic applications. The main focus of this course is to provide students more advanced programming in object oriented programming languages (i.e. Python). In addition, students will develop a proficiency in applying these advanced programming principles to manipulating spatial data sources within the Geographic Information Systems (GIS).
Prerequisite: GEOG373 and GEOG376; or permission of BSOS-Geography department. And must have completed MATH220; or must have completed or be concurrently enrolled in MATH120, MATH130, or MATH140.
Restriction: Must be in Geography program; or must be in GIS minor.

GEOG498 Topical Investigations (1-3 Credits)
Independent study under individual guidance.
Prerequisite: Restricted to advanced undergraduate students; and 24 credits in GEOG courses. Or restricted to graduate students.
Repeatable to: 6 credits if content differs.