EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

150. (COML151, GRMN150) WATER WORLDS.

SM 543. (COML544, ENGL584, GRMN543, SPAN543) ENVIRONMENTAL HUMANITIES.

SM 319. Penn in the Alps. Reto Giere. 10 day summer program

The aim of this 10-day summer program is to introduce inquisitive students to the nature, culture, history and languages of the European Alps in Switzerland and Italy. We will be exploring the geology of the Alps and how it influences the development of wildlife, flora, history, religion, culture and of entire regions, how humans have altered the environment, and how humans respond to climate change in Alpine ecosystems. We will learn how to observe nature in a spectacular landscape, visit cultural sites off the beaten track and explore some of the well-known localities, such as Zurich, Valtellina, Bellinzona, and the Engadine.

330. (GEOL634) Chemical Oceanography: Role of the Ocean in the Global Carbon Cycle. Murray.

The field of chemical oceanography has evolved from one of discovery to an interdisciplinary science that uses chemical distributions to understand physical, biological, geological and chemical processes in the sea. The study of chemical oceanography includes much of the background required to understand the global carbon cycle on all time scales. In this course, the main unifying science Theme #1 is The Global Carbon Cycle. The syllabus is organized into three broad subthemes. Theme #2. What controls the composition of seawater and are humans changing it? Theme #3. What are the chemical constraints on biological production in the ocean? Theme #4. What is the fate of organic matter produced by biological production and what are the impacts of this organic matter on the ocean and underlying sediments?

ENVIRONMENTAL STUDIES (ENVS)-----Note: Listings for GEOL follow ENVS 999

SM 073. (PHIL073) Topics in Ethics. (M) Meyer, M..

Topics vary each semester.

169. (STSC169) ENGINEERING PLANET EARTH.

181. (GRMN181) Comparative Cultures of Sustainability. (L) Simon Richter.

Sustainability is more than science, engineering, policy, and design. Surveyingthe world, we see that the politics and practice of sustainability play out in different ways depending on cultural factors. Some cultures are more prone to pursue ecological goals than others. Why? Do the environmental history and experience of a nation affect policy? Do nature and the environmentplay a crucial role in the cultural memory of a nation? Can cultural componentsbe effectively leveraged in order to win approval for a politics of sustainability? And what can we, as residents of a country where climate changeand global warming are flashpoints in an enduring culture war, learn from other cultures? This course is designed to equip undergraduate students with the historical and cultural tools necessary to understand the cultural aspects of sustainability in two countries noted for their ecological leadership and cultural innovation, Germany and the Netherlands.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

L/R 200. Introduction to Environmental Earth Science. (C) Physical World Sector. All classes. Plante.

This course will expose students to the principles that underlie our understanding of how the Earth works. The goal of Earth Systems Science is to obtain a scientific understanding of the entire Earth system by describing its component parts (lithosphere, hydrosphere, atmosphere, biosphere) and their interactions, and describe how they have evolved, how they function, and how they may be expected to respond to human activity. The challenge to Earth Systems Science is to develop the capability to predict those changes that will occur in the next decade to century, both naturally and in response to human activity. Energy, both natural and human-generated, will be used as a unifying principle. Knowledge gained through this course will help students make informed decisions in all spheres of human activity: science, policy, economics, etc.

204. Global Climate Change. (A) Physical World Sector. All classes. Irina Marinov.Prerequisite(s): Any of the following courses: ENVS 200 or GEOL 100 or GEOL 130 or GEOL 125 or GEOL 103 or Instructor Permission.

Public perceptions and attitudes concerning the causes and importance of globalwarming have changed. Global Climate Change provides a sound theoretical understanding of global warming through an appreciation of the Earth's climate system and how and why this has changed through time. We will describe progress in understanding of the human and natural drivers of climate change, climate processes and attribution, and estimates of projected future climate change. We will assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation.

SM 279. (STSC279) Nature's Nation: Americans and Their Environment. (M) Greene.

The United States has been described as "nature's nation. The presence of enormous, resource-rich and sparsely settled continent has been a component of American identity, prosperity and pride--it has even been described as the source of the democratic political system. From the beginning, Americans transformed their natural environment, even as, over time, they grew to value environmental preservation and protection. This course traces the interaction of Americans and the natural world in, studying how Americans changes the natural environment over time, in order to understand why environmental change occurred and occurred in the manner it did. What have Americans believed about the nature of the nation's nature, and what attidues and policies have followed from these ideas? After surveying American environmental history from the 17th to the 20th century, we will examine specific topics and problems in the long relationship between Americans and their environment. (Possible topics: national parks and wilderness preservation, environmental politics, chemical pollution, invasive species). This seminar fulfills the research requirement for the History major because students will complete a 20-page paperof original research.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

295. Maritime Science and Technology: Woods Hole Sea Semester. (C) Andrews.Prerequisite(s): Laboratory course in physical or biological science or its equivalent; college algebra or its equivalent. This set of courses requires special application procedures. Contact Maria Andrews for information and an application. Only the "SEA semester: Ocean Exploration" and "SEA Semester: Oceans and Climates" can be taken for Penn credit without taking a leave, and all students must have permission from Maria Andrews before registering at SEA.

A rigorous semester-length academic and practical experience leading to an understanding of the oceans. The Sea Semester is composed of two intensive six-week components taken off-campus. The Shore Component is six weeks at Woods Hole, Massachusetts, with formal study in: Oceanography, Maritime Studies, and Nautical Science. This is followed by six weeks aboard a sailing research vessel, during which students conduct oceanographic research projects as part of the courses, Practical Oceanography I and II.

Maritime Studies. A multidisciplinary study of the history, literature, and art of our maritime heritage, and the political and economic problems of contemporary maritime affairs.

Nautical Science. The technologies of operation at sea. Concepts of navigation, naval architecture, ship construction, marine engineering systems, and ship management are taught from their bases in physics, mathematics, and astronomy.

Practical Oceanography I. Taken aboard SSV Westward or SSV Corwith Cramer. Theories and problems raised in the shore component are tested in the practice of oceanography at sea. Students are introduced to the tools and techniques of the practicing oceanographer. During two lectures daily and while standing watch, students learn the operation of basic oceanographic equipment, the methodologies involved in the collection, reduction, and analysis of oceanographic data, and the attendant operations of a sailing oceanographic research vessel. Practical Oceanography II. Taken aboard SSV Westward or SSV Corwith Cramer. Students assume increasing responsibility for conducting oceanographic research and the attendant operations of the vessel. The individual student is responsible directly to the chief scientist and the master of the vessel for the safe and orderly conduct of research activities and related operation of the vessel. Each student completes an individual oceanographic research project designed during the shore component.

299. Independent Study. (C) Staff.Prerequisite(s): Permission of department. May be repeated for credit

Directed study for individuals or small groups under supervision of a faculty member.

301. Environmental Case Studies. (A) dmochowski.Prerequisite(s): ENVS 200.

A detailed, comprehensive investigation of selected environmental problems. Guest speakers from the government and industry will give their acccounts of various environmental cases. Students will then present information on a case study of their choosing.

327. Principles of Sustainability. Alain Plante.

What is sustainability? Can any fundamental concepts, principles or framework be constructed that adequately describes the search for sustainability? Is there a meaningful methodology? Sustainability science is a trans-disciplinary approach in which the quantitative and qualitative, natural and social,and theory and practice are reconciled and creatively combined. The objective of this course is to provide an in-depth analysis of the foundational concepts, principles, processes and practices of sustainability science. The course will explore three foundational laws governing sustainability:the law of limits to growth, the second law of thermodynamics, and the law of self-organization. Students will examine how these laws operate in biological, ecological, and physical systems, and then apply them to social, economic and political systems.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

L/R 312. (ENVS640, PHYS314) Ocean-Atmosphere Dynamics and Implications for Future Climate Change. (B) Marinov.Prerequisite(s): MATH 114 or permission of the instuctor.

This course covers the fundamentals of atmosphere and ocean dynamics, and aims to put these in the context of climate change in the 21st century. Large-scale atmospheric and oceanic circulation, the global energy balance, and the global energy balance, and the global hydrological cycle. We will introduce concepts of fluid dynamics and we will apply these to the vertical and horizontal motions in the atmosphere and ocean. Concepts covered include: hydrostatic law, buoyancy and convection, basic equations of fluid motions, Hadley and Ferrel cells in the atmosphere, thermohaline circulation, Sverdrup ocean flow, modes of climate variability (El-Nino, North Atlantic Oscillation, Southern Annular Mode). The course will incorporate student led discussions based on readings of the 2007 Intergovernmental Panel on Climate Change (IPCC) report and recent literature on climate change. Aimed at undergraduate or graduate students who have no prior knowledge of meteorology or oceanography or training in fluid mechanics. Previous background in calculus and/or introductory physics is helpful. This is a general course which spans many subdisciplines (fluid mechanics, atmospheric science, oceanography, hydrology).

325. Sustainable Goods. Hagan.

The study of sustainability-the long term viability of humans in harmony with the environment-has been identified as a critical issue for society and industry and is evolving to examine how society should conduct itself in order to survive.This issue impacts the consumer goods that we use in our lives,the processes that are designed to make these goods, and the raw materials that we obtain to create these goods.The questions that we will examine will be:can these goods be obtained,made,and consumed in a fashion that allows the current quality of life to be mantained (or enhanced) for future generations? Can these processes be sustainable? A review of consumer goods is necessary as the starting point in order to understand the basic needs of people in society and why people consume goods as they do. Subsequently,each student will choose a product to examine in detail and will research the product for its impact with respect to natural resource selection,production,use,and disposal/reuse.

326. GIS: Mapping Places & Analyzing Spaces. KRISTA HEINLEN.

This course is a hands-on introduction to the concepts and capabilities of geographic information systems (GIS). Students will develop the skills necessary for carrying out basic GIS projects and for advanced GIS coursework. The class will focus on a broad range of functional and practical applications,ranging from environmental science and planning to land use history, social demography, and public health. By the end of the course, students will be ableto find, organize, map, and analyze data using both vector (i.e. drawing-based) and raster (i.e. image-based) GIS tools, while developing an appreciation for basic cartographic principles relating to map presentation.This course fulfillsthe spatial analysis requirement for ENVS and EASC Majors. Previous experiencein the use of GIS is not required.

SM 399. (GEOL399) Environmental Studies Research Seminar for Juniors. (B) Dmochowski.Prerequisite(s): ENVS 200.

This seminar is designed to help Juniors prepare for the Senior Thesis research. Topic selection, advisor identification, funding options, and basic research methods will be discussed.

SM 400. Environmental Studies Seminar. (B) Plante. May be repeated for credit

Application of student and faculty expertise to a specific environmental problem, chosen expressly for the seminar.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 404. (HSOC404) Urban Environments: Speaking About Lead in West Philadelphia. (B) Natural Science & Mathematics Sector. Class of 2010 and beyond. Pepino. ABCS Course. Requires community service in addition to class time.

Lead poisoning can cause learning disabilities, impaired hearing, behavioral problems, and at very high levels, seizures, coma and even death. Children up to the age of six are especially at risk because of their developing systems; they often ingest lead chips and dust while playing in their home and yards.

In ENVS 404, Penn undergraduates learn about the epidemiology of lead poisoning, the pathways of exposure, and methods for community outreach and education. Penn students collaborate with middle school and high school teachers in West Philadelphia to engage middle school children in exercises that apply environmental research relating to lead poisoning to their homes and neighborhoods.

SM 410. Clean Water - Green Cities. (M) Neukrug.Prerequisite(s): ENVS 200, GEOL 100 or equivalent. An academically-based curriculum service learning approach to using water, science and politics to create a sustainable Philadelphia.

This course will provide an overview of the cross-disciplinary fields of civil engineering, environmental sciences, urban hydrology, landscape architecture, green building, public outreach and politics. Students will be expected to conduct field investigations, review scientific data and create indicator reports, working with stakeholders and presenting the results at an annual symposium. There is no metaphor like water itself to describe the cumulative effects of our practices, with every upstream action having an impact downstream. In our urban environment, too often we find degraded streams filled with trash, silt, weeds and dilapidated structures. The water may look clean, but is it? We blame others, but the condition of the creeks is directly related to how we manage our water resources and our land. In cities, these resources are often our homes, our streets and our communities. This course will define the current issues of the urban ecosystem and how we move toward managing this system in a sustainable manner. We will gain an understanding of the dynamic, reciprocal relationship between practices in an watershed and its waterfront. Topics discussed include: drinking water quality and protection, green infrastructure, urban impacts of climate change, watershed monitoring, public education, creating strategies and more.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 406. (HSOC406) Community Based Environmental Health. (A) Pepino. ABCS Course. Requires community service in addition to class time.

From the fall of the Roman Empire to Love Canal to the epidemics of asthma, childhood obesity and lead poisoning in West Philadelphia, the impact of the environment on health has been a continuous challenge to society. The environment can affect people's health more strongly than biological factors, medical care and lifestyle. The water we drink, the food we eat, the air we breathe, and the neighborhood we live in are all components of the environment that impact our health. Some estimates, based on morbidity and mortality statistics, indicate that the impact of the environment on health is as high as 80%. These impacts are particularly significant in urban areas like West Philadelphia. Over the last 20 years, the field of environmental health has matured and expanded to become one of the most comprehensive and humanly relevant disciplines in science.

This course will examine not only the toxicity of physical agents, but also the effects on human health of lifestyle, social and economic factors, and the built environment. Topics include cancer clusters, water borne diseases, radon and lung cancer, lead poisoning, environmental tobacco smoke, respiratory diseases and obesity. Students will research the health impacts of classic industrial pollution case studies in the US. Class discussions will also include risk communication, community outreach and education, access to health care and impact on vulnerable populations. Each student will have the opportunity to focus on Public Health, Environmental Protection, Public Policy, and Environmental Education issues as they discuss approaches to mitigating environmental health risks.

This honors seminar will consist of lectures, guest speakers, readings, student presentations, discussions, research, and community service. The students will have two small research assignments including an Environmental and Health Policy Analysis and an Industrial Pollution Case Study Analysis. Both assignments will include class presentations. The major research assignment for the course will be a problem-oriented research paper and presentation on a topic related to community-based environmental health selected by the student. In this paper, the student must also devise practical recommendations for the problem based on their research.

SM 407. (HSOC407) Urban Environments: Prevention of Tobacco Smoking in Adolescents. (B) Pepino. ABCS Course. Requires community service in addition to class time.

Cigarette smoking is a major public health problem. The Centers for Disease Control and Prevention Control reports that more than 80% of current adult tobacco users started smoking before age 18. The National Youth Tobacco Survey indicated that 12.8% of middle school students and 34.8% of high school students in their study used some form of tobacco products.

In ENVS 407, Penn undergraduates learn about the short and long term physiological consequences of smoking, social influences and peer norms regarding tobacco use, the effectiveness of cessation programs, tobacco advocacy and the impact of the tobacco settlement. Penn students will collaborate with teachers in West Philadelphia to prepare and deliver lessons to middle school students. The undergraduates will survey and evaluate middle school and Penn student smoking. One of the course goals is to raise awareness of the middle school children to prevent addiction to tobacco smoke during adolescence. Collaboration with the middle schools gives Penn students the opportunity to apply their study of the prevention of tobacco smoking to real world situations.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 408. (HSOC408) Urban Environments: The Urban Asthma Epedemic. (B) Pepino. ABCS Course. Requires community service in addition to class time.

Asthma as a pediatric chronic disease is undergoing a dramatic and unexplained increase. It has become the number one cause of public school absenteeism and now accounts for a significant number of childhood deaths each year in the USA.The Surgeon General of the United States has characterized childhood asthma as an epidemic. In ENVS 408, Penn undergraduates learn about the epidemiology of urban asthma, the debate about the probable causes of the current asthma crisis, and the nature and distribution of environmental factors that modern medicine describes as potential triggers of asthma episodes.

Penn students will collaborate with the Childrens Hospital of Philadelphia (CHOP) on a clinical research study entitled the Community Asthma Prevention Program. The Penn undergraduates will co-teach with CHOP parent educators asthma classes offered at community centers in Southwest, West, and North Philadelphia. The CHOP study gives the Penn students the opportunity to apply their study of the urban asthma epidemic to real world situations.

498. (GEOL498) Senior Thesis. (F) Giegengack.Prerequisite(s): ENVS 400-level course and declaration of the ENVS major. The Environmental Studies major, as of the fall of 2008, requires 1 semester of ENVS399 and two semesters of ENVS498.

The culmination of the Environmental Studies major. Students, while working with an advisor in their concentration, conduct research and write a thesis.

SM 411. Air Pollution: Sources & Effects in Urban Environments. (A) Andrews and Howarth.

This is an ABCS course designed to provide the student with an understanding of air pollution at the local, regional and global levels. The nature, composition, and properties of air pollutants in the atmosphere will also be studied. The course will focus on Philadelphia's air quality and how air pollutants have an adverse effect on the health of the residents. The recent designation by IARC of Air Pollution as a known carcinogen will be explored. How the community is exposed to air pollutants with consideration of vulnerable populations will be considered. Through a partnership with Philadelphia Air Management Service (AMS) agency the science of air monitoring and trends over time will be explored. Philadelphia's current non-attainment status for PM2.5. and ozone will be studied. Philadelphia's current initiatives to improvethe air quality of the city will be discussed. Students will learn to measure PM2.5 in outdoor and indoor settings and develop community-based outreach tools to effectively inform the community of Philadelphia regarding air pollution. The outreach tools developed by students may be presentations, written materials, apps, websites or other strategies for enhancing environmental health literacy of the community. A project based approach will be used to include student monitoring of area

schools, school bus routes, and the community at large. The data collected will be presented to students in the partner elementary school in West Philadelphia . Upon completion of this course, students should expect to have attained a broad understanding of and familiarity with the sources, fate, and the environmental impacts and health effects of air pollutants.

416. (BIOL415) Freshwater Ecology. (M) Bott.Prerequisite(s): BIOL 101 or 121 and one semester of college chemistry.

Survey of the physical, chemical and biological properties of freshwater ecosystems, both riverine and lentic, natural and polluted.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 463. (ENVS643, URBS463, URBS663) The Historical, Scientific, & Policy Dimensions of "Brownfields". (M) Keene. Offered through LPS - See current timetable

This course gives an overview of the genesis of the so-called "Brownfield" problem and of the various efforts that our society is taking to try to solve, or at least ameliorate it. The course will place the "Brownfield" problem in the broader context of the growth and decline of industrial base cities like Philadelphia. Students will study the general constitutional and statutory framework within which we approach the problems of orphan, polluted sites and the disposal of contemporary solid wastes. They will also analyze the principal actions that have been taken by federal and state governments to address remediation and redevelopment of abandoned industrial sites. In addition, the course will explore environmental equity issues.

507. Wetlands. (M) Willig. Offered through LPS - See current timetable

The course focuses on the natural history of different wetland types including climate, geology, and,hydrology factors that influence wetland development Associated soil, vegetation, and wildlife characteristics and key ecological processes will be covered as well. Lectures will be supplemented with weekend wetland types, ranging from tidal salt marshes to non-tidal marshes, swamps, and glacial bogs in order to provide field experience in wetland identification, characterization, and functional assessment. Outside speakers will discuss issues in wetland seed bank ecology, federal regulation, and mitigation. Students will present a short paper on the ecology of a wetland animal and a longer term paper on a selected wetland topic. Readings from the text, assorted journal papers, government technical documents, and book excerpts will provide a broad overview of the multifaceted field of wetland study.

530. Rocky Mountain Field Geology and Ecology. (L) Giegengack/Bordeaux. Field work is done in and around Red Lodge, Montana. An additional fee for Room and Board applies. Permission of the Instructor is required for non-MES students.

Designed for the MES program (open to non-MES students by permission of the instructor). This is a two-week intensive field course in the geology, natural history, and ecology of the Greater Yellowstone Ecosystem, which comprises a range of environments from the mile-high semi-deserts of intermontane basins to the alpine tundra of the Beartooth Plateau above 12,000 feet. The program is based at the Yellowstone-Bighorn Research Association (YBRA) field station on the northeast flank of the Beartooth Mountains near Red Lodge, Montana. The course includes day trips from the field station as well as overnight visits to sites within Yellowstone National Park. Pre-trip classes will be held online before the trip to ensure that all students are adequately familiar with basic principles of field-based natural science.

SM 533. Research Methods in Environmental Studies. (M) Kulik.

This course is designed to prepare Master of Environmental Studies students to undertake their Capstone exercises. In this course, we discuss how to identify an appropriate research project, how to design a research plan, and how to prepare a detailed proposal. Each student should enter the course with a preliminary research plan and should have identified an advisor. By the end of the course, each student is expected to have a completed Capstone proposal that has been reviewed and approved by his/her advisor.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 606. Ornithology. (A) McGraw.

This class will explore the foundations of avifaunal biology and ecology using a combination of hands-on classroom and in-the-field experiences. Classroom content includes physiology, anatomy, and morphology of birds. The fall migration of birds in North America is an epic and often tragic event. Sampling birds in migration has resulted in foundational understandings about stopover habitats, species-specific energy budgets and has helped realize the complete life cycle of hundreds of species. We will enter the field and participate in actual ornithological research, explore avifaunal ecology through birdwatching, and meet with regional leaders in the ornithological field.

541. Modeling Geographical Objects. (M) Tomlin.

This course offers a broad and practical introduction to the acquisition, storage, retrieval, maintenance, use, and presentation of digital cartographic data with both image and drawing based geographic information systems (GIS) for a variety of environmental science, planning, and management applications. Its major objectives are to provide the training necessary to make productive use of at least two well known software packages, and to establish the conceptual foundation on which to build further skills and knowledge in late practice.

SM 601. Proseminar: Contemporary Issues in Environmental Studies. (M) Pfefferkorn/Bordeaux/Scatena. Offered through LPS - See current timetable

A detailed, comprehensive investigation of selected environmental problems. This is the first course taken by students entering the Master of Environmental Studies Program.

604. Conservation and Land Management. (M) Harper. Some Saturday field trips will be required.

Using protected lands in the Delaware Valley, this field-based course will explore various strategies for open-space conservation and protection. In addition, students will be introduced to land management techniques used on such sites to restore or preserve land trust proerties in accordace with goals set for their use or protection.Sustainable land uses such as community supported agriculture, ecovillages, and permaculture design will be covered. Emphasis will be placed on developing skills in "Reading the Landscape" to determine conservation and restoration priorities. Students will produce a site assessment report on sites that they visit.

610. Regional Field Ecology. (L) Willig. Offered through LPS - See current timetable. Some Sunday field trips required.

Over the course of six Sunday field trips, we will travel from the barrier islands along the Atlantic Ocean in southern New Jersey to the Pocono Mountains in northeastern Pennsylvania, visiting representative sites of the diverse landscapes in the region along the way. At each site we will study and consider interactions between geology, topography, hydrology, soils, vegetation, wildlife, and disturbance. Students will summarize field trip data in a weekly site report. Evening class meetings will provide the opportunity to review field trips and reports and preview upcoming trips. Six all-day Sunday field trips are required.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 611. Environmental Law. (B) Keene.

This course will provide an introduction to environmental law and the legal process by which environmental laws are implemented and enforced. The course will examine the common law roots of environmental regulation in tort principles such as nuisance, negligence and trespass. We will examine important Constitutional principles in substantive and procedural law as well as significant environmental laws and approaches. Finally, we will examine emerging theories of citizen's rights and the government's role in environmental law and regulation. Students will learn how to read and analyze course decisions and apply some of the elements of legal thinking to actual cases and current problems.

612. Economics and the Environment. (M) Handy.

This course provides a comprehensive introduction to basic economic tools and methods, as they are applied to environmental issues -- including pollution control, resource depletion, the global commons, intergenerational equity, and policy decision-making. The course is designed for those with little or no prior economics background; disciplined sceptics are welcome.

SM 613. (ENVS413) Business and the Natural Environment. (B) Heller. Offered through LPS - See current timetable

This course explores dramatic changes taking place at the interface of business, society, and the natural environment. Previously, business and environmental interests were believed to be adversarial. Now, some contemporary thinkers are suggesting that environmental capabilities can be a source of competitive advantage for corporations. A recent Harvard Business Review article refers to the sum of these changes as "The Next Industrial Revolution." In this course we will study examples on the cutting edge of these developments. We will look at corporations that are creating a "double bottom line" by strategizing about the ecological impact of their decisions, as well as the economic impact. We will learn about industrial designers who are rethinking everything from tennis shoes to corporate headquarters' buildings with the environment in mind. We will consider new alliances among business, environmental activists and government regulators -- all stakeholders in a sustainable society.

615. Professional Case Studies in Environmental Analysis and Management. (M) Laskowski.

This course is designed for students nearing the end of their MES program. It will provide students with hands-on experience working with local environmental professionals on projects in the Delaware Valley region. Each student will select a project made available by a local public or private agency. Among the tasks that students will perform are data collection and analysis, project planning, and documentation. Each student will prepare a detailed report under the direction of the agency representative that can be the basis for a Capstone project. Those interested in continuing on to the Capstone phase will use the report as the basis for a publishable document to be prepared in conjunction with the participating agency.

SM 620. How to Quantify Sustainable Practices in Business and Manufacturing. (B) Baer.

This course is designed to survey the various sustainability tools currently available to evaluate business performance. We will concentrate on the Triple Bottom line views of sustainability. Emphasis will be on Data driven approaches to Life Cycle Assessment, Environmental Product Declarations, ISO standards, and Green Construction. Special sessions will review the business drivers and market pull for sustainable products and practices. We will focus on US Green Building Council LEED requirements as well as the expectations of retailers for environmental information with regard to consumer packaged goods.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 616. (ENVS426) Risk Assessment: Science & Policy Challenges. (L) Pepino.

How do government policy-makers make decisions about potential threats to human health and the environment in the face of scientific uncertainty? The course develops the concept of Risk Assessment from the publication of the 1983 National Research Council (NRC) report commonly known as the "Red Book" which was used to rank the initial hazardous waste sites under the Superfund program. Using a variety of teaching tools, including lectures, panel discussions, and case studies, the course examines how public policy decisions regarding environmental risk are made and how effective those decisions are at reducing risks to affected populations. The course focuses on the complex interaction of science, economics, politics, laws, and regulations in dealing with environmental and public health risks. The course will begin with a review of the policy process and methods used in evaluating human health and environmental risks, including the traditional steps in the risk assessment process, including quantitative and qualitative aspects of hazard identification, dose-response assessment, exposure assessment, and risk characterization.

The course will then focus on how scientific uncertainty, risk perceptions, socio-economic disparities, risk communication, and politics influence environmental risk-based decision-making. Issues such as special populations (e.g., children, elderly, immune-compromised, woman of pregnancy age, etc.) must be considered when developing risk reduction strategies. The use of the "precautionary principle" will be discussed in the context of different types of environmental stressors (e.g., pesticides, chemicals, climate change, air pollution, water quality, and land use) and how this important controversial principle is applied differently in contrasting national and European risk management policies.

SM 617. Innovative Environmental Management Strategies. (M) Laskowski. Offered through LPS - See current timetable

This course will evaluate innovative environmental management strategies used by corporations, governments, the public, and NGOs including approaches such as the concept of pollution prevention, environmental management systems, green buildings, green product design, product labeling, environmental education, the power of information, market-based techniques, and industrial ecology. Some professionals believe that these innovative approaches have the potential to result in more environmental improvement than will be realized by additional regulatory requirements. This course will address which approaches work best and identify critical elements needed to ensure the best approaches to specific problems. Students will be exposed to real-life situations through expert guest lecturers, case studies, and "hands on" projects.

SM 619. Environmental Leadership in Philadelphia. (C) Laskowski.

Philadelphia-area individuals and organizations have provided progressive leadership on many local, national, and international issues. These leaders come from government, business, NGOs, and academia. This course, given over a two week period, provides students with an opportunity to meet with these leaders at their place of employment. These experts will discuss their organization, their environmental priorities, and their thoughts on career opportunities. Each expert will also provide an in-depth explanation one or two of their progressive, sometimes cutting-edge, approaches to environmental management and science.

SM 621. Comparative Environmental Regulation. (B) Hagan.

In order to guide organizations and companies in an aligned fashion on environmental and sustainability issues, we need to understand the specific approaches that governments take in regulating environmental issues and the underpinning philosophies that drive these regulatory frameworks. This course will therefore require an evaluation of the different tools that governments have to influence, guide and command environmental outcomes from different segments of society. We will specifically examine the environmental regulatory approaches in a number of countries such as the United States, the European Union, China, India and Brazil.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 622. Environmental Enforcement. (A) Lisa.

The goal of the course is to provide students with an introduction to the role of enforcement in federal, state and local environmental regulatory programs. Emphasis will be placed on federal enforcement actions initiated by the U.S. Environmental Protection Agency and U.S. Department of Justice. The course will provide students with an introduction to the American Legal System and legal concepts, like standing, jurisdiction, and burden of proof. A number of case studies and classroom exercises will be utilized as part of the discussion of civil and criminal enforcement actions. For example, a detailed case study will be presented concerning a successful prosecution by the federal government of a wastewater treatment plant operator (from the receipt of the initial tip through the sentencing of the defendant). A theme of all classes, presentations and assignments will be the role of the environmental professional in the enforcement context (e.g., the environmental professional who testifies as an expert in a judicial proceeding, or performs an audit that becomes the subject of a self-disclosure to EPA).

SM 629. The US Water Industry in the 21st Century. (A) Neukrug.

The course will explore all 4 sectors of the water business in the United States: The Drinking Water Industry, The Stormwater Utility, Water Resources (rivers, streams, reservoirs) Management and the Water Pollution Control Industry. The course will have 2 primary foci: 1. The influences on the industry from new technologies and infrastructure, acceptable levels of risk, public and private sector competition, climate change, the bottled water industry, resource recovery, rates and affordability and other influences will be investigated. 2. The management of a 21st century utility will be explored, including topics of organization and leadership, the role of environmentalism, infrastructure financing, water / wastewater treatment facility operations, public affairs and media, and designing a capital improvement program are examples of topic areas.

SM 623. Climate Change and Security. (A) Thomas.

Climate change is increasingly presented as posing significant security risks, but the relationship is much more complex than such a simple cause-effect statement might suggest. Researchers from diverse fields including geography, climatology, and political science are actively engaging questions about what kinds of security are threatened by climate change and through what mechanisms. For example, will severe drought lead to violent conflict? Who is vulnerable to reduced soil moisture or increased coastal erosion and why? What are the consequences of viewing a problem as a livelihood versus national security risk? Who are the winners and losers of climate change-based security interventions? This course will orient students to the evolving debate on the relationship between climate change and its impacts on national, human, and environmental security.

625. Overview of Environmental Justice: Issues, Actions and Visions for the Future. (B) Harris and Thompson. Offered through LPS-See current Timetable.

Many people refer to the Environmental Justice Movement as the most significant social rights movement to occur in this country since the Civil Rights Movement.Communities around the United States have expressed concerns related to the siting, permitting and clean up of hazardous waste sites in minority and low-income areas. Beginning with the protests in Warren County, North Carolina, Environmental Justice has become a most critical and controversial issue in this country. This course will provide an overview of the history, guiding principles, and issues of concern regarding Environmental Justice and will examine the approaches taken by communities, EPA, state and local government over the years to address these concerns. Students will be expected to evaluate and assess the various issues and case studies presented to them in a critical fashion, discuss these case studies, and make recommendations for appropriate action.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 627. The Politics of Water. (B) Thomas.

Despite decades of scientific research and policy action aimed at managing water resources equitably and sustainably, it remains that the world's water resources continue to be severely polluted, pose grave hazards to lives and infrastructure, and be obstinately unevenly distributed in space and time. Moreover, a growing number of people (currently estimated at over 700 million) lack sufficient quantities of clean water. Although such challenges have long been approached with technical expertise (e.g. hydro-engineering, economic models), this course examines the social and political dynamics that underpin these problems. Organized as a survey of problems and responses, this seminar examines key concepts, major approaches, and current debates regarding water governance in various regions of the world. Course topics include the privatization of water, water as a human right, and human vulnerability to water hazards. In viewing water provision and management as not solely a technical concern but as inherently political, the course seeks to provide a set of analytical tools that is both critical and constructive.

SM 631. Current EPA Regulatory Practices and Future Directions. (A) Laskowski.

The regulatory approach continues to be the foundation of environmental protection in the US. This course provides an overview of key environmental laws and regulations, and the processes used to write permits, conduct inspections and take enforcement actions. It is taught mainly from the perspective of the federal government and will also include perspectives from the states, NGOs, and the regulated community. Techniques used to set priorities, ensure fairness, and encourage compliance are included. Current issues in major regulatory programs will be reviewed and future directions will be discussed.

SM 634. Closing the Loop on Climate Change. (C) Chu.

Historical consumption of materials and land resources has resulted in increasing per capita waste and greenhouse gas emissions. This course will explore opportunities to address the challenges of climate change through sustainable closed-loop approaches for materials and land. Alternative views of the drivers of climate changing greenhouse gases and the relative contributions of various sectors of the U.S. economy will be presented. The implications of climate change, economic costs of climate change mitigation and adaptation, rising energy prices, land use, and waste management issues will be discussed. The course will identify policy needs at all levels (international, national, state, and local) as well as practical solutions for greenhouse gas reductions. The course will explore in depth local policies and actions (e.g., recycling efforts and land use planning) that complement national and international efforts (e.g., cap and trade system and carbon tax).

639. Policy to Practical in Environmental Management: Water Issues. (C) Laskowski. Offered through LPS - See current timetable

This course explores some of the most challenging national and global water-related topics and includes guest lectures by and trips to meet representatives from several of the leading organizations addressing these these issues. Examples of these topics include meeting the UN Millennium Development Goal of halving the number of people worldwide who do not have adequate drinking water and sanitation; the control of polluted runoff from farms and urban areas; the management of multi-state water pollution programs; and assessment of the impacts of low-level toxics in water. In addition to learning about the environmental issues, students will also visit regional and global experts in such places as the Philadelphia, Washington DC, and New York City. Students must attend two full-day field trips and one afternoon trip.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 635. Major Global Environmental Problems of Today and How We Must Deal With Them Tomorrow.. (B) Laskowski. Offered through LPS - See current timetable

Global environmental problems of today are some of the greatest challenges of the new millennium. Almost everyone is in some way part of the problem and increasingly will be asked to be a part of the solution. The problems that we face today often differ from those of the past because it is sometimes difficult for the international community to agree on the extent, causes, and impacts of the problem and how to allocate responsibility for the resolution of the problem. Governments, businesses and NGOs around the world have recognized the need to take the initiative and address these issues through regulation, voluntary approaches, and cooperation on an international level. How best to manage these problems is the constant challenge. This course will provide an overview of several of the major global environmental problems facing the world today, and how they are connected by common causes, underlying themes and concepts critical to the understanding and management of these issues. It will examine the over-arching concepts of sustainability and globalization as well as frameworks for assessing and managing the issues.

The course will also consider the role of the major players/stakeholders in the situation, including governments, non-government organizations, and private sector individuals/participants, and where appropriate, touch on such issues as intergenerational aspects and the potential long-term irreversibility. With the assistance of regional and national experts, we will address specific problems, such as: human populations and their environmental impact; issues surrounding resources such as food, water, habitats, and energy; global climate change; the ozone layer; and problems of international/environmental terrorism, catastrophes, and disease. Each student will prepare a report and presentation on some aspect of a topic discussed during the term.

637. Global Water Issues. (A) Laskowski. Offered through LPS - See current timetable

Water- related illnesses are estimated by some to kill up to 5000 people per day worldwide and many of these casualties are children. This course will explore the causes of this global crisis and what is being done to address the issue. It will provide an overview of international agreements, wastewater and water supply issues, technological advances, political/financial/cultural and other barriers to success, and what students can do to become involved in resolving the issues. Guest lecturers and case studies will provide insights to problems in problem areas around the world. Students will be asked to evaluate specific problems and suggest improved approaches to improving access to clean water.

SM 638. Global Water Policy and Governance. (A) Laskowski.

At the turn of the 21st century the United Nations established a series of goals to assist developing countries. These Millennium Development Goals [MDG] include targets for water and sanitation: " by the year 2015 to reduce by one half the percent of the world's population that does not have access to safe water and adequate sanitation". This course explores the policies and actions being taken by the world community, the United States, and NGOs to meet these targets. It will also address water governance issues such as financing, community leadership, and capacity building for water/sanitation in developing countries. Two mandatory full-day field trips are included [one to the United Nations in New York City; another to US Government leaders in Washington, DC].

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 642. Global Water Conference in Stockholm, Sweden. (L) Laskowski.

The global water and sanitation crisis kills over 4,000 children each day and represents one of the biggest health problems in the world. At the University of Pennsylvania school year 2010-2011 was declared the "Year of Water" in recognition of the many challenges that lie ahead as global increases in population and affluence and the influences of climate change will stress limited water resources. Each year the Stockholm International Water Institute convenes a Conference with experts from around the globe to exchange the latest water research findings and develop new networks. Students will attend the Conference, present research by presentations/posters, document a key issue, interview experts, and meet colleagues with common interests. They will also help other organizations at the Conference.

SM 645. Water Environment Federation Conference. (A) Neukrug.

SM 643. (ENVS463, URBS463, URBS663) The Historical, Scientific, & Policy Dimensions of "Brownfields". (M) Keene. Offered through LPS - See current timetable

This course is intended to give students an overview of the genesis of the so-called "Brownfield" problem and of the various efforts our society is taking to solve or, at least, ameliorate it. The course will place the "Brownfield" problem in the broader context of the growth and decline of the industrial base of cities like Philadelphia. Students will study the general constitutional and statutory framework within which we approach the problems of orphan, polluted sites and the disposal of contemporary solid wastes. They will also analyze the principal actions that have been taken by Federal and state government to address remediation and redevelopment of abandoned industrial sites. The course will also explore environmental equity issues.

The students will collaborate with high school students at the West Philadelphia High School to identify sites in their neighborhoods and to learn how to determine the sites ownership and land use history. The students will study ways of determining environmental risk and the various options that are available for remediation in light of community ideas about re-use. Students will be expected to participate actively in the seminar and the sessions with high school students. Students in the course are required to prepare and present a term paper on a topic in the general area of "Brownfield" analysis and remediation.

SM 644. Energy, Waste and the Environment. (B) Giere.

The aim of this course is to provide an incentive to use geochemical and mineralogical principles to address and solve major environmental problems. The students identify the problems that are associated with different types of waste. This course covers a wide range of problems associated with the waste arising from the generation of electricity. The main topics will be the uranium cycle, characterization of nuclear waste, and the containment and disposal of nuclear waste. Based on insights from the nuclear fuel cycle, solutions are presented that diminish the environmental impacts of coal and biomass combustion products, incineration of municipal solid waste, toxic waste due to refuse incineration, and landfills and landfill gases.

SM 647. Urban Ecology. (C) Bathala.

Urban Ecology provides an examination of the ways in which humans and other animals interact in shared and contiguous environments. A focus of the course will be the impact of urbanization on our natural resources. Topics covered include historical and ethical perspectives of wildlife, general ecological principles, biodiversity and endangered species management, eco-tourism and environmental sustainability. Students will be required to keep a weekly journal of current news articles and responses in lieu of a textbook. Additionally, a museum trip or evening lecture series event may be incorporated. Students will have the opportunity to collect data for an Urban Bird Watch project. Laboratory exercises will also be required which demonstrate various ecological measures.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

652. God, Gold & Green: Themes and Classics in American Environmental Thought. (C) Blaine. Offered through LPS - See current Timetable

Through an exploration of enduring themes and classics, this course traces environmental thought in America from the first European settlements to the present. We begin by considering the preconceptions that Europeans brought to the New World and the realities they found when they arrived. We look at the issues raised by the unprecedented industrial and urban expansion of the 19th century and the accompanying westward migration that filled the continent. We examine how the conflict between economic growth and environmental limits created competing models of prosperity, equality and justice. And finally, we look at ways to transcend those divides and build a sustainable and equitable future. The primary vehicles for understanding the evolution of environmental thinking across several centuries are some of the classic texts of environmental thought - from The Book of Genesis to Henry Thoreau's Walden to Rachel Carson's Silent Spring to Al Gore's An Inconvenient Truth. The course seeks to provide a theoretical and historical framework that will help students understand current issues and address real problems.

SM 656. Environmental Futures. (B) Laskowski.

As global population and affluence increases in the 21st century, the world is faced with many environmental challenges. Global climate change, declines in fisheries, water supply shortages, limited fossil fuels, habitat destruction, species extinction, and low- level toxins are a few concerns. Many studies of these issues have projected disastrous impacts on the environment, human health, and the economy. But, how accurate are those projections? And, what needs to happen to make these projections more optimistic? In this course students will select one of the many global environmental problems of the 21st century, research projections made about the impact of the problem to the year 2050, assess the accuracy of the assumptions behind these projections, and apply creative thinking to what needs to happen to make these projections more optimistic (eg, could there be technological breakthroughs?; better international agreements?; improved monitoring?; shifts in cultural attitudes?; regulation and market-based solutions?). Environmental management topics such as strategic planning, environmental indicators, pollution prevention, innovative technologies, and the importance of quality science will be addressed.

678. Advanced Biogeochemistry. (B) Vann. A soils course would be helpful, but not required

The course will cover nature of the field of biogeo chemistry and its application. Topics include, elemental cycling at various scales,from global to watershed level,the interaction between geology and biology in controlling how these relationships have changed over the Earth's history and man's influence on these cycles.

The course will include an examination of the CENTURY computer model, a popular model for examining nutrient cycling in terrestrial ecosystems. Students will submit a term paper on a related subject, such as comparing the functioning of two watersheds or summarizing current understanding of a particular cycle, etc.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 662. Green Design and the City. (B) Berman. Offered through LPS - See current timetable

Can our cities become examples of sustainable design? Does inner city revitalization tie into sustainability? Are there successful examples to learn from? This seminar will focus on how existing cities attempt to integrate green design principles within them. It will look at case studies, both in the US and abroad.

Urban design and transportation will be examined within this context, including how to create pedestrian friendly spaces. Infill construction and the adaptive use of existing buildings will be discussed, as well as the reuse of brownfield sites. We will also look at what types of construction actually constitute green buildings.

We will take advantage of our local resources within Philadelphia, and include visits to nearby sites, along with talks by local experts. There will be a series of short projects given throughout the term. They will usually include both a written component and a presentation to the class. The energetic execution of these projects, their presentations and the subsequent discussions, will be a key part of this seminar.

SM 664. Sustainable Design. (C) Berman. Offered through LPS - See current timetable

This seminar will focus on how physical design can improve sustainability. It will be broken down into 3 parts: Green Buildings, Green Urbanism, and Smart Growth Planning. Starting small, we will begin by looking at which types of construction actually constitute Green Buildings and which of these are the most effective. Our look at Green Urbanism will focus on existing cities and towns. They will be examined in terms of how urban design and transportation can promote sustainability. Finally, Smart Growth planning concepts for new developments will be discussed. This will include a survey of New Urbanism. Both these closely allied approaches are recent attempts to guide new growth in a more sensitive manner. We will also take advantage of local resources within our region, and include visits to nearby sites, along with talks by local experts.

SM 674. Life Cycle Assessment. (A) Hagan.

681. Modeling Geographical Space. (M) Tomlin. Offered through LPS - See current timetable

This course explores the nature and use of digital geographic information systems (GIS) for the analysis and synthesis of spatial patterns and processes through 'cartographic modeling'. Cartographic modeling is a general but well defined methodology that can be used to address a wide variety of analytical mapping applications in a clear and consistent manner. It does so by decomposing both data and data-processing tasks into elemental components that can then be recomposed with relative ease and with great flexibility.

699. (GEOL699) Masters of Environmental Studies Capstone Seminar. (C) Bordeaux. Permission of instructor required. Offered through LPS - See current timetable

999. Independent Study. (C) Staff. Permission of instructor required

Directed study for individuals or small groups under supervision of a faculty member.

GEOLOGY (GEOL)

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 096. Field Approaches to Understanding the Earth & Environmental Science. (A) Scatena. Corequisite(s): GEOL 100 or GEOL 109 highly recommended.This is a field based course. Weekend fieldtrips are required.

Understanding landscapes and the relationships between the natural world and society is fundamental to the natural sciences, architecture, medicine and public health, real estate and finance, urban studies and a range of other disciplines. The primary goal of this course is to expose students to the science of reading landscapes and disciplines that are founded in observation and hypothesis testing in the field. In addition, the course will orient incoming students to the physical environment in which they will be living while they are at Penn.

The course will be centered around lectures and discussions that are based on ten or more field trips that will take place on weekends and afternoons throughout the semester. The trips will be led by faculty members and will cover topics of plate tectonics, bedrock and surficial geology, geomorphology, hydrology, environmental geology, pollution and field ecology.

L/R 100. Introduction to Geology. (A) Physical World Sector. All classes. Omar. Field trips required.

An introduction to processes and forces that form the surface and the interior of the Earth. Topics include, changes in climate, the history of life, as well as earth resources and their uses.

L/R 103. Natural Disturbances and Human Disasters. (A) Physical World Sector. All classes. Scatena.

Natural disturbances play a fundamental role in sculpturing landscapes and structuring natural and human-based ecosystems. This course explores the natural and social science of disturbances by analyzing their geologic causes, their ecological and social consequences, and the role of human behavior in disaster reduction and mitigation. Volcanoes, earthquakes, floods, droughts, fires, and extraterrestrial impacts are analyzed and compared.

109. Introduction to Geotechnical Science. (A) Physical World Sector. All classes. Omar.

Open to architectural and engineering majors as well as Ben Franklin Scholars. Field trips. Relations of rocks, rock structures, soils, ground water, and geologic agents to architectural, engineering, and land-use problems.

201. (GEOL521, GEOL531) Mineralogy. (A) Omar.Prerequisite(s): GEOL 100 and CHEM 001 or 101.

Crystallography, representative minerals, their chemical and physical properties. Use of petrographic microscope in identifying common rock-forming minerals in thin section.

111. Geology Laboratory. (C) Omar.Prerequisite(s): GEOL 100 preferably taken concurrently. Field trips required.

Hands-on study of earth materials and processes. Identification and interpretation of rocks, minerals and fossils. Topographic and geologic maps. Evolution of landscapes. Field trips lead to a synthesis of the geologic history of southeastern Pennsylvania.

L/R 125. Earth and Life Through Time. (C) Physical World Sector. All classes. Willingbring.

Origin of Earth, continents, and life. Continental movements, changing climates, and evolving life.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

L/R 130. Oceanography. (B) Physical World Sector. All classes. Dmochowski.

The oceans cover over 2/3 of the Earth's surface. This course introduces basic oceanographic concepts such as plate tectonics, marine sediments, physical and chemical properties of seawater, ocean circulation, air-sea interactions, waves, tides, nutrient cycles in the ocean, biology of the oceans, and environmental issues related to the marine environment.

205. (GEOL405) Paleontology. (B) Living World Sector. All classes. Pfefferkorn. Two field trips required.

Geologic history of invertebrates and their inferred life habits, paleoecology, and evolution. Introduction to paleobotany and vertebrate paleontology.

206. (GEOL506) Stratigraphy. (A) Jerolmack.Prerequisite(s): GEOL 100 or permission of instructor. Two field trips, field project

Introductory sedimentary concepts, stratigraphic principles, depositional environments, and interpretation of the rock record in a paleoecological setting.

208. (GEOL630) Structural Geology. (B) Phipps.Prerequisite(s): GEOL 100 and 111; PHYS 150 strongly recommended. Three field trips required

Introduction to deformation as a fundamental geologic process. Stress and strain; rock mechanics. Definition, measurement, geometrical and statistical analysis, and interpretation of structural features. Structural problems in the field. Maps, cross-sections, and three-dimensional visualization; regional structural geology.

299. Independent Study. (C) Staff.Prerequisite(s): Permission of department. May be repeated for credit

Directed study for individuals or small groups under close supervision of a faculty member.

305. (GEOL545) Earth Surface Processes. (B) Physical World Sector. All classes. Jerolmack.Prerequisite(s): ENVS 200, GEOL 100, or permission of the instructor. This course includes two required weekend field trips, and a hands-on laboratory.

Patterns on the Earth's surface arise due to the transport of sediment by water and wind, with energy that is supplied by climate and tectonic deformation of the solid Earth. This course presents a treatment of the processes of erosion and deposition that shape landscapes. Emphasis will be placed on using simple physical principles as a tool for (a) understanding landscape patterns including drainage networks, river channels and deltas, desert dunes, and submarine channels, (b) reconstructing past environmental conditions using the sedimentary record, and (c) the management of rivers and landscapes under present and future climate scenarios. The course will conclude with a critical assessment of landscape evolution on other planets, including Mars.

317. (GEOL417) Petrology and Petrography. (B) Omar.Prerequisite(s): GEOL 201. Two field trips

Occurrences and origins of igneous and metamorphic rocks; phase equilibria in heterogeneous systems. Laboratory study of rocks and thin sections as a tool i interpretation of petrogenesis.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

318. Glaciers,Ice & Climate. Goldsby.Prerequisite(s): Students should have basic knowledge of Calculus. MATH 114 or equivalent.

All forms of frozen water at Earth's surface define the cryosphere. These icy environmnets are an integral part of the global climate system, with important linkages and feedbacks resulting from their influences on surface energy and moisture fluxes, clouds, precipitation, hydrology, and circulation in the atmosphere and oceans. This course will survey the various components of the cryosphere and their interactions with climate, with a strong emphasis on the dynamics of glaciers and ice sheets. Broad topics to be covered are 1)the rudimentary mechanics of glacier and ice sheet flow, 2)fast-flowing ice streams and factors limiting their motion, 3)ice-quakes and their origins, 4)the nature of climate data recorded in natural ice bodies, 5)the influence of climate on the stability of ice sheets and glaciers, and 6)glacier-like flow on other planetary bodies. This will be a lecture-based course with written assignmnets and problems sets.

401. Environmental Geology. (M) Willig.

The purpose of this course is to better understand the interactions of humans and the environment through an examination of geologic processes and features as they influence, and are influenced, by human activities. the ultimate goal of such study is to make better land use decisions. Following a review of some basic geologic concepts, we will study hazardous geologic processes including; volcanic eruptions, earthquakes, river flooding,coastal flooding and erosion, landslides, and subsidence. Next, we will discuss environmental impacts associated with the use of fossil fuels, water, and soils. The course will conclude with student presentations of selected topics in environmental geology.

405. (GEOL205) Paleoecology. (A) Natural Science & Mathematics Sector. Class of 2010 and beyond. Bordeaux.Prerequisite(s): GEOL 205 or permission of instructor.

Relationship of fossil assemblages to life assemblages; structure of ancient communities, and interaction of organisms with each other and with the physica environment; evolution of communities.

417. (GEOL317) Advanced Petrology. (A) Omar.Prerequisite(s): GEOL 317.

Chemistry, physics, phase equilibria, microscope study in igneous and metamorphic petrology.

SM 409. (GEOL509) Intro to Remote Sensing. Dmochowski.Prerequisite(s): PHYS151 and MATH114 or equivalent are preferable, but not required. See instructor.

This course will introduce students to the principles of remote sensing, characteristics of remote sensors, and remote sensing applications. Image acquisition, data collection in the electromagnetic spectrum, and data set manipulations for earth and environmental science applications will be emphasized. We will cover fundamental knowledge of the physics of remote sensing; aerial photographic techniques; multispectral, hyperperspectral, thermal, and other image analysis. Students will pursue an independent research project using remote sensing tools, and at the end of the semester should have a good understanding and the basic skills of remote sensing.

411. Intro Soil Science. Plante.Prerequisite(s): GEOL 100 or equivalent.

Soil is considered the "skin of the Earth", with interfaces between the lithosphere, hydrosphere, atmosphere, and biosphere. It is a mixture of minerals, organic matter, gases, liquids and a myriad of organisms that can support plant life. As such, soil is a natural body that exists as part of the environment. This course will examine the nature, properties, formation and environmental functions of soil.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

418. Geochemistry. (M) Giere.

This course provides a comprehensive introduction to theory and applications of chemistry in the earth and environmental sciences. Theory covered will include atomic structure, chemical bonding, cosmic abundances, nucleosynthesis,radioactive decay, dating of geological materials, stable isotopes, acid-base equilibria, salts and solutions, and oxidation-reduction reactions. Applications will emphasize oceanography, atmospheric sciences and environmental chemistry, as well as other topics depending on the interests of the class. Although we will review the basics, this course is intended to supplement, rather than to replace, courses offered in the Department of Chemistry. It is appropriate for advanced undergraduate as well as graduate students in Geology, Environmental Science, Chemistry and other sciences, who wish to have a better understanding of these important chemical processes.

420. Introduction to Geophysics. (M) Doheny/Bechtel.Prerequisite(s): GEOL 100 or 109, two semesters Math and Physics, and/or instructor's permission.

This course will cover the application of geophysical investigation techniques to problems of the earth's plantary structure, local subsurface structure and mineral prospecting. The topics will include principles of geophysical measurements and interpretation with emphasis on gravity measurement, isostasy, geomagnitism, sesmic refraction and reflection,electrical prospecting, electromagnetics and groung radar.

421. (GEOL541) Elemental Cycling in Global Systems. (B) Plante.Prerequisite(s): ENVS 200, GEOL 100, or permission of the instructor.

Humans have an enormous impact on the global movement of chemical materials. Biogeochemistry has grown to be the principal scientific discipline to examine the flow of elements through the global earth systems and to examine human impacts on the global environment. This course will introduce and investigate processes and factor controlling the biogeochemical cycles of elements with and between the hydrosphere, lithosphere, atmosphere and biosphere. Students will apply principles learned in lectures by building simple computer-based biogeochemical models.

422. (GEOL622) Rates and Dates: Applications and Methods of Modern Geochronology. (C) Willenbring.Prerequisite(s): Students need GEOL100 or an equivalent course or a solid background in physical sciences, including either chemistry or physics.

This course is designed to give advanced undergraduate students and graduate students an understanding of the science behind numerical dating techniques in geological and archaeological contexts. This course will provide a background in the physics of radioactive decay and natural radiation sources. We will also cover various radiometric dating methods, and non-radiometric alternatives for younger samples. Numerous case studies involving questions of both geological and archaeological importance will be studied in this context. This class will cater to students interested applying chronologic tools to the areas of archeology, physical anthropology, soil science, tectonics, sea level change, climate change, land use change and ocean processes.

498. (ENVS498) Senior Thesis. (F) Giegengack.Prerequisite(s): GEOL400-level and declaration of the EASC major. The Earth Science major, as of the fall of 2008, requires 1 semester of GEOL399 and two semesters of GEOL498.

The culmination of the Earth Science major. Students, while working with an advisor in their concentration, conduct research and write a thesis.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

423. (GEOL623) ADVANCED METHODS IN COSMOGENIC NUCLIDES. (C) Prerequisite(s): GEOL 422/622 or by permission of the instructor. Corequisite(s): Earth is constantly bombarded with primary cosmic rays, high energy charged particles that interact with atoms in the atmosphere, producing a cascade of secondary particles. in turn, interact and reduce their energies in many reactions as they pass through the atmosphere. By the time the cosmic ray cascade reaches the surface of Earth, it is primarly composed of neutrons which produce nuclides in materials such as rocks and sediment at the Earth's surface. Most of these cosmogenic nuclides are produced by neutron spallation within the upper meter of mass. Using certain cosmogenic radionuclides, scientists can datehow long a particular surface has been exposed, how long a certain piece of material has been burried, or how quickly a location or drainage basin is eroding. The basic principle is that these radionuclides are produced at a known rate, and also decay at a known rate. In this course, students will learn the details and history of cosmic ray production rate estimates over .

Earth is constantly bombarded with primary cosmic rays, high energy charged particles that interact with atoms in the atmosphere, producing a cascade of secondary particles. These particles, in turn, interact and reduce their energies in many reactions as they pass through the atmosphere. By the time the cosmic ray cascade reaches the surface of the Earth, it is primarily composed of neutrons which produce nuclides in materials such as rocks and sediment at the Earth's surface. Most of these cosmogenic nuclides are produced by neutron spallation within the upper meter of mass. Using certain cosmogenic radionuclides, scientists can date how long a particular surface has been exposed, how long a certain piece of material has been buried, or how quickly a location or drainage basin is eroding. The basic principle is that these radionuclides are produced at a known rate, and also decay at a known rate. In this course, students will learn the details and history of cosmic ray production rate estimates over the globe and through geologic time. A primer to the various accepted scaling methods will be discussed as well as age and erosion rate calculations and advanced and new applications.

428. Introduction to Isotope Geochemistry. (A) Giere.

477. Introduction to Vertebrate Paleontology. (M) Dodson.Prerequisite(s): GEOL 100, BIOL101, GEOL205 or similar course.

501. Pleistocene Geology. (M) Giegengack.Prerequisite(s): GEOL 100 or equivalent.

Origin, extent in space and time, and effect on geologic processes of Late Cenozoic climatic change; Pleistocene stratigraphy in different parts of the world.

503. Earth Systems and Earth Hazards. (B) Phipps.Prerequisite(s): Geology 100 (introductory physical geology,) or permission of the instructor. The course is intended for Masters' students in Environmental Studies and Applied Geology, as well as upperclass geology majors.

This course will examine the hazards that arise from living on an active planet from a large-scale systems standpoint. We will briefly survey the Earth's major systems, emphasizing energy generation, storage, and flow within the Earth, and then proceed to an examination of the hazards that result. This will include earthquakes and tsunamis, volcanic eruptions, river and coastal flooding, and hurricanes, tornadoes, and other major storms. We will touch briefly on global warming and other current topics.

SM 508. The Geology and Geography of Energy Resources. (M) Phipps.Prerequisite(s): Geol100 or equivalent is preferred. Possible field trips.

This course will survey the way geology controls the formation and location of energy resources. Questions we'll address include, "How are oil and gas fields formed?", "Why does the Middle East have so much oil?", "What are the best locations in the US for wind and solar energy generation, and why?". We will discuss hydrocarbon, nuclear, solar, wind, and tidal energy sources.

EARTH AND ENVIRONMENTAL SCIENCE (AS) {EESC}

SM 509. (GEOL409) Intro to Remote Sensing. Dmochowski.Prerequisite(s): PHYS151 and MATH114 or equivalent are preferable, but not required. See instructor.

This course will introduce graduate students to the principles of remote sensing, characteristics of remote sensors, and remote sensing applications. Image acquisition, data collection in the electromagnetic spectrum, and data set manipulations for earth and environmental science applications will be emphasized. We will cover fundamental knowledge of the physics of remote sensing; aerial photographic techniques; multispectral, hyperspectral, thermal, and other image analysis. Students will pursue an independent research project using remote sensing tols, and at the end of the semester should have a good understanding and the basic skills of remote sensing. Expectations for the graduate student independent research projects will be at the graduate level and can relate to their capstone or Ph.D. thesis research topics.

510. Geophysical Fluid Dynamics. Nathan Paldor.Prerequisite(s): Math 114 or equivalent or permission by the instructor.

This class will discuss physical principles fundamental to the theoretical,observational, and experimental study of geophysical fluids, the equations of motion for rotating fluids; hydrostatic and Boussinesq approximations; circulation theorem; conservation of potential vorticity; scale analysis, geostrophic wind, quasigeostrophic system; wave theory and applications, flow instabilities, geophysical boundary layers. Depending on student interest, the class will be adapted to include applications from Oceanography, Meteorology, Geophysics or Engineering.

SM 527. Applied Techniques in Paleontology. (B) Manning.Prerequisite(s): Geol205 or equivalent is suggested.

The development of surveying, imaging, and analytical techniques has facilitated many advances in the field of paleontology in recent years. This course will review the application of new and existing technologies to the analysis and interpretation of fossil remains. The research areas to be reviewed include: Light Detection and Range (LiDAR) applications to trackway and body mass estimates in dinosaurs; soft tissue preservation in the fossil record and the techniques to recognize and identify biomarkers; dinosaur locomotor reconstruction (using Gaitsym); geochemical and elemental analysis (particularly specializing in synchotron based techniques); application of high-performance computing; mechanical analysis of biomaterials (both extant and extinct); finite element analysis and the application of high resolution X-ray tomography. Given the fluid nature of developing applications, the course will include additional techniques which are a function of the research program evolving between the Universities of Manchester and Pennsylvania.

511. Soil Science w Lab. (A) Plante.Prerequisite(s): GEOL 100 or equivalent. Field trips

Soil is considered the "skin of the earth", with interfaces between the lithosphere, hydrosphere, atmosphere, and biosphere. It is the mixture of minerals, organic matter, gases, liquids and a myriad of organisms that can support plant life. As such, soil is a natural body that exists as part of the environment. This course will examine the nature, properties, formation and environmental functions of soil. In addition to lectures, the course includes biweekly labs or field trips, and a multi-day field trip to held during Spring Break.

SM 515. Evolution/Revolution of Land Ecosystems. (M) PFEFFERKORN.

Origin and diversification of land ecosystems. Interaction between plants and animals. Effects of past climatic change and other external factors. The importance of past changes in land ecosystems to our understanding of current global change.

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521. (GEOL201, GEOL531) Mineralogy of Rock Preservation. (A) Omar. Graduate School of Fine Arts students only.

Advanced crystallography, representative minerals, their chemical and physical properties, with emphasis on building stone preservation. Use of petrographic microscope in identifying common rock-forming minerals in thin section.

528. Aqueous Geochemistry. (M) Andrews.Prerequisite(s): GEOL 100 Intro to Geology or permission of instructor.

Chemical composition and interactions of soils and soil water with applications to current problems.

531. (GEOL201, GEOL521) Advanced Mineralogy. (A) Omar.

Advanced crystallography, representative minerals, their chemical and physical properties. Use of petrographic microscope in identifying common rock-forming minerals in thin section.

540. Geotectonics. (M) Phipps.Prerequisite(s): GEOL 205, 206, 208, 317 and 420, or permission of instructor. Field trip

Bulk structure of the Earth. Plate tectonics and plate boundaries. Plumes, rifting, and intraplate tectonics. Geotectonics and seismicity.

541. (GEOL421) Elem Cycling in Global. (B)

SM 546. Basin Analysis. (M) Phipps.

599. Independent Study. (C) Staff.

Directed study for individuals or small groups under supervision of a faculty member.

602. Geotechnics: Introduction to Geotechnical Engineering. (B) Doheny.

The course begins with a study of the Earth's composition, the formation of soil materials by the weathering process (Physical and Chemical), and a discussion of soil mineralogy, with particular emphasis on the clay minerals. Following this introduction, soil classification systems and physical properties of soils will be presented, as well as the State of Stress in a Soil Mass together with Seepage Theory and Groundwater Flow. The technical portion of the course will conclude with the development of Consolidation Theory and Analyses, Shear Strength Theory, Lateral Earth Pressure Theory and Application, and Slope Stability Analysis.

The course will conclude with the presentation of two Case History Sessions, presenting applications of Geotechnical Engineereing Practice and the influence of the Geologic setting.

SM 603. Luquillo Critical Zone Research Seminar. (M) Scatena.Prerequisite(s): This course is designed for PhD and MS students working on their Luquillo projects.

Classic primary readings on the geology and ecology of the Luquillo mountains and surrounding regions will be read and discussed in sessions led by EES Faculty and graduate students who are involved in Luquillo CZ research.

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604. Geostatistical Analysis. (A) Vann.Prerequisite(s): STAT 101 or equivalent statistics course; BioL 556 suggested or other Inferential Statistics courses, covering uni- and multi-variate techniques.

Univariate and multivariate approaches to the analysis of spatial correlation and variability. Many disciplines, including geology, ecology and the environmental sciences regularly need to analyze and make predictions from data that is spatially autocorrelated. Mine reserve estimation, pollutant dispersal and the use of randomization tests in ecology are examples of where spatial statistics may be applied.

SM 606. Topics in Sedimentary Petrology and Stratigraphy. (M) Pfefferkorn.Prerequisite(s): GEOL 205, 206, 706 or permission of instructor.

Analysis of selected paleoenvironmental, stratigraphic, and sedimentological problems in the field and laboratory.

ADVANCED STRATIGRAPHY: In-depth study of sedimentology, stratigraphic principles, and paleoecological interpretation based on the rock record.

SEDIMENTARY PETROLOGY: Interpretation of rocks using microscopic techniques. Students will make thin-sections of various sedimentary rock types collected from regional depositional basins (Geol 706). Diagenetic, syn- and post-depositional processes will be investigated.

SM 615. Advanced Vertebrate Paleontology Seminar. (C) Dodson. May be repeated for credit

Topics in vertebrate paleontology and paleoecology.

SM 611. Field Study of Soils. (B) Johnson.Prerequisite(s): GEOL 511 or permission of instructor. All day field trips

Processes of soil development in a variety of temperate environments. Effects of lithology and climate on soil properties.

SM 614. Regional Geology and Ecology of North America. (A) Phipps.

616. Geology of the Carboniferous Period. (M) Pfefferkorn.

Paleogeography, biogeography, stratigraphy, paleoclimatology, flora, and fauna of the Carboniferous Period.

SM 617. Topics in Sedimentology. (M) Prerequisite(s): GEOL 206 or permission of instructor.

CLIMATE CHANGES THRU TIME: Issues of anthropologenically-induced climate changes are hotly debated. However, it is not possible to make meaningful predictions of future climates without understanding the forces that have controlled past climates. This course will review the geologic evidence for past climate changes and discuss processes that affect global climate changes. It will involve analysis and modeling of various sedimentary environments, systems, and processes.

ANCIENT TERRESTRIAL ENVIRONMENTS: Multi-disciplinary approaches and techniques that enable the extraction of comprehensive information (weathering, deposition, diagenisis, tectonics) from ancient continental deposits. The goal is the reconstruction of integrated environmental, geographic, and climatic conditions for selected time slices.

SM 618. Geochemistry Seminar. (C) Staff.

Topics in geochemistry.

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619. Instrumentation for the Geosciences. (B) Vann.

An introduction to the theory, operation and application of modern analytical instrumentation used in geo- and environmental sciences. Primarily focused on laboratory instrumentation such as mass spectroscopy, elemental analyses and x-ray techniques. Some field instruments will be introduced as well. Students will be expected to develop projects utilizing the various instruments.

SM 620. Geophysics Seminar. (M) Staff.

Topics in solid Earth geophysics.

SM 621. Advanced Biogeochemistry. (M) Plante.Prerequisite(s): Geol421 or permission from instructor.

Through close readings from the primary literature, students will undertake an in-depth study of biogeochemical cycling and human disturbance of biogeochemical cycles. Special emphasis will be on carbon and nitrogen cycling in terrestrial ecosystems, but may include other topics based on the interests of enrolled students.

623. (GEOL423) ADV COSMOGENIC NUCLIDES. (C)

SM 625. Advanced Paleobotany Seminar. (M) Pfefferkorn. May be repeated for credit

Topics in paleobotany, paleoecology and evolution.

627. SPEC TOPIC PALEONTOLOGY.

SM 628. Seminar in Isotope Geochemistry. (M) Staff.Prerequisite(s): Intermediate background in chemistry, physics, biology, or geology.

This course is for advanced undergraduates and graduate students interested in learning about or pursuing applications of isotope geochemistry, with an emphasis on biological and climatic processes (e.g. plant physiology, soils, nutrient cycling, and atmospheric chemistry).We will meet to discuss readings both from the literature and textbook chapters where necessary for backround. Grading will be on the basis of class participation and short weekly writing assignments. The latter will be completed prior to the class by both students and professor to ensure thorough discussion of each topic.

SM 630. (GEOL208) Advanced Structural Geology Seminar. (M) Phipps. May be repeated for credit. Four-day field trip

Topics in tectonophysics and/or regional structural geology.

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SM 631. Reconstructing Former Sea Levels. (B) Horton. Course includes a mandatory several day-long field trip.

The significance of relative sea level since the last glacial maximum is recognized by disciplines across the Earth sciences. Relative sea-level histories are important for calibrating and constraining geophysical models of Earth's rheology and the isostatic adjustment of Earth to ice and water loads. Sea level is crucial to any study of coastal evolution as it serves as the ultimate baseline for continental denudation. The stability of sea level in recent past has been an important factor in sustaining coastal communities and may have profoundly influenced the very initiation of human civilization. The Intergovernmental Panel on Climate Change (IPCC) recently re-emphasized the importance of sea level as a barometer of climate and drew attention to the potentially devastating consequences of future climate change. However, the IPCC also highlighted the uncertainty with which the driving mechanisms of recent sea-level change are understood and the disconnect between long-term geological and recent observational trends. In this course we will begin to fill this important knowledge gap.

636. Quantitative Paleoclimatology. (M) Staff.

This course provides a comprehensive, rigorous survey of our knowledge of the Earth's climate system from ancient to modern.Topics to be covered will include geological evidence for past climate changes, with an emphasis on quantitative methods using geochemistry and geophysics; the basis of earth system modeling; statistical climatology; climate change detection; time-series analysis in climatology.

651. Geocomputations I. (M) Mastropaolo. Offered through LPS - See current timetable

Review and applications of selected methods from differential equations, advanced engineering mathematics and geostatistics to problems encountered in geology, engineering geology, geophysics and hydrology.

SM 637. Recent Climate Change. (A) Staff.

Increases in "greenhouse gases" produced through human activity appear to be affecting the Earth's climate. This course will examine climate change over the last 500 years. We will examine the available instrumental records over this time period as well as proxy climate records such as ice core, tree ring, sediment cores, coral cores and others. Students will research individual topics and present them regularly, review published articles, and attend some seminars.

SM 639. Isotopes in Paleoclimatology. (A) Staff.

Isotope records in tree rings, ice cores, corals, and sediments can be used to reconstruct past climate variables such as temperature, salinity, atmospheric CO2, El Nino events, cloud cover and precipitation. This course focuses on isotope techniques and applications in paleoclimatology. Special emphasis will be placed on stable carbon, stable oxygen and radiocarbon. This course is suitable for upper level undergraduates and graduate students.

SM 646. First Billion Years: The Early History of Earth and Life. (A) Phipps.

The course will cover the origin of the Earth. Topics will range constituent atoms to planetesimals; the formation of the Earth including its accretion and differentiation; the early bombardment history of the earth and the formation of the Moon; the cooling of the Earth and the origins of continents and oceans. additionally variour theries for origin of life will be covered including the Archean world, tectonics, the evolution of the atmosphere and oceans, and early life.

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652. Physical Geology for Environmental Professionals. (A) Doheny. Offered through LPS - See current timetable

Study of the genesis and properties of earth materials (minerals,rocks,soil, water); consideration of volcanic,erosional, glacial, and earthquake processes along with the characterization of the earth's deep interior crustal and near-surface structure.Classroom study of minerals, crystals, fossils, and rocks as time permits.

653. Introduction to Hydrology. (A) Sauder. Offered through LPS - See current timetable

Introcudction to the basic principles of the hydrologic cycle and water budgets, precipitation and infiltration, evaporation and transpiration, stream flow, hydrograph analysis (floods), subsurface and groundwater flow, well hydraulics, water quality, and frequency analysis.

SM 654. Geomechanics I: Solids. (A) Duda.

Mechanical properties of solid and fluid earth materials, stress and strain, earth pressures in soil and rock, tunnels, piles, and piers; flow through gates, wiers, spillways and culverts, hydraulics, seepage and Darcy's law as applied to the hydrologic sciences.

655. CRITICAL ZONE SCIENCE: Baselines for Industry Applications. (B) Jimenez.Prerequisite(s): Physical Geology, Calculus , Hydrology and Aqueous Geochemistry.

What is Critical Zone Science? Why does it matter to Industry? Why does it matter to you and me? This course will introduce students to Critical Zone science research and its application to diverse fields of the environmental and geoscience industries. This is an advanced multidisciplinary problem solving course exploring the underlying critical zone processes of hydrology, biogeochemistry and geomorphology and their application to multi-faceted industry related problems. Emphasis will be placed on completion of quantitative problem sets and related written reports that require a multidisciplinary understanding of real world problems. Lectures by guest speakers from the worlds of Critical Zone science research and the consulting industry will aid students in the solving of complex problems.

656. Fate and Transport of Pollutants. (A) Mastropaolo.

This course covers basic groundwater flow and solute transport modeling in one-,two- and three-dimensions. After first reviewing the principles of modeling, the student will gain hands-on experience by conducting simulations on the computer. The modeling programs used in the course are MODFLOW (USGS), MT3D, and the US Army Corps of Engineers GMS (Groundwater Modeling System).

657. Field Geophysics. (B) Doheny.Prerequisite(s): GEOL 420: Introduction to Geophysics.

Use of geophysics field equipment (gravity, magnetic, seismic, electrical,electromagnetic, and radar) to collect geologic site investigation data. Theoretical analysis of collected geophysical and geological data to interpret subsurface conditions.

SM 658. Geostatistics. (C) Mastropaolo.

Statistical analysis of data from geological, geotechnical, and geohydrologic sources.

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659. Surface Water Hydrology. (B) Bellini.

This course will focus on various aspects of surface water hydrology. Topics covered include: study of all aspects of precipitation and runoff; study of the natural occurrences of floods and droughts; the establishment of design floods; methods of preventing or alleviating damages due to floods; water losses through evaporation, transpiration, and infiltration; storm water management; and hydrologic considerations in environmental issues.

SM 660. Department of Earth and Environmental Science Seminar.

661. Environmental Groundwater Hydrology. (B) Mastropaolo.

This course is designed to introduce the major definitions and concepts regarding groundwater flow and contaminant transport. The theory underlying concepts, including mathematical derivations of governing equations used to model groundwater flow and contaminant transport, will be discussed and applications to environmental problems addressed.

663. GROUNDWATER FLOW AND TRANSPORT MODELING II. (B) Mastropaolo.

This course is designed to introduce the major concepts regarding geochemistry and geochemical modeling. The course introduces two United States Geological Survey (USGS) computer models, PHREEQC, a geochemical speciation model, and PHAST, a transport module which is coupled with PHREEQC output. These are highly respected, world-renowned models that are free-ware via the USGS, complete with documentation. Once familiar with the models, the student can continue to work with them beyond the course experience.

PHREEQC is designed to perform a wide variety of aqueous geochemical calculations and can be used to simulate chemical reactions and transport processes in natural or polluted waters. PHREEQC is capable of modeling both equilibrium and kinetic reactions. Some of the simulations pursued during the course include: Speciation of precipitation water; Iron speciation; Zinc sorption onto hydrous ferric oxide; Oxidation of organic carbon and the sequence of electron donors in natural waters; Benzene advective transport in g

665. Engineering Geology & Geotechnics. (A) Freed.

Based on numerous case histories, the theme of this course is characterization of the geologic environment for engineering and environmental investigations. Covered are the various exploration tools and methods, including interpretation of remotely sensed imagery; field and laboratory measurments of material properties; and instrumentation monitoring. Rock masses and the significance of discontinuities are discussed as are soil formations in terms of occurrence and mode of deposition, and their typical physical properties. The latter half of the course is dedicated to the geologic hazards; i.e. ground subsidence and collapse, landslides and earthquakes, with emphasis on prediction, prevention and damage control.

666. Geology Field Work. (C) Giegengack. 4-8 weeks during the summer.

667. Landfill Design. (C) Calabria.

Topics for this course include: landfill regulations (Federal/State); permitting; siting considerations; environmental assessment; geotechnical issues; hydrogeologic investigations; landfill component design (QA/QC); linear systems; leachate collection; final cover; gas control; monitoring; surface water management; and operational, closure, post-closure considerations.

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668. Geomechanics II: Fluids. (B) Duda.

Static and Dynamic mechanical properties of fluid in earth materials, as applied to the Hydrologic Sciences; Principles of Fluid Mechanics and Hydraulics applied to open channel flow in earth materials; flow through gates, weirs, spillways, and culverts; Applications of Darcy's Law to subsurface flow and seepage.

SM 677. Seminar in Environmental Geology. (M) Giegengack.

706. Topics in Regional Geology. (M) Phipps.Prerequisite(s): GEOL 208 &/or 206, preferably both; GEOL 390. Field Trips required

Topics in sedimentology, stratigraphy, petrology, and/or structural geology of selected regions. Regional geologic synthesis and tectonics.

FORELAND BASINS: Structure, sedimentology, and biology/paleobiology of forelandbasins, based on the study of modern and ancient examples. These will include the modern Persian Gulf region, and the ancient Carboniferous Appalachian basin. There will be at least one field trip.

DEPOSITIONAL BASINS: Investigation and interpretation of a number of different tectonically-controlled basins throughout the region. Field work essential. All-day and weekend field trips required. Students will integrate stratigraphic, sedimentological, structural, and tectonic principles within various basinal settings.

SM 750. Topics in earth Science. Jane Willenbring. Open only to PhD students

This course will use the weekly EES seminar series to survey historic breakthrogh papers or topics in the earth sciences, as well as modern papers - written by the seminar speakers - that often put the classics in perspective. Graduate students (Ph.D. only) in the Department of Earth and Environmental Science will engage in the material through reading, presentation, and discussion. The course has several goals. (1.) To engender an understanding and appreciation of major breakthroughs in our field. (2.) To develop skills in presenting and discussing scientific results. And (3.) to refine students' understanding of what constitutes great science.

SM 777. Seminar in Quaternary Environments. (M) Giegengack.

Interdisciplinary approach to selected environmental problems of the Pleistocene.

999. Independent Study and Research. (C) Staff.Prerequisite(s): Permission of departmental committee. Hours and credits to be arranged.

Directed study for individuals or small groups under supervision of a faculty member.