Geography and Environmental Engineering

The Department of Geography and Environmental Engineering is concerned with the improved understanding and description of environmental problems including questions of pollutant fate and transport, water resources engineering, environmental chemistry, geomorphology, drinking water and wastewater treatment, ecosystem dynamics, and technology, society, and environmental change. Drawing from a number of disciplines and approaches, elements within these systems are examined, and interconnections among elements are explored. Some broadly defined examples of subjects collaboratively studied by our faculty and students are listed below.

- Engineering processes to alleviate environmental problems. This requires knowledge of both natural processes and engineering design. The former addresses phenomena that are basic to understanding how engineering can help solve environmental problems. The latter involves the application of such understanding to problem solutions.
- Surficial, atmospheric and subsurface processes involving interactions of chemical, biological, and hydrological processes in the environment.
- Application of engineering solutions in the context of the public decision making process including economic, social, and administrative factors.
- Analysis of interrelationships between engineering and administrative decisions and cultural, institutional, and governmental sectors of society, especially in the urban environment.

Engineering designs and public decisions must rest upon a sound knowledge of fundamental scientific processes as well as economic policy and social science. Research and study are focused on both basic, and the applied aspects of environmental problems. Interdisciplinary work is necessary, combining, for example, the basic sciences, engineering, and environmental economics. Because of its diversity of interests and association with other departments of the university, the department can offer a broad range of graduate programs based on the natural, social, and engineering sciences.

Department Areas of Interest, Study, and Research

The following areas of interest help illustrate the depth and breadth of academic and research opportunities available through the Department of Geography and Environmental Engineering. The interests and expertise of students and faculty within the department are continually expanding and changing. Students are encouraged to work with their advisors to build upon these areas of interest to construct a program that best suits their interests and professional goals and includes sufficient depth and rigor. Unique combinations of course work and research experience make it possible for students to identify and address issues in new, imaginative ways.

The Environmental Engineering area of interest is concerned with issues that involve water and wastewater treatment, transport and fate of contaminants in natural and engineered environments, hazardous and solid waste management, hydrology, and environmental fluid dynamics. Current research efforts are directed to:

- applying biological, chemical, and physical processes to treatment of contaminants in drinking water or wastewaters;
- evaluating colloidal stability in natural and engineered systems;
- exploring contaminant transport and interphase transfer, and the influence of these processes on chemical or biological transformations; and
- examining heat and mass transport and scaling mechanics at the land-atmosphere interface.

The Water and Air Resources Engineering area of interest is concerned with the occurrence, movement, and management of water and air through and above the surface of the Earth. This area involves many faculty in the department and has close interactions with faculty and students throughout Hopkins including those in the Center for Environmental and Applied Fluid Mechanics. Research in this area currently deals with:

- surface hydrology and groundwater;
- the dispersion of pollutants in the atmosphere and surface and subsurface waters;
- water supply, distribution, and risk analysis;
- measurement and modeling of turbulent environmental flows;
- mathematical modeling of subsurface and atmospheric transport phenomena;
- movement of water and chemicals in the vadose zone and in water supply aquifers;
- the impact of climate change on water resources; and
- river system dynamics.

The Environmental Chemistry area of interest is devoted to understanding the chemical and biological reactions and mobility of contaminants in natural environments and engineered aquatic systems. Research is focused on

- identifying chemical and biological constituents of aquatic environments that catalyze, inhibit, or react with organic and inorganic contaminants;
- exploring how protonation, complex formation, sorption, and partitioning affect rates of contaminant transformation;
- examining interconnections between physical, chemical, and biological phenomena affecting contaminants; and
- developing structure-property and structure-reactivity relationships that provide a basis for predicting transformation and fate.

The goal of the area of interest in Systems Analysis and Economics for Public Decision Making is to develop competence in the modeling and analysis of public policy alternatives and private sector responses to those policies. To achieve this goal, students typically emphasize economics or systems analysis or a blend of these two disciplines. Those emphasizing economics undertake specialized training in resource economics, microeconomic theory, cost-benefit analysis, public finance, and econometrics. Example applications include the economics of public works, water and energy pricing and regulation, demand forecasting, natural resource valuation, and public utility financing. Students focusing on systems analysis take courses in the mathematics of optimization and decision analysis, including linear and non-linear programming, integer programming, stochastic programming, simulation, Bayesian analysis, and multiobjective decision making.
Example applications include water resources management, siting of urban and regional facilities for services and/or distribution, pollution management, simulation of market responses to environmental policies, and integrated assessment of climate policy and impacts.

The Geomorphology, Hydrology, and Ecology area of interest promotes the fundamental understanding of processes at the Earth's surface. Research is presently focused on:

- physical dynamics of tidal freshwater wetland evolution;
- land use impacts on forest dynamics;
- sediment transport, channel dynamics, and benthic ecology in rivers;
- acquisition of metals by plants, fungi, and bacteria;
- estuarine paleoecology; and
- maintenance and flushing flows in mountainous rivers.

The Technology, Society, and Environmental Change area of interest focuses primarily on the relationships among social organization, technological and industrial change, the production of space and place, government policy and environmental outcomes. Substantive domains of inquiry include:

- globalization and regional/local processes of economic, political, and cultural change. In particular, this entails grappling in particular with the behavior of multinational corporations and governments and the regional/local consequences of technological changes and institutional activities and decision making. Comparative studies of industrial transformations and their social and environmental consequences are emphasized.
- urbanization and regional growth and decay. This involves the study of spatial differentiation in population distributions and their well-being arising out of the spatial mobilities of capital and labor, shifts in industrial structure, and processes of technological and cultural change. Comparative studies of urbanization processes—particularly Baltimore's—are encouraged; and
- the dynamics of environmental and social change. This requires consideration of philosophic, economic, and broad-based cultural backgrounds to environmental problems. Issues such as environmental justice, environmental ethics, and a critical application of appropriate knowledge (scientific, economic, cultural) for environmental decision making are strongly emphasized.

Facilities

Student and staff offices and laboratories are located in Ames and Krieger halls. A large teaching laboratory is equipped for biological and chemical examination of water and wastewater. Laboratories for research and teaching provide opportunities for research involving chemistry and microbiology. These include a number of environmental control rooms along with research opportunities involving sediment transport as well as pilot scale process investigations. Excellent facilities and instrumentation for atmospheric field studies exist, including laser radar for aerosols, fast response turbulence instruments, and radiation meters. Students also have access to treatment plants and other municipal and state facilities that may be useful in conducting research, as well as to vehicles and boats for field trips and field research of all types. Extensive computer facilities are available both in the department and in the university as a whole.

The Department of Geography and Environmental Engineering offers:

- an undergraduate Bachelor of Science (B.S.) degree in Environmental Engineering
- four focus areas within the environmental engineering major:
  - Environmental Management and Economics
  - Environmental Engineering Science
  - Environmental Transport
  - Environmental Health Engineering
- an undergraduate Bachelor of Arts (B.A.) in Geography
- two focus areas within the Geography major:
  - Human Geography
  - Physical Geography
- three minors:
  - a minor in environmental engineering
  - a minor in environmental sciences
  - a minor in engineering for sustainable development
- a five-year combined (B.S./M.S. or B.S./M.S.E.) program.

As part of these minor programs, or as part of other programs of the student’s own design, the department offers electives in such areas as ecology, geomorphology, water and wastewater pollution treatment processes, environmental systems analysis, and environmental policy studies.

Major in Environmental Engineering

The mission of our undergraduate program is to provide students with a broadly based yet rigorous education in the fundamental subjects central to the field, in a milieu that fosters development of a spirit of intellectual inquiry and the problem-solving skills required to address the open-ended issues characteristic of the real world.

Our B.S. program provides a strong foundation in the physical, chemical, and biological sciences, as well as in mathematics, engineering science, and engineering design. It is broad and flexible enough to accommodate students with a variety of interests in environmental engineering. This training should provide an ideal preparation for future employment in business or industry or for subsequent training at the graduate level, either in environmental engineering or in a field such as environmental law, public health, or medicine.

Program Objectives

The B.S. in Environmental Engineering degree program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

The Program in Environmental Engineering educates students to think critically, communicate clearly, and collaborate effectively as they apply the fundamental scientific principles of engineering to environmental problems. We emphasize the importance of intellectual growth, professional ethics, and service to society. Our graduates are prepared to be successful:

- engineering professionals in private and governmental organizations, and
- students in the best graduate programs.

Our department is noted for our students’ exceptionally high pass rate of the “Fundamentals of Engineering” (FE) exam offered by the National Council of Examiners for Engineering and Surveying (NCEES).
Focus Areas within the Environmental Engineering (EE) Major

Students must select among four different focus areas:

- Environmental Management and Economics
- Environmental Engineering Science
- Environmental Transport
- Environmental Health Engineering

With the assistance of a faculty advisor, each student will plan a curriculum suited to his or her ultimate career goals. The program also encourages and supports individual study and research. Program requirements total 125 credits.

Mathematics with a focus on applications (19 credits)

Required Courses:

- AS.110.108 Calculus I
- AS.110.109 Calculus II (For Physical Sciences and Engineering)
- AS.110.202 Calculus III
- or AS.110.211 Honors Multivariable Calculus
- EN.550.291 Linear Algebra and Differential Equations
- or AS.110.302 Diff Equations/Applic

An advanced course (300-level or higher) in probability and statistics. The Department of Applied Mathematics and Statistics offers a number of suitable courses.

Total Credits: 7

Basic Science (BS) (24-25 credits)

Required courses:

- AS.171.101 General Physics: Physical Science Major I
- or AS.171.107 General Physics for Physical Sciences Majors (AL)
- AS.171.102 General Physics: Physical Science Major II
- or AS.171.108 General Physics for Physical Science Majors (AL)
- AS.173.111 General Physics Laboratory I
- AS.173.112 General Physics Laboratory II
- One year of introductory chemistry (i.e. AS.030.101 Introductory Chemistry I and AS.030.102 Introductory Chemistry II)
- AS.030.105 Introductory Chemistry Lab I
- AS.030.106 Introductory Chemistry Laboratory II
- EN.570.205 Ecology
- EN.030.205 General Biology I, or EN.570.328 Geography & Ecology of Plants

Note: Premedical Students could substitute:

- AS.020.305 Biochemistry
- AS.020.306 Cell Biology
- AS.020.315 Biochemistry Laboratory
- AS.020.316 Cell Biology Lab

Premedical students should also take additional chemistry courses as electives, such as:

- AS.030.205 Organic Chemistry I
- AS.030.206 Organic Chemistry II

Total Credits: 22

Humanities and Social Sciences (HS) (18 credits)

A minimum of six courses totaling 18 credits in Humanities or Social Sciences. The six courses must include:

1. one advisor-approved course that specifically develops writing skills (e.g., a how to write class),
2. EN.570.334 Engineering Microeconomics, and
3. four additional Humanities and Social Sciences courses with at least two at the 300-level or higher. EN.570.406 Environmental History can be taken as part of these requirements.

Please note that the writing course will fulfill one of the two writing intensive courses required by the university.

Note: most medical schools require a year of English literature and/or composition.

Required course:

- EN.570.334 Engineering Microeconomics

Elective examples for DoGEE:

- EN.570.406 Environmental History

Writing course examples:

- AS.220.105 Fiction Poetry Writing I
- or AS.220.106 Fiction Poetry Writing II
- AS.220.146 Introduction to Science Writing
- AS.220.202 Introduction to Non-Fiction: Matters of Fact

Either AS.060.113 or AS.060.114; both cannot be counted for H/S credit.

- AS.060.113 Expository Writing
- or AS.060.114 Expository Writing

Total Credits: 18

General Engineering (GE) (16 credits)

Required courses:

- EN.570.108 Introduction Environmental Engineering
- EN.570.210 Computation/Math Modeling
- EN.540.203 Engr Thermodynamics & EN.510.312 Thermodynamics/Materials
- EN.530.231 Mechanical Engineering Thermodynamics

A course in Statics, such as:

- EN.560.201 Statics & Mechanics of Materials
- or EN.530.201 Statics and Mechanics of Materials
- EN.570.351 Introduction to Fluid Mechanics

Total Credits: 13

Design Experience and Engineering Laboratory (Senior Design) (D) (9 credits)

Required courses:

- EN.570.305 Environmental Engineering Systems Design
The Design and Synthesis sequence is a five-credit project course (2 credits fall semester, 3 credits spring semester) and involves a comprehensive study of the engineering design process from problem definition to final design. The course involves team projects that include written and oral presentations. Students will form small teams that will work with local companies or government agencies in executing the project. Prerequisite: senior standing in Environmental Engineering.

**Environmental Engineering Requirements (26 credits)**

**Required courses: (15 credits)**

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**Environmental Engineering Electives (12 credits):**

Students take at least two courses from one of the following focus areas, and at least one course from two of the other focus areas. Courses to be selected in consultation with advisor. Changes in courses must be accompanied by a Waiver/Substitution Form.

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Environmental Management and Economics x
EN.570.418/.618 Multiobjective Programming and Planning
EN.570.496 Urban and Environmental Systems
EN.570.497 Risk and Decision Analysis
EN.570.490 Solid Waste Engineering and Management
EN.570.491 Hazardous Waste Engineering and Management
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**Environmental Engineering Science**

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* Note: 600-level courses require permission of instructor
* These courses are offered on the Bloomberg School of Public Health campus. For more information: http://www.jhsph.edu/courses

**Technical Electives (TE) (minimum of 12 credits)**

(selected in consultation with an advisor)

At least three Engineering, Quantitative Studies, or Natural Sciences at or above the 300-level, subject to approval by the department totalling at least 12 credits.

Technical electives must fulfill the following requirements:

1. TEs must total 12 credits of advanced 300-level Engineering, Quantitative Studies, or Natural Sciences courses, and
2. must be approved by the department. (For ABET requirements at least one from: Solid Waste; Hazardous Waste; Air Pollution; Environmental Health Engineering, if not satisfied as part of the Environmental Engineering electives.) Up to six credits of independent study or research may be applied toward engineering requirements (e.g., EN.570.501 Undergraduate Research/EN.570.502 Undergraduate Research, EN.570.505 Undergraduate Independent Study, or Senior Thesis). Note earlier comments for premedical majors.

It is strongly recommended that students take additional advanced classes in computing and numerical methods. EE students are strongly encouraged to take at least one course in organic chemistry (e.g., AS.030.205 Organic Chemistry I). The organic chemistry course will meet the TE requirement.

**Guidance for Technical Electives for the EE Major**

Technical electives are intended to provide students with courses with technical content and extend mastery in appropriate subject matter.

- **TEs require use of fundamental science or mathematics, have appropriate prerequisites (e.g., university-level calculus, physics, chemistry, or other N or Q courses) and generally at a 300-level or higher.**
- **TEs must have the appropriate level of rigor which is defined as encompassing both of the following requirements:**
  - 5-10 homework assignments; and
  - a culminating project (final project, group project, paper) or final examination. Lecture-only classes (no homework or exams) will not qualify as a TE for the EE major.
- **TEs require accumulation and depth of analytical skill or knowledge.** In general, this precludes survey courses or courses that have no technical prerequisites that are taught by multiple professors or a series of guest lecturers, or cover a broad spectrum of a topic instead of building mastery in one area.

Exceptions are possible only with the approval of either the Departmental Chair or Director of Undergraduate Studies.
Sample EE Program (Focus Area: Environmental Engineering Science)

**Note:** This program is based on the assumption that students have not previously completed A.P. courses in calculus, physics, chemistry, etc.

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<td>3</td>
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<tr>
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<tr>
<td>Environmental Engineering or Technical Elective (EEE or TE)</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>15</td>
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</tr>
</tbody>
</table>

**Total Credits: 121**

Math (M) = 19 credits; Humanities and Social Sciences (HS) = 18 credits; Basic Science (BS) = 24 credits; General Engineering (GE) = 16 credits; Environmental Engineering Requirement (EER) = 15 credits; Environmental Engineering Electives (EEE) = 12 credits; Technical Electives (TE) = 12 credits; Design (D) = 9 credits

### Minor in Environmental Engineering

Environmental engineers play particularly pivotal roles as professionals who bridge the gap between understanding complex scientific concepts and helping to formulate public policies that affect the environment. Environmental engineering has become an important aspect of engineering practice in most engineering fields, and the discipline spans the professional spectrum from the private sector through governmental agencies to academia. An undergraduate minor in environmental engineering allows engineering students to pursue an interest in this field and to incorporate aspects of environmental engineering into careers in other engineering disciplines.
Students in any undergraduate major in the Whiting School of Engineering are eligible for admission to the environmental engineering minor program. Students will work with an advisor in the Department of Geography and Environmental Engineering to develop a program that meets the requirements for the minor and is consistent with the educational requirements of their major field of engineering study.

Requirements of the EE minor program consist of:

- a set of required core science and mathematics courses, already common to civil and chemical engineering majors;
- four required courses in environmental engineering (total of 12 credits, listed below); and
- two elective courses, one taken at the freshman or sophomore level, and the other taken at the junior or senior level.

### Core Courses (EE Minor)

Advanced placement credits and/or equivalent courses in other schools or departments are acceptable, subject to advisor approval.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.110.108</td>
<td>Calculus I</td>
</tr>
<tr>
<td>AS.110.109</td>
<td>Calculus II (For Physical Sciences and Engineering)</td>
</tr>
<tr>
<td>AS.110.202</td>
<td>Calculus III</td>
</tr>
<tr>
<td>or AS.110.211</td>
<td>Honors Multivariable Calculus</td>
</tr>
<tr>
<td>EN.550.291</td>
<td>Linear Algebra and Differential Equations</td>
</tr>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
</tr>
<tr>
<td>AS.030.102</td>
<td>Introductory Chemistry II</td>
</tr>
<tr>
<td>AS.030.105</td>
<td>Introductory Chemistry Lab I</td>
</tr>
<tr>
<td>AS.030.106</td>
<td>Introductory Chemistry Laboratory II</td>
</tr>
<tr>
<td>AS.171.101</td>
<td>General Physics: Physical Science Major I</td>
</tr>
<tr>
<td>or AS.171.107</td>
<td>General Physics for Physical Sciences Majors (AL)</td>
</tr>
<tr>
<td>AS.173.111</td>
<td>General Physics Laboratory I</td>
</tr>
<tr>
<td>AS.173.112</td>
<td>General Physics Laboratory II</td>
</tr>
</tbody>
</table>

#### Required Courses (total of 12 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.570.301</td>
<td>Environmental Engineering Fundamentals I</td>
</tr>
<tr>
<td>EN.570.302</td>
<td>Water &amp; Wastewater Treatment</td>
</tr>
<tr>
<td>EN.570.304</td>
<td>Environmental Engineering Laboratory</td>
</tr>
<tr>
<td>EN.570.305</td>
<td>Environmental Engineering Systems Design</td>
</tr>
</tbody>
</table>

| Group A     | Elective Courses                                   |

- Introductory courses at the freshman and sophomore level. One course required.*
  - EN.570.108 Introduction Environmental Engineering

- Engineering science courses that are developed for juniors and seniors and also introductory graduate-level courses. One course is required.

For further information, contact Dr. William P. Ball, EE Minor Coordinator, 410-516-5434, bball@jhu.edu, or Adena Rojas, Senior Academic Program Coordinator, 410-516-5533, arojas@jhu.edu.

### Minor in Environmental Sciences

The environmental sciences minor has been developed to encourage and facilitate studies in environmental sciences by students completing degrees in the other science and engineering disciplines. The environmental sciences (ES) minor requires:

- completion of a set of courses in the core sciences,
- two introductory courses dealing with the environment, and three or more upper-level environmental sciences courses, as described.

#### Core Sciences (ES Minor)

Because of the interdisciplinary nature of environmental science, it is important that professionals from various areas of expertise acquire a common language and set of core concepts to make discussion and cooperation possible. The following courses represent the minimum set of requirements:

<table>
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<tbody>
<tr>
<td>AS.110.108</td>
<td>Calculus I</td>
</tr>
<tr>
<td>AS.110.109</td>
<td>Calculus II (For Physical Sciences and Engineering)</td>
</tr>
</tbody>
</table>

- At least one of the these four courses:
  - AS.110.201 Linear Algebra
  - or AS.110.212 Honors Linear Algebra
Pairing a Major with the ES Minor

Many of the most creative and productive advances in environmental sciences in recent years have come from scientists trained in traditional disciplines (biology, chemistry, geology, physics, and engineering) who have devoted themselves to the study of environmental problems. Completion of the degree requirements of a traditional discipline provides depth and rigor that, when supplemented with additional academic training in environmental science, can be applied to professional work in a variety of environmental subjects, as the following examples show:

**Biology (3 credits)**
One course, such as:
- AS.110.202 Calculus III
- or AS.110.211 Honors Multivariable Calculus
- AS.110.302 Diff Equations/Applic
- EN.550.291 Linear Algebra and Differential Equations

**Environmental Sciences**

Students must take two introductory courses dealing with the environment and three or more of the upper-level environmental science courses on the following lists:

**Introductory Courses (6 credits)**
- EN.570.110 Introduction to Engineering for Sustainable Development
- EN.570.205 Ecology
- EN.570.239 Emerging Environmental Issues
- AS.270.110 Freshman Seminar: Sustainable + Non-Sustainable Resources
- AS.270.220 The Dynamic Earth: An Introduction to Geology
- AS.270.221 The Dynamic Earth Laboratory

**Upper-Level Courses (9 credits)**
- EN.570.239 Emerging Environmental Issues
- EN.570.301 Environmental Engineering Fundamentals I
- EN.570.302 Water & Wastewater Treatment
- EN.570.328 Geography & Ecology of Plants
- EN.570.353 Hydrology
- EN.570.411 Engineering Microbiology
- EN.570.441 Environmental Inorganic Chemistry
- EN.570.442 Environmental Organic Chemistry
- EN.570.443 Aquatic Chemistry
- EN.570.445 Physical and Chemical Processes
- EN.570.446 Biological Process of Wastewater Treatment
- EN.570.491 Hazardous Waste Engineering and Management
- AS.270.302 Aqueous Geochemistry
- AS.270.311 Geobiology
- AS.270.313 Isotope Geochemistry
- AS.270.314 Planetary Tectonics and Geodynamics
- AS.270.350 Sedimentary Geology
- AS.270.369 Geochem Earth/Environment

**Chemistry (13 credits)**
- AS.030.101 Introductory Chemistry I
- AS.030.105 Introductory Chemistry Lab I
- AS.030.106 Introductory Chemistry Laboratory II

**Total Credits** 15


**Environmental Systems**

Environmental modeling, risk assessment, environmental systems design, pollution control strategies. Illustrative majors: Civil Engineering, Applied Mathematics and Statistics.

**Faculty Advising**
A faculty advisor is assigned to each student in the environmental sciences minor program to assist in planning his/her academic program and to approve the choice of courses to satisfy the minor. Faculty advisors are available in the following areas:

- **Biology Processes:** Edward J. Bouwer
- **Physical Processes:** TBD
- **Environmental Chemistry:** Alan T. Stone
- **Environmental Systems:** Ben Hobbs
- **Human Geography:** Erica J. Schoenberger

**Minor in Engineering for Sustainable Development**

Engineers will be increasingly called upon to help devise solutions to the tremendous problems of poverty, inequality, and social and environmental dislocation that afflict major parts of the globe in the 21st century. Working as an engineer in this context involves negotiating highly complex social, economic, and political realities and dealing with a wide range of institutions and actors, including national and local governments, multilateral lenders such as the World Bank, diverse non-governmental organizations (NGOs), and local communities. It also increasingly involves working in interdisciplinary teams with social scientists, public health and medical workers, humanitarian aid...
workers, bankers, politicians, and the like. “Sustainable” development implies a development path that is socially equitable, culturally sensitive, and environmentally appropriate over a multi-generational time frame. The minor in Engineering for Sustainable Development exposes engineering students to some of the key issues related to development, methods of information-gathering in diverse and difficult settings, and working effectively with non-engineers on complex problems.

The minor encompasses seven courses. The core course is EN.570.110 Introduction to Engineering for Sustainable Development. Five additional courses will be selected in a program devised in consultation with the minor advisor.

Of the Five Additional Courses

• Three must be grouped around a specific theme, region or within a specific discipline. Themes might include, for example, public health, environment, or economic development. Regions include Africa, Latin America, or Asia. Disciplinary concentrations might be in Anthropology, Economics, Geography, History, Political Science, Public Health, or Sociology.
• Three of the courses must be at the 300-level or above.
• One of the courses must cover methods for gathering and evaluating information in a development context.

Examples include:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>AS.070.319</td>
<td>Logic of Anthropological Inquiry</td>
</tr>
<tr>
<td>AS.070.347</td>
<td>Anthropology and Public Action</td>
</tr>
<tr>
<td>AS.280.345</td>
<td>Public Health Biostatistics</td>
</tr>
<tr>
<td>AS.280.350</td>
<td>Fundamentals of Epidemiology</td>
</tr>
<tr>
<td>AS.230.202</td>
<td>Research Methods for the Social Sciences</td>
</tr>
</tbody>
</table>

Bachelor of Arts in Geography

Geographical knowledge constitutes a vital store of information concerning the distribution over the earth’s surface of those environmental conditions (both naturally occurring and anthropogenic) essential to support an immense diversity of human life and activity.

The study of Geography focuses on understanding how physical, biotic, social, and economic processes are perpetually reshaping environments and landscapes in ways either favorable or unfavorable for different life forms in general and for different and distinctive kinds of human occupancy and culture in particular. Geographical education seeks to instill a deep appreciation of the grand diversity of ways in which the people of the earth have learned to use and modify their environments creatively. It also focuses on the environmental problems that arise in association with such processes of modification. While geography in general looks to maintain a strong bond between physical and human dimensions of landscape formation, specialization within that general framework is also encouraged.

Human Geography is primarily concerned with the detailed specification of the economic, social, political, and cultural processes that lead to the substantive modification of natural environments through the draining of marshes, the damming of rivers, the development of agriculture, mining, and industry, and the construction of human settlements. It is also crucially concerned with the forms of interaction (trade, communications, capital flows, and migrations) between people over space and the effects of such interactions upon the people of the world. The barriers to interaction (political boundaries, for example, and the acquisition by human populations of strong senses of local, regional, and territorial identity) are likewise a key topic for examination.

Physical geography is primarily concerned with those physical processes—climatic, ecological, geological, hydrological—which have shaped and which continue to shape the earth's surface, creating distinctive physical and ecological conditions for different life forms. Training in physical geography aims to build sufficient technical expertise to handle a wide range of environmental problems concerning the atmosphere, the Earth, and the hydrosphere, with special emphases upon water, surficial processes, and ecology.

Requirements for the B.A. Degree

(See also General Requirements for Departmental Majors (http://e-catalog.jhu.edu/undergrad-students/academic-policies/requirements-for-a-bachelors-degree) and Writing Requirement sections.)

The B.A. in geography offers a broad background in the sciences (particularly biological and ecological), the social sciences, and the humanities. All geography majors must fulfill the general university requirements and take four fundamental courses in geography. They may then choose a concentration in either physical or human geography. In addition to these courses focused on their special interest, they may freely select electives to fill the 120 credit hours required for the B.A. degree. Students work closely with their faculty advisor to create a program that fulfills their individual academic objectives and includes sufficient depth and rigor.

Focus Areas within the Geography Major

Students may select between two different focus areas within the geography major:

Human Geography

Requirements

• And knowledge of one foreign language at the intermediate level.
• at least four appropriate introductory courses (12 or more credits) are also required in such fields as anthropology, economics, humanities, political science, and sociology.
• a minimum of nine courses (about 27 credits) at or above the intermediate level in their field of major interest (in consultation with the geography advisor).

The aim here is to enable students to build their own combination of departmental courses and courses from relevant cognate disciplines. Someone specializing in economic geography, for example, might include courses on natural resources, society and environment, environmental economics, and political ecology combined with courses in anthropology, political science, sociology, or economics. A student interested in urban geography might combine course work in the department with courses in the humanities, in political science, or in urban economics, while taking advantage of the seminar-internship on urban policy in a government department or with a community organization. A student interested in environmental issues could work across the physical-human divide and combine course work in ecology and geology with seminars on environmental policy, ethics, and philosophy. Someone specializing in cultural geography could combine
work on the social and geographical landscape with courses in social and cultural anthropology.

**Physical Geography**

The major with a focus area in physical geography consists of four parts:

1. mathematics,
2. the basic natural sciences,
3. those sciences directly related to the student’s area of specialization, such as environmental chemistry, physical geography, or biogeography, and
4. courses which focus on the environment itself: the atmosphere, earth, and hydrosphere.

**Requirements**

- AS.110.202 Calculus III; EN.550.310 Probability & Statistics for the Physical and Information Sciences & Engineering (or the equivalent).
- at least four appropriate introductory courses (12 or more credits) are also required in such fields as chemistry, biology, geology, or physics.
- a minimum of eight courses (about 24 credits) at the intermediate level in their field of major interest (in consultation with their geography minor advisor).

Undergraduates with an interest in environmental chemistry, for example, would take fundamental courses such as organic chemistry, biochemistry, and thermodynamics, while those oriented toward the earth sciences would take courses in petrology, thermodynamics, fluid mechanics, and other aspects of geology. For a student interested in biogeography—dealing with the spatial pattern of plants, the role of environmental factors in influencing those distributions, and the effect of changes in vegetation on the landscape—the department offers courses in plant geography, ecology, and paleoecology.

**Program in Public Decision Making**

Undergraduates majoring in geography may satisfy departmental requirements through the program in Systems Analysis and Economics for Public Decision Making. In addition to prerequisites from other departments (e.g., EN.550.361 Introduction to Optimization-EN.550.362 Introduction to Optimization II and AS.180.101 Elements of Macroeconomics-AS.180.102 Elements of Microeconomics), students in this program take at least four courses from the public decision making curriculum, including EN.570.495 Optimization Foundations for Environmental Engineering and Policy Design and EN.570.493 Economic Foundations for Environmental Engineering and Policy Design.

**Ph.D. Degree**

The goals for students in the Ph.D. program are

- to develop reasoning skills that can be applied to new and unanticipated issues;
- learn how to pose questions and answer them in a logical manner;
- acquire a depth of understanding and technical knowledge in a particular study area, on par with others worldwide; and
- make a significant contribution to our understanding in this particular study area. The emphasis in the Ph.D. degree is upon a sound foundation in the fundamentals required in a given area with considerable flexibility in course selection determined by the interests and background of each graduate student. The doctoral student must take the equivalent of about two full academic years of formal course work. Roughly half of this is done in the principal subject, and the rest is chosen from allied fields. The minimum residence requirement is two consecutive semesters registered as a full-time student.

All students must pass departmental and Graduate Board oral examinations for the doctorate. Usually these examinations are taken after two years of academic work. Research leading to the dissertation should make an original contribution to the chosen field of specialization, and the result must be worthy of publication. A final dissertation defense that involves an open seminar and a closed oral examination is required of all DoGEE doctoral students.

**Master of Science (M.S.) Degree**

The M.S. degree is open to students with undergraduate degrees in engineering, mathematics, biology, chemistry, physics, geology, and
other scientific disciplines. The M.S. degree program includes the following requirements:

- a minimum of 30 credits including no more than 1 credit of seminar, 1 credit of intersession course work, and 6 credits of independent research counting toward the 30 credits.
- at least 50% of the required 30 credits must come from courses within the department.
- students are permitted to apply up to two classes with a grade of “C” toward their degree.
- up to two semesters of AAP or EP courses can be taken and counted to receive a master’s degree as long as there is sufficient rigor as deemed by the advisor. Students must have written consent from advisor (an email will suffice) prior to signing up for the course.

M.S. students have the option to complete an independent research project, submitted as a formal essay. A minimum of two semesters is required to complete the M.S. degree without the research project option. Three to four semesters are typically required to complete the degree with a research project.

M.S. students are strongly recommended to take as prerequisites for the M.S. program mathematics through differential equations and computing skills. Additionally, M.S. students who choose to follow Contaminant Fate and Transport, Environmental Process Engineering, and Water Resources Engineering concentrations are encouraged to take an introductory fluid mechanics course. Whether introductory fluid mechanics will count towards an M.S. student’s graduation credits is decided on a case-by-case basis by the department. Each individual’s program of study is planned by the student in consultation with department faculty and must be approved by the faculty advisor.

Concentrations for the M.S. Degree

Environmental Science

This concentration provides a broad yet rigorous background for environmental professionals. Using the department’s areas of interest, study, and research as guides and in consultation with their advisors, M.S. students can construct their own concentration that complements and expands their interests and professional goals. Additionally, M.S. students can choose to follow or pull from the M.S.E. concentration tracks: Contaminant Fate & Transport, Environmental Management and Economics, Environmental Process Engineering, and Water Resources Engineering.

Environmental Science and Policy

This concentration is similar to Environmental Science but includes economics and systems courses. Four courses are recommended in environmental science, including the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.570.445</td>
<td>Physical and Chemical Processes</td>
</tr>
<tr>
<td>EN.570.446</td>
<td>Biological Process of Wastewater Treatment</td>
</tr>
<tr>
<td>EN.570.448</td>
<td>Physical and Chemical Processes II</td>
</tr>
</tbody>
</table>

M.A. and M.S. students pursuing this program who do not have prior background in environmental engineering can substitute EN.570.301 Environmental Engineering Fundamentals I and EN.570.302 Water & Wastewater Treatment in lieu of the courses suggested above.

The other environmental science courses should be chosen from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>EN.570.411</td>
<td>Engineering Microbiology</td>
</tr>
<tr>
<td>EN.570.442</td>
<td>Environmental Organic Chemistry</td>
</tr>
<tr>
<td>EN.570.443</td>
<td>Aquatic Chemistry</td>
</tr>
<tr>
<td>EN.570.491</td>
<td>Hazardous Waste Engineering and Management</td>
</tr>
</tbody>
</table>

Four courses are required in environmental policy, including:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.570.493</td>
<td>Economic Foundations for Environmental Engineering and Policy Design</td>
</tr>
<tr>
<td>EN.570.495</td>
<td>Optimization Foundations for Environmental Engineering and Policy Design</td>
</tr>
</tbody>
</table>

Choose one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.570.496</td>
<td>Urban and Environmental Systems</td>
</tr>
<tr>
<td>EN.570.497</td>
<td>Risk and Decision Analysis</td>
</tr>
<tr>
<td>EN.570.607</td>
<td>Energy Policy and Planning Models</td>
</tr>
<tr>
<td>EN.570.608</td>
<td>Data Analytics for Engineering, Policy Analysis and Management</td>
</tr>
<tr>
<td>EN.570.657</td>
<td>Air Pollution</td>
</tr>
<tr>
<td>EN.570.676</td>
<td>Stochastic Programming</td>
</tr>
</tbody>
</table>

The final two courses would be a project or electives in environmental science, engineering, policy, or systems that are appropriate to the student’s goals.

Master of Science in Engineering (M.S.E.) Degree

The M.S.E. degree is open to students with an ABET-accredited undergraduate engineering degree or demonstrated equivalent. The M.S.E. degree program includes the following requirements:

- a minimum of 30 credits including no more than 1 credit of seminar, 1 credit of intersession course work, and 6 credits of independent research counting toward the 30 credits.
- at least 50% of the required 30 credits must come from courses within the department.
- students are permitted to apply up to two classes with a grade of “C” toward their degree.
- 5-6 required courses and 4-5 recommended elective courses depending on concentration (Note: In order to substitute an alternate course for a recommended elective, students must receive written approval from their advisor).
- prerequisites (required) for the M.S.E. program includes mathematics through differential equations and computing skills.
- up to two semesters of AAP or EP courses can be taken and counted to receive a master’s degree as long as there is sufficient rigor as deemed by the advisor. Students must have written consent from advisor (an email will suffice) prior to signing up for the course.

The M.S.E. program is typically a two semester program based on course work alone. However, M.S.E. students have the option to complete an independent research project, submitted as a formal essay or group project report. An M.S.E. degree with significant research components will usually require three to four semesters for completion and is generally intended for those students planning to work in engineering practice. Each individual’s program of study is planned by the student in consultation with department faculty and must be approved by the faculty advisor. M.S.E. students select from the concentrations below.
Recommended Electives Note: Students should select elective courses from the list of recommended electives appropriate for each concentration. In order to substitute an alternate course for a recommended elective, students must receive written approval from their advisor and should submit a copy of the approval to the Department for their permanent file.

Concentrations for the M.S.E. Degree

Contaminant Fate and Transport
This concentration emphasizes understanding of physical, chemical, and biological phenomena that affect the movement and transformation of pollutants in the environment.

Required courses:
- EN.570.411 Engineering Microbiology
- EN.570.441 Environmental Inorganic Chemistry
- EN.570.442 Environmental Organic Chemistry
- EN.570.443 Aquatic Chemistry
- EN.570.452 Experimental Methods in Environmental Engineering Chemistry

One course in applied mathematics, numerical analysis, or engineering mathematics, such as:
- EN.570.495 Optimization Foundations for Environmental Engineering and Policy Design
- EN.570.496 Urban and Environmental Systems

Recommended electives include:
- EN.570.446 Biological Process of Wastewater Treatment
- EN.570.657 Air Pollution

Environmental Process Engineering
This concentration involves the analysis and design of processes of water treatment, waste treatment, and environmental remediation, and includes a solid grounding in the chemical, biological, and physical principles underlying treatment and remediation technologies.

Required courses:
- EN.570.411 Engineering Microbiology
- EN.570.441 Environmental Inorganic Chemistry
- EN.570.442 Environmental Organic Chemistry
- EN.570.443 Aquatic Chemistry
- EN.570.452 Experimental Methods in Environmental Engineering Chemistry

One course in applied mathematics, numerical analysis, or engineering mathematics, such as:
- EN.570.495 Optimization Foundations for Environmental Engineering and Policy Design
- EN.570.496 Urban and Environmental Systems
- EN.530.661 Applied Mathematics for Engineering

Recommended electives include:
- EN.570.446 Biological Process of Wastewater Treatment
- EN.570.657 Air Pollution

Water Resources Engineering
This concentration combines a solid grounding in environmental fluid mechanics and hydrology with electives in modeling, water development planning, policy, and contaminant fate and transport.

Required courses:
- EN.570.353 Hydrology
- EN.570.395 Principles of Estuarine Environment: Chesapeake Bay
- AS.270.405 Modeling the Hydrological Cycle

One course in applied mathematics, numerical analysis, or engineering mathematics, such as:
- EN.530.661 Applied Mathematics for Engineering
- EN.570.495 Optimization Foundations for Environmental Engineering and Policy Design
- EN.570.496 Urban and Environmental Systems

Additional requirements: an introductory fluid mechanics course. If this prerequisite is lacking, it can be taken as part of the course of study, but the credits will not be counted toward the 30-credit requirement.

Recommended electives include:
- At least one course in Systems Analysis and Economics
- EN.570.493 Economic Foundations for Environmental Engineering and Policy Design
- EN.570.497 Risk and Decision Analysis
- EN.570.443 Aquatic Chemistry
- EN.570.445 Physical and Chemical Processes

Environmental Management and Economics
This concentration focuses on using models of physical and economic systems to analyze and improve the design of public policies and environmental control systems.

Required courses:
- EN.570.493 Economic Foundations for Environmental Engineering and Policy Design
- EN.570.495 Optimization Foundations for Environmental Engineering and Policy Design
- EN.570.496 Urban and Environmental Systems
- EN.570.497 Risk and Decision Analysis

Recommended electives include:
- At least one course in physical, chemical, or biological processes
- EN.570.607 Energy Policy and Planning Models
- EN.570.618 Multiobjective Programming and Planning
- EN.570.676 Stochastic Programming
- Or other environmental economics course.
M.A. Degree

The M.A. degree is open to students with undergraduate degrees in social sciences or the humanities. It requires:

- a minimum of 30 credits including no more than 1 credit of seminar, 1 credit of intersession course work, and 6 credits of independent research counting toward the 30 credits.
- at least 50% of the required 30 credits must come from courses within the department.
- students are permitted to apply up to two classes with a grade of “C” toward their degree.
- up to two semesters of AAP or EP courses can be taken and counted to receive a master’s degree as long as there is sufficient rigor as deemed by the advisor. Students must have written consent from advisor (an email will suffice) prior to signing up for the course.

In addition to these course credits, M.A. students have the option to complete an independent research project, submitted as a formal essay. Students can focus on one of the department’s areas of interest, study, or research or construct their own program that complements and expands their undergraduate experience; three semesters are typically required to complete the degree. Each program of study is planned by the student in consultation with department faculty and must be approved by the faculty advisor.

Financial Aid

Financial aid is granted on the basis of merit and availability. Criteria for consideration for these awards include academic excellence, professional or research experience, and career commitment to the field. Continued support is subject to the student’s performance, availability of research or TA funds, and requisite staffing of current projects. Ph.D. students receive priority for full financial support. Pending available funding, partial tuition fellowships are offered to qualified master’s students. Ph.D. applicants are nominated by the department for consideration for fellowships.

Furthermore, many students within the department have been awarded graduate research fellowships available to Ph.D. and Masters students through programs administered by the National Science Foundation and the Environmental Protection Agency. The Johns Hopkins Environment, Energy, Sustainability & Health Institute (E²SHI) invites applications for one-year fellowships of up to $25,000 to support Johns Hopkins University doctoral students pursuing interdisciplinary research in environment, energy, sustainability, or health topics.

For current faculty and contact information go to http://engineering.jhu.edu/dogee/faculty.html

Faculty

Chair
Edward J. Bouwer
Abel Wolman Professor of Environmental Engineering: environmental microbiology, waste treatment

Professors
William P. Ball
Professor: environmental engineering, physical and chemical processes, water quality

Grace S. Brush

Professor: ecology, paleoecology, plant geography

J. Hugh Ellis
Professor: environmental systems

Paul Ferraro
Bloomberg Distinguished Professor of Water and Environmental Economics: evaluation of environmental program impacts, behavioral economics

Steve H. Hanke
Professor: applied micro- and macroeconomics and finance

Benjamin F. Hobbs
Theodore K. and Kay W. Schad Professor of Environmental Management: environmental, energy, and water systems, economics

A. Lynn Roberts
Professor: environmental chemistry

Erica J. Schoenberger
Professor: economic geography, environmental history, environmental politics and policy, history of mining, history of the automobile, interdisciplinary scientific collaboration

Alan T. Stone
Professor: environmental and aquatic chemistry

Assistant Professors
Kai Loon Chen
Assistant Professor: physiochemical processes, particle interaction, membrane processes, environmental nanotechnology

Ciaran Hamman
Assistant Professor: landscape hydrology and transport

Sarah Preheim
Assistant Professor: environmental microbiology, microbial ecology, bioinformatics

Associate Teaching Professor
Hedy V. Alavi
Associate Teaching Professor: hazardous and solid waste engineering and management

Professor Emeritus
John J. Boland
Professor Emeritus: environmental economics and policy

Research Professor Emeritus
Eugene D. Shchukin
Research Professor Emeritus: colloid and surface science

Associate Research Professor
Seth Guikema
Associate Research Professor: probabilistic systems modeling techniques, risk analysis, uncertainty modeling, infrastructure modeling, and decision making under uncertainty

Peter Wilcock
Research Professor: sediment transport, river mechanics, management and restoration
Lecturer
Justin C. Williams
Senior Lecturer: environmental and urban systems

Joint, Part-Time, and Visiting Appointments
Markus Hilpert
Senior Scientist (Environmental Health Sciences, Bloomberg School of Public Health): environmental flow and transport, groundwater contaminant hydrology, air pollution

Joseph Katz
Professor (Mechanical Engineering): experimental fluid mechanics, development of advanced diagnostics techniques

Charles Meneveau
Professor (Mechanical Engineering): environmental fluid mechanics, engineering, turbulence

Marc B. Parlange
Adjunct Professor: hydrology, environmental fluid mechanics, atmospheric interactions

Andrea Prosperetti
Professor (Mechanical Engineering): fluid mechanics, bubble mechanics, numerical simulations

Kellogg Schwab
Associate Professor (Environmental Health Engineering, Bloomberg School of Public Health): environmental public health, pathogen microbiology

For current course information and registration go to https://isis.jhu.edu/classes/

Courses

EN.570.108. Introduction Environmental Engineering.
Overview of environmental engineering including water/air quality issues, water supply/ wastewater treatment, hazardous/solid waste management, pollution prevention, global environmental issues, public health considerations/environmental laws, regulations and ethics. Cross listed with Public Health Studies.
Instructor(s): H. Alavi
Area: Engineering.

EN.570.110. Introduction to Engineering for Sustainable Development.
Instructor(s): E. Schoenberger
Area: Humanities, Social and Behavioral Sciences.

EN.570.130. Climate, Environment and Society.
Climate change will put major stress on the environment and society. Some predict wars over water and climate-induced mass migration. What can the past teach us about how we cope or fail to cope with climate change? What do we think the future holds and what do we think we can do about it? The class involves reading, discussion, debate and research. Freshman only.
Instructor(s): E. Schoenberger
Area: Humanities, Social and Behavioral Sciences.

EN.570.147. Adam Smith & Karl Marx.
Smith and Marx are iconic figures in the history of political economic thought, often cited, rarely read. They are positioned as polar opposites in highly consequential debates about how society should be ordered. In this class, we will read and discuss their work, closely and carefully. We concentrate on the two iconic texts – The Wealth of Nations and Capital, Vol. 1 – but also explore some of their less well-known writings. Freshmen Only.
Area: Humanities, Social and Behavioral Sciences.

EN.570.205. Ecology.
Introduction to processes governing the organization of individual organisms into populations, communities, and ecosystems. Interactions between individual organisms, groups of organisms, and the environment, including adaptation, natural selection, competition.
Instructor(s): G. Brush
Area: Natural Sciences.

An introduction to the use of computers in developing mathematical models. A structured approach to problem definition, solution, and presentation using spreadsheets and mathematical software. Modeling topics include elementary data analysis and model fitting, numerical modeling, dimensional analysis, optimization, simulation, temporal and spatial models. Recommended Course Background: AS.110.108 or equivalent.
Instructor(s): M. Beaudin
Area: Engineering, Quantitative and Mathematical Sciences.

EN.570.221. Sustainability Science.
What is sustainability science? What are the core questions in sustainable development of societies? How can we guide the coupled human-environment systems along more sustainable trajectories? This course lays out the fundamentals of sustainability science and discusses some of the core questions and research gaps in sustainability science. Frameworks for conceptualizing the risks and resiliency of engineered infrastructure will be discussed in the context of sustainability science.
Instructor(s): R. Nateghi; S. Guikema
Area: Engineering, Social and Behavioral Sciences.

EN.570.222. Environment and Society.
Humans make their living in the environment. How do we do that changes nature and changes us. This class explores human impacts on the environment, how we have thought about our relationship to nature over the millennia, and contemporary environmental discourses.
Instructor(s): E. Schoenberger
Area: Humanities, Social and Behavioral Sciences.

This course will begin with a high-level understanding of globalization, and proceed to explore sustainable development and appropriate technology through the lens of case studies of engineering projects in the developing world. The goals for students are to learn specifics of various implemented projects, to be able to critically and contextually analyze these projects, and to develop an understanding of what leads to the success or failure of a technical development project.
Instructor(s): E. Kibbe
Area: Social and Behavioral Sciences.
EN.570.239. Emerging Environmental Issues.
Scientific principles underpinning environmental issues, with an emphasis on potential impacts of anthropogenic perturbation on human and ecosystem health. Recommended Course Background: two semesters of Chemistry.
Instructor(s): A. Roberts
Area: Engineering, Natural Sciences.

This course combines anthropological perspectives with the discussion and examination of technology-based interventions in the field of development and aid policies, with particular focus on activities related to water resources, sanitation, and hygiene. Readings and discussions analyze some of the theoretical, historically rooted, and practical issues that challenge those who hope to provide effective aid. A key aim of this course is to provide students with better understanding of cultural, social, environmental and economic issues relevant to technical intervention in developing countries.
Instructor(s): E. Cervone; W. Ball
Area: Humanities, Social and Behavioral Sciences.

EN.570.301. Environmental Engineering Fundamentals I.
Fundamentals and applications of physical and chemical processes in the natural environment and engineered systems. This class will cover material balances, chemical equilibrium, chemical kinetics, vapor pressure, dissolution, sorption, acid-base reactions, transport phenomena, reactor design, water quality, and environmental implications of nanotechnology.
Instructor(s): K. Chen
Area: Engineering, Natural Sciences.

EN.570.302. Water & Wastewater Treatment.
Theory and design of water and wastewater treatment processes including coagulation, sedimentation, filtration, adsorption, gas transfer, aerobic and anaerobic biological treatment processes, disinfection, and hydraulic profiles through treatment units.
Prerequisites: EN.570.301 or permission required.
Instructor(s): W. Weiss
Area: Engineering, Natural Sciences.

EN.570.304. Environmental Engineering Laboratory.
Introduction to laboratory measurements relevant to water supply and wastewater discharge, including pH and alkalinity, inorganic and organic contaminants in water, reactor analysis, bench testing for water treatment, and measurement and control of disinfection by-products. Recommended Course Background: EN.570.210 or Instructor Permission; Corequisite: EN.570.302.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.
Instructor(s): A. Roberts
Area: Engineering, Natural Sciences.

Techniques from systems analysis applied to environmental engineering design and management problems: reservoir management, power plant siting, nuclear waste management, air pollution control, and transportation planning. Design projects are required.
Instructor(s): J. Ellis
Area: Engineering, Quantitative and Mathematical Sciences.

EN.570.314. Microbial Ecology.
This course will highlight the latest methods in biotechnology revealing ecological principles determining the diversity and dynamics of microbial communities in a variety of ecosystems. We will explore advanced topics in ecology, such as niche theory, cooperation and speciation with examples from human health, engineering and environmental microbiology. Recommended Course Background: Ecology - EN.570.205 or Microbiology - AS.020.329
Instructor(s): S. Preheim
Area: Natural Sciences.

EN.570.320. Topics on Appropriate and Sustainable Technology for Developing Communities.
Lectures, readings and discussions on general and location-specific issues related to collaborative student projects about appropriate technology-based interventions. Focus is on improving student understanding about some of the environmental, social, health, and economic issues relevant to the development of sustainable technical interventions for under-developed communities and about the role of engineers in designing, planning, implementing, and evaluating such interventions.
Instructor(s): W. Ball
Area: Engineering, Social and Behavioral Sciences.

EN.570.321. Practicum on Appropriate and Sustainable Technology for Developing Communities.
Permission required Academic and practical support for students working on engineering projects in developing countries. Readings and discussions on general and location-specific issues related to collaborative student projects about appropriate technology-based interventions.
Instructor(s): W. Ball
Area: Engineering, Social and Behavioral Sciences.

EN.570.322. Projects in Appropriate and Sustainable Technology.
Corequisite: EN.570.311
Instructor(s): W. Ball.

EN.570.328. Geography & Ecology of Plants.
Patterns of aquatic and terrestrial plant species; historical changes in patterns using paleobotanical techniques; emphasis on biological and physical mechanisms controlling the patterns; the role of climate and man on plant distributions; several field trips; project required, which is the basis for the final grade.
Instructor(s): G. Brush
Area: Natural Sciences.

This course uses a calculus-based approach to introduce principles of engineering economics and microeconomics (demand and production theory) and their uses in engineering decision making. Recommended Course Background: AS.110.202
Instructor(s): P. Ferraro
Area: Quantitative and Mathematical Sciences, Social and Behavioral Sciences.
EN.570.335. Introduction to Applied Econometrics.
This course provides an introduction to quantitative methods for 
the analysis of economic phenomena. Topics will include basic 
regression models; hypothesis testing; Ordinary Least Squares; choice 
of independent variables and functional form; multicollinearity; serial 
correlation; heteroskedasticity. Computer assignments in EViews, one 
of the leading econometric software packages, represent an important 
part of the course. Particular emphasis will be placed on applications in 
the field of energy economics. Prerequisite: Introduction to probability 
and statistics, economic theory and linear algebra.
Instructor(s): C. Lo Prete
Area: Quantitative and Mathematical Sciences, Social and Behavioral 
Sciences.

EN.570.351. Introduction to Fluid Mechanics.
Introduction to the use of the principles of continuity, momentum, and 
energy to fluid motion. Topics include hydrostatics, ideal-fluid flow, 
laminar flow, turbulent flow. Recommended Course Background: Statics, 
Dynamics, and AS.110.302
Instructor(s): M. Karweit
Area: Engineering.

EN.570.353. Hydrology.
The occurrence, distribution, movement, and properties of the waters 
of the Earth. Topics include precipitation, infiltration, evaporation, 
transpiration, groundwater, and streamflow. Recommended Course 
Frequency include the frequency of floods and droughts, time-series analyzes, flood routing, 
and hydrologic synthesis and simulation. Recommended Course 
Background: AS.110.302, EN.570.351
Instructor(s): C. Harman
Area: Social and Behavioral Sciences.

EN.570.375. Groundwater.
This introductory course emphasizes the fundamental principles 
governing the movement of water and contaminants in groundwater 
systems. Topics include groundwater hydraulics, well hydraulics, 
groundwater recharge, and solute transport. Prerequisites: EN.550.291/ 
AS.110.302; Corequisites: EN.570.351
Instructor(s): M. Hilpert.

EN.570.395. Principles of Estuarine Environment: Chesapeake 
Bay.
Topics include the physical, chemical, and biological components 
of the Chesapeake Bay ecosystem from the time it started to form 
some 10,000 to 12,000 years ago, when sea level began to rise as 
the continental glaciers receded; the geology, geomorphology, and 
biology of the watershed drained by the estuary; relationships between 
the watershed and the estuary through the millennia and the effect of 
climate, geomorphology, and humans on the ecology of the ecosystem 
and its economic productivity.
Instructor(s): G. Brush
Area: Engineering, Natural Sciences.

EN.570.397. Intro to Decision Analysis in Energy and 
Environment.
This course will provide an overview of the methods used in decision 
analysis by using case studies from energy and environment. Decision 
modeling, uncertainty modeling and preference modeling will be 
introduced. Emphasis will be given on structuring decision problems, 
identifying and evaluating alternatives, constructing and solving 
decision trees, and utility theory. The class will be interactive and 
students will work in groups to apply the decision analysis techniques 
covered in the class.
Instructor(s): V. Prava
Area: Engineering, Quantitative and Mathematical Sciences.

EN.570.402. Practicum on Appropriate and Sustainable 
Technology for Developing Communities.
Suggested: Microeconomics, Introductory Statistics and Optimization.
Instructor(s): W. Ball
Area: Engineering.

EN.570.403. Ecology.
This is a graduate level of EN.570.205; Additional Writing Requirements.
Instructor(s): G. Brush
Area: Natural Sciences.

Environmental history explores the interactions between social 
change and environmental transformation, or the ways in which 
societies modify landscapes and are themselves affected by geological, 
climatological and changing ecological conditions. Topics include 
the relationship between climate change and human evolution, the 
environmental impacts of market-based commodity production and 
regional economic specialization; the relationship between urbanization 
and environmental change; how warfare affects and is affected by 
environmental conditions.
Instructor(s): E. Schoenberger
Area: Humanities, Social and Behavioral Sciences.

EN.570.407. Comparison of Environmental Challenges and 
Governance in China and the US.
In cooperation with the School of the Environment at Nanjing University, 
Nanjing, China, this course will study China’s environmental challenges 
and governance in the context of America’s own environmental 
challenges and governance system. Case studies will involve 
greenhouse gas emissions and a comparison of water quality issues in 
Tai Lake and the Chesapeake Bay. We will consider how developments 
may shape business, government, and culture, and the ways in which 
China and America may learn from one another. The class sessions 
will be conducted in part “live,” in part by teleconference with Nanjing 
University, and in part by web (including communications with Nanjing 
University students and faculty). The objectives for the course are to 1) 
Provide students with basic information and concepts of law, business, 
and governance needed to understand 21st century environmental 
governance challenges; 2) Provide students exposure to important 
environmental problems facing both China and America; 3) Provide 
students with alternative frameworks needed to sift through and 
understand the wealth of information about environmental challenges 
and opportunities faced by China in the globalization world; and 4) 
Encourage students to learn to observe and think independently about 
how to frame and address questions of China environmental challenges 
and governance which may be key to the 21st century.
Instructor(s): E. Bouwer; H. Alavi
Area: Social and Behavioral Sciences.
This three-day intersession class will be a high-level overview of the US energy industry. We will focus on electricity, natural gas, oil, renewables and other forms of energy. We will discuss how each commodity is produced and traded from the perspective of the producer, the distributor, and the end user. The class will provide an overview of the technologies that convert energy into useful work, as well as the market and policy structures that influence investment in production, delivery, and consumption of electricity and natural gas. The goal is to provide a basis for further study, and to motivate students to consider a career in the industry. There are no prerequisites or textbooks, and the class is open to all. The course will be a mix of economics, basic engineering, financial mathematics, and sociology.
Instructor(s): C. Liggio.

This 2 day intersession class will explore in detail the Oil and Wind industry. All facets of the oil industry will be covered from exploration and production transportation and refining to economics and trading. This section will end with a discussion of alternative and synthetic fuels. The wind section will cover the US wind industry including technologies, project development and energy renewable energy policy. There are no prerequisites or textbooks, and the class is open to all. It is highly recommended to take Energy 101. Instructors are alumni from the industry.
Instructor(s): C. Liggio
Area: Social and Behavioral Sciences.

EN.570.410. Energy 103: Energy Demand & Efficiency.
This three day intersession class will explore in detail the demand for energy in the built environment. Co-taught by the Johns Hopkins Energy Manager students will look at how buildings use energy and what steps they can take to reduce energy. The class will emphasize understanding behavior, economics and technologies and explore the meaning of sustainability. Case studies from the University will be presented. Day three will be focused on how energy (conservation, efficiency and renewable) projects can be financed.
Instructor(s): C. Liggio.

EN.570.411. Engineering Microbiology.
Fundamental aspects of microbiology and biochemical as related to environmental pollution and water quality control processes, biogeochemical cycles, microbiological ecology, energetics and kinetics of microbial growth, and biological fate of pollutants.
Area: Engineering, Natural Sciences.

EN.570.412. Landscape Hydrology and Watershed Analysis.
The purpose of this class is to understand the landscape-scale controls on the fluxes of water and waterborne materials through watersheds. This class differs from the Hydrology and Hydrologic Modeling classes in its focus on data analysis, and its embrace of the complexity of real landscapes. There will be significant quantitative components to the material taught, but emphasis will be on developing a greater sense of the way that landscapes “function”, and how this function is related to real-world issues of water resources and pollution. Students will gain an understanding of how climate, geologic and ecologic setting, and human impacts control the partitioning of water between different fates, the flowpaths through the landscape and the storage and residence time of water. They will also learn conceptual and practical tools for analyzing hydrologic and other landscape data, and integrating this data in a holistic approach to watershed analysis. The class will be of interest for students intending to go into watershed or landscape management, and anyone wishing to pursue research in hydrology, geomorphology or ecology at landscape and watershed scales. The class will include at least one field trip to an instrumented watershed. GIS skills will be an advantage but are not required.
Prerequisites: AS.270.405 or EN 570.353 or equivalent.
Instructor(s): C. Harman.

This two day intersession class will introduce basic financial aspects of the energy business. We will begin with how energy projects are financed and describe capital structures, sources of financing and typical loan covenant restrictions. Then we will go on to describe concepts of trading and risk management as applied to the various energy commodities, and discuss price and credit risk trade-offs. The goal is to provide a basis for understanding how to make financial decisions in the presence of uncertainty. Concepts that are often taught using probability theory, option pricing, and other advanced mathematical concepts will be taught intuitively using in-class games. Students desiring a more in-depth treatment of energy commodities should take EN.550.653: Commodities and Commodity Markets.
Recommended Course Background: EN.570.408
Instructor(s): C. Liggio; G. Schultz
Area: Engineering, Social and Behavioral Sciences.

Whether financing clean energy projects or setting policy, it is important to understand how different electricity sources can be compared. This intersession course economically compares renewable and energy efficiency investment options. Simple techniques for matching load with generation and clean technologies will be developed. Detailed life-cycle cost analysis will be prepared including uncertainty. Energy efficiency cost-effectiveness will be determined using basic cost tests and varying policy issues will be discussed. Avoided costs and operational impacts of renewable energy will be computed using different state requirements. The goal is to provide the basic computational and policy framework for determining the economics of a wide range of energy options and understand the limitation of various techniques. Students should bring a calculator or laptop computer.
Instructor(s): C. Bothwell.
EN.570.418. Multiobjective Programming and Planning.
Public sector problems are typically characterized by a multiplicity of objectives and decision makers. This course presents a relatively new area of systems analysis which is useful for such problems: multiobjective programming or vector optimization theory. The fundamental concepts are developed and various methods are presented, including multiattribute value and utility theory. Undergraduate level of EN.570.618. Recommended Course Background: EN.570.495 or Permission Required.
Instructor(s): J. Williams
Area: Engineering.

EN.570.419. Environmental Engineering Design I.
Through general lectures and case study examples, this course will expose students to some of the non-technical professional issues that they will face as professional engineers and in their second-semester senior design project.
Instructor(s): E. Bouwer
Area: Engineering.

EN.570.420. Air Pollution.
The course consists of an introduction to the fundamental concepts of air pollution. Major topics of concern are aspects of atmospheric motion near the earth’s surface; basic thermodynamics of the atmosphere; atmospheric stability and turbulence; equations of mean motion in turbulent flow, mean flow in the surface boundary layer; mean flow, turbulence in the friction layer; diffusion in the atmosphere; statistical theory of turbulence; plume rise. Emphasis is placed upon the role and utility of such topics in a systems analysis context, e.g., development of large and mesoscale air pollution abatement strategies. Comparisons of the fundamental concepts common to both air and water pollution are discussed. This course meets with EN.570.657, Air Pollution.
Instructor(s): J. Ellis.

EN.570.421. Environmental Engineering Design II.
Engineering design process from problem definition to final design. Team projects include written/oral presentations. Students will form small teams that work with local companies or government agencies in executing the project. Recommended Course Background: EN.570.302, EN.570.352, and EN.570.419
Instructor(s): E. Bouwer; H. Alavi
Area: Engineering.

EN.570.422. Principles of Geomorphology.
Analysis of the factors responsible for the form of the landscape. The concept of the cycle of erosion is discussed primarily in terms of the principles that govern the processes of erosion. Climate, conditions of soil formation, and the distribution of vegetation are considered as they relate to the development of landforms. Recommended Course Background: AS.270.220 or permission required.
Instructor(s): P. Wilcock
Area: Natural Sciences.

EN.570.428. Problems in Applied Economics.
This course focuses on a monetary approach to national income determination and the balance of payments. Money and banking, as well as commodity and financial markets, are dealt with under both central banking, as well as alternative monetary regimes. Particular emphasis is placed on currency board systems. Students learn how to properly conduct substantive economic research, utilizing primary data sources, statistical techniques and lessons from economic history. Findings are presented in the form of either memoranda or working papers of publishable quality. Exceptional work may be suitable for publication through the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise. Advanced excel programming skills are required and students are expected to be pre-screened for research at the Library of Congress in Washington, D.C.. Bloomberg certification is a pre-requisite.
Prerequisites: EN.660.203 AND AS.180.101 AND AS.180.102
Instructor(s): S. Hanke
Area: Social and Behavioral Sciences.

Sediment entrainment, transport, and deposition; the interaction of flow and transport in shaping river channels. Review of boundary layer flow; physical properties of sediment; incipient, bed-load, and suspended-load motion; bed forms; hydraulic roughness; velocity and stress fields in open channels; scour and deposition of bed material; bank erosion; size, shape, planform, and migration of river channels. Techniques of laboratory, theoretical, and numerical modeling are developed and applied to problems of channel design, restoration, and maintenance.
Recommended Course Background: EN.570.351
Instructor(s): P. Wilcock
Area: Engineering, Natural Sciences.

EN.570.441. Environmental Inorganic Chemistry.
Advanced undergraduate/graduate course that explores the chemical transformations of elements of the periodic table. Thermodynamic, kinetic, and mechanistic tools needed to address the multiple chemical species and interfaces that are present in natural waters and water-based technological processes are emphasized. Ligand exchange, metal ion exchange, adsorption/desorption, precipitation/dissolution, electron and group transfer reactions, and other concepts from coordination chemistry will be covered. Applications include elemental sources and sinks in ocean waters, reactive transport in porous media, weathering and soil genesis, nutrient and toxic element uptake by organisms, water treatment chemistry, and rational design of synthetic chemicals.
Instructor(s): A. Stone
Area: Natural Sciences.

EN.570.442. Environmental Organic Chemistry.
Advanced undergraduate/graduate course focusing on examination of processes that affect the behavior and fate of anthropogenic organic contaminants in aquatic environments. Students learn to predict chemical properties influencing transfers between hydrophobic organic chemicals, air, water, sediments, and biota, based on a fundamental understanding of intermolecular interactions and thermodynamic principles. Recommended Course Background: AS.030.104 or permission required.
Instructor(s): A. Roberts
Area: Engineering, Natural Sciences.
EN.570.443. Aquatic Chemistry.
Equilibrium speciation of natural waters, biofluids, and engineered systems. Electrolyte solutions, acids and bases, complex formation, precipitation and dissolution, oxidation and reduction. Recommended Course Background: One year of both Chemistry and Calculus.
Instructor(s): A. Stone
Area: Engineering, Natural Sciences.

The application of basic physical and chemical concepts to the analysis of environmental engineering problems. Principles of chemical equilibrium and reaction, reaction engineering, interphase mass transfer, and adsorption are presented in the context of process design for unit operations in common use for water and wastewater treatment. Topics addressed include mass balances, hydraulic characteristics of reactors, reaction kinetics and reactor design, gas transfer processes (including both fundamentals of mass transfer and design analysis), and adsorption processes (including both fundamentals of adsorption and design analysis).
Prerequisites: EN.570.301 AND EN.570.302 or permission of instructor
Instructor(s): W. Ball
Area: Engineering.

EN.570.446. Biological Process of Wastewater Treatment.
Fundamentals and application of aerobic and anaerobic biological unit processes for the treatment of municipal and industrial wastewater. Recommended Course Background: EN.570.411
Instructor(s): E. Bouwer
Area: Engineering, Natural Sciences.

EN.570.448. Physical and Chemical Processes II.
Fundamentals and applications of physical and chemical processes used in water and wastewater treatment. This class will cover particle interactions, coagulation, flocculation, granular media filtration, membrane processes, and emerging water treatment processes. Recommended Course Background: EN.570.445 or Permission Required.
Instructor(s): K. Chen
Area: Engineering.

EN.570.449. Social Theory for Engineers.
Engineers work in a social context. This course addresses a number of questions about that social context. How should we understand how societies come about, how they evolve, and why the rules of the game are what they are? What is the relationship between the individual and society, what does it mean to be 'modern,' are there different forms of rationality? How might all this impinge on what it means to be an engineer?
Instructor(s): E. Schoenberger
Area: Humanities, Social and Behavioral Sciences.

An advanced laboratory covering principles of modern analytical techniques and their applications to problems in environmental sciences. Topics include electrochemistry, spectrometry, gas and liquid chromatography. The course is directed to graduate students and advanced undergraduates in engineering and natural sciences.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class. Prequisite: EN.570.443
Instructor(s): A. Stone
Area: Engineering, Natural Sciences.

EN.570.460. Environmental Colloidal Phenomena.
This class will introduce fundamental concepts of colloidal and interfacial phenomena and apply them to natural and engineered aquatic systems. This course will also include topics related to the environmental applications and implications of nanotechnology. Modern measurement techniques employed in the laboratory to study colloidal behavior and interfacial interactions will be discussed. Lab demonstrations will be conducted and students will be given opportunities to review research papers related to topics covered in class. Topics include: Brownian motion and diffusion, size and surface characterization, electric double layer, electrokinetic phenomena, DLVO theory, Non-DLVO forces, aggregation, deposition, modern measurement techniques in the laboratory, fate and transport of engineered nanoparticles in the environment, and environmental applications of nanotechnology (e.g., sensors, remediation, antimicrobial agents).
Instructor(s): K. Chen.

This course focuses on company valuations, using the proprietary Hanke-Guttridge Discounted Free Cash Flow Model. Students use the model and primary data from financial statements filed with the Securities and Exchange Commission to calculate the value of publically-traded companies. Using Monte Carlo simulations, students also generate forecast scenarios, project likely share-price ranges and assess potential gains/losses. Stress is placed on using these simulations to diagnose the subjective market expectations contained in current objective market prices, and the robustness of these expectations. During the weekly seminar, students' company valuations are reviewed and critiqued. A heavy emphasis is placed on research and writing. Work products are expected to be of publishable quality.
Prerequisites: EN.660.203 AND ( EN.570.428 OR AS.360.528)
Instructor(s): S. Hanke
Area: Quantitative and Mathematical Sciences, Social and Behavioral Sciences.

EN.570.490. Solid Waste Engineering and Management.
This course covers advanced engineering and scientific concepts and principles applied to the management of municipal solid waste (MSW) to protect human health and the environment and the conservation of limited resources through resource recovery and recycling of waste material.
Instructor(s): H. Alavi
Area: Engineering.

EN.570.491. Hazardous Waste Engineering and Management.
This course addresses traditional and innovative technologies, concepts, and principles applied to the management of hazardous waste and site remediation to protect human health and the environment.
Instructor(s): H. Alavi
Area: Engineering.

EN.570.492. M. Gordon Wolman Seminar.
Undergraduates only with permission of instructor.
Instructor(s): K. Chen.
This course includes an exposition of intermediate level price theory, combined with a survey of applications to the analysis of public sector decisions. Theoretical topics include demand, supply, the function and behavior of the market, and introductory welfare economics. Recommended Course Background: AS.180.101-AS.180.102, AS.110.202 or equivalent.
Instructor(s): B. Hobbs; J. Boland
Area: Quantitative and Mathematical Sciences, Social and Behavioral Sciences.

A collection of systems analytic techniques which are frequently used in the study of public decision making is presented. Emphasis is on mathematical programming techniques. Primarily linear programming, integer and mixed-integer programming, and multiobjective programming. Recommended Course Background: AS.110.106-AS.110.107/AS.110.109
Instructor(s): J. Ellis
Area: Engineering, Quantitative and Mathematical Sciences.

EN.570.496. Urban and Environmental Systems.
The mathematical techniques learned in EN.570.305 and EN.570.495 are applied to realistic problems in urban and environmental planning and management. Examples of such problems include the siting of public-sector and emergency facilities; natural areas management, protection and restoration; solid waste collection, disposal, and recycling; public health; the planning and design of energy and transportation systems; and cost allocation in environmental infrastructure development.
Instructor(s): J. Williams
Area: Engineering, Quantitative and Mathematical Sciences.

EN.570.497. Risk and Decision Analysis.
This class introduces the decision analysis approach to making decisions under risk and uncertainty. Topics covered include decision trees, Bayes law, value of information analysis, elicitation of subjective probabilities, multiattribute utility, and their applications to environmental and energy problems. Textbook: R.T. Clemen, Making Hard Decisions, 2014. Recommended Course Background: introductory statistics and probability.
Instructor(s): B. Hobbs
Area: Engineering, Quantitative and Mathematical Sciences.

EN.570.501. Undergraduate Research.
Instructor(s): Staff.

EN.570.502. Undergraduate Research.
Instructor(s): Staff.

EN.570.504. Financial Market Research.
This course investigates the workings of financial, foreign exchange, and commodity futures markets. Research is focused on price behavior, speculation, and hedging in these markets. Extensive research and writing of publishable quality are required. Exceptional work may be suitable for publication through the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise. An approved research proposal is a pre-requisite.
Instructor(s): S. Hanke.

EN.570.505. Undergraduate Independent Study.
Instructor(s): Staff.

EN.570.506. Maryland Department of the Environment Independent Study.
This independent study within the MDE’s Water Management Administration (WMA) will engage the student in scientific/policy literature and data research and management, field investigations, or evaluation of emerging issues and innovative approaches to surface and ground water protection and drinking water management, wastewater management, wetlands and non-point source pollution control. Each independent course will focus on a scientific, regulatory or policy topic designed to further the mission of the administration, which is to protect the public health and the aquatic environment. The student will be assigned to a WMA engineer, scientist or project manager to develop a course of study. Hours can be tailored to accommodate student’s schedule.
Instructor(s): E. Bouwer.

This Independent Study within Baltimore City’s Energy Office will engage students in local energy policies, energy initiatives, data and City operations. Interns will have the chance to apply optimization and modeling skills to one of many projects. These projects can include: • Measurement and verification of performance contracts with energy service contractors • Collection of data from City operated co-generation and solar plants and developing operation models • Analyzing energy usage data from City buildings and making recommendations As part of an independent student project, students will be required to submit a final report and present their findings to the City. Hours can be tailored to accommodate student’s schedule but a minimum of 10 hours per week during the semester is required. Permission required.
Instructor(s): E. Bouwer.

EN.570.510. Internship-Geog/Envr Eng.
Instructor(s): E. Bouwer.

EN.570.570. Independent Study.
Instructor(s): E. Schoenberger; G. Brush.

EN.570.574. Research.
Instructor(s): E. Schoenberger.

EN.570.576. Internship.
The research will focus on how environmental improvements can be factored into the decision making process when consumers purchase vehicles.
Instructor(s): B. Hobbs.

EN.570.590. Internship-Summer.
Instructor(s): E. Bouwer; G. Brush; S. Guikema.

EN.570.597. Research-Summer.
Instructor(s): Staff.

EN.570.599. Independent Study.
Instructor(s): A. Roberts; B. Hobbs; S. Guikema.

This course builds on the basis gain in risk and decision analysis in 570.497. This course covers more advanced analytical methods useful in risk and decision analysis, particularly for dealing with uncertainty. This includes Bayesian methods and Bayesian updating of prior distributions, Markov Chain Monte Carlo, Bayesian belief networks and influence diagrams, and simulation for risk analysis models. The focus is both on the fundamentals of the methods and how they are used in risk and decision analysis. 570.497 is a required prerequisite.
Instructor(s): S. Guikema.
EN.570.601. IGERT Water, Climate and Health Colloquium.
Recommended Course Background: Microeconomics, Introductory Statistics, and Optimization.
Instructor(s): G. Brush.

EN.570.602. IGERT-Water, Climate & Health-Capstone.
Instructor(s): G. Brush.

EN.570.605. Interdisciplinary Research Practice in Sustainability and Health.
Through the application of interdisciplinary research methods and skills to case studies in environmental sustainability and health, the course will provide hands-on training in the management, coordination, and practice of interdisciplinary research. The goal is to enable doctoral students to work effectively on interdisciplinary research and prepare them for professional success in an increasingly interdisciplinary funding environment. This course will be in the format of a weekly seminar and laboratory and is open to all Johns Hopkins University doctoral students from any School. No prior knowledge of sustainability or public health is required.
Instructor(s): A. Monopolis; B. Hobbs.

This course assumes a basic familiarity with programming in R. Some knowledge of probability and statistics will be a plus. The course introduces some key methods in implementing data-driven research. The course starts with a very brief review of programming in R and basics of probability and statistics and then spans into topics such as random variable generation, Monte Carlo integration, variance reduction techniques, uncertainty estimation, MCMC, probability density estimation and numerical methods. Recommend Course Background: EN.570.608 or equivalent.
Instructor(s): R. Nateghi.

Methods for optimizing operation and design of energy systems and for analyzing market impacts of energy and environmental policies are reviewed, emphasizing both theory and solution of actual models. Review of linear and nonlinear programming and complementarity methods for market simulation. Recommended Course Background: EN.570.493 and EN.570.495 or equivalent.
Instructor(s): B. Hobbs.

EN.570.608. Data Analytics for Engineering, Policy Analysis and Management.
Data analytics is the use of computational statistics and data mining to draw insights and build predictive models based on large data sets. As data becomes more prevalent in across many different areas of importance in engineering, policy analysis, and management, analytics is becoming an increasingly important topic. This course assumes a working knowledge of regression and statistics and builds from this to introduce modern data analytics. This course covers major classes of methods beyond linear regression, including additive models, tree-based models, Bayesian networks, boosting, bagging, and model averaging. The course focuses on the application and interpretation of the methods while also providing an understanding of the underlying basis and theory behind them. Assignments, exams, and the term project are primarily data-driven analytic exercises. Recommended Course Background: EN.550.420 and EN.550.430 or equivalent (by approval of instructor).
Instructor(s): S. Guikema
Area: Engineering, Quantitative and Mathematical Sciences.

EN.570.611. Natural Resource Economics.
Development of the economic theory of depletable and renewable private and common property natural resources, including those which may be recyclable or storable.
Instructor(s): J. Boland.

EN.570.612. Infrastructure Modeling, Simulation, and Analysis.
This course will be a mix of seminar-style guided discussions and student presentations and lectures on specific topics based on the current research literature in the field. It will give an overview of the infrastructure systems that form the basis for health, security, and economic prosperity in the developed world and give an overview of some of the most pressing infrastructure challenges in the developing world. The focus will be on quantitative modeling of infrastructure performance, sustainability, and resilience for supporting infrastructure management and policy decision-making. Suggested: Microeconomics, Introductory Statistics, and Optimization.
Instructor(s): S. Guikema
Area: Engineering, Natural Sciences.

EN.570.618. Multiobject Programming and Planning.
Public sector problems are typically characterized by a multiplicity of objectives and decision makers. This course presents a relatively new area of systems analysis which is useful for such problems: multiobjective programming or vector optimization theory. The fundamental concepts are developed and various methods are presented, including multiattribute value and utility theory. Graduate level of EN.570.418. Recommended Course Background: EN.570.495 or Permission Required.
Instructor(s): J. Williams
Area: Engineering.

This graduate level course will provide a practical knowledge of molecular methods used to identify microorganisms present with a sample and gain insight into their function and dynamics. It will provide theoretical background into how to identify microorganisms and infer functional capabilities from genetic material, practical knowledge of common molecular methods and computational skills needed to analyze the resulting sequence data. No background in molecular biology, computation or microbiology is necessary. Course objectives include (1) understanding key aspects of microbial community composition from literature reports; (2) recognizing major microbial taxonomic groups and understanding phylogenetic relationships; (3) developing molecular biology lab skills required to create gene amplicon libraries from an aquatic samples; (4) working knowledge of statistical methods used to associate taxonomic and functional gene information with specific environmental conditions. Recommended Course Background: Microeconomics, Introductory Statistics, Optimization
Instructor(s): S. Preheim

EN.570.633. Stochastic Simulation and Game Theory.
This course provides an introduction to stochastic simulation and game theory. It covers a mix of the theoretical background and the practical use of these two methods. The stochastic simulation portion of the course covers both discrete event and time step methods. It also covers random number generators, analysis of output, comparison of systems, variance reduction techniques, and linkages between simulation and optimization. The game theory portion of the course provides an introduction to the basic types of games: static games of complete information, dynamic games of complete information, static games of incomplete information, and dynamic games of incomplete information. Several case studies are covered.
Instructor(s): S. Guikema.
EN.570.634. Foundational Literature of Risk and Decision Analysis.
This course will be a guided reading, discussion, and assessment of the foundational literature from the fields of risk and decision analysis. We will read work by authors such as Ramsey, Savage, Raiffa, Laplace, and others that have established the foundations on which the fields are built. The goal is to provide Ph.D. students with a strong foundation in the field and an understanding of the literature underlying the development of the field. PhD students or permission of instructor.
Prerequisites: EN.570.497
Instructor(s): S. Guikema.

Detailed investigation of mechanisms of abiotic and biochemical transformations of organic pollutants in natural and engineered environments. Recommended Course Background: EN.570.442.
Instructor(s): A. Roberts
Area: Engineering, Natural Sciences.

EN.570.646. Water Quality and Treatment: Global Issues and Solutions.
This course involves extensive student participation and is intended for motivated graduate students from both engineering and non-engineering disciplines who are interested in understanding technological aspects water quality in the contexts of drinking water treatment, wastewater disposal, and sanitation for public health. The course involves extensive outside reading, in-class reflections on those readings, and a combination of instructor- and student-led in-class presentations. After this course, students should have improved understanding of: (1) Fundamental concepts of water quality and treatment as related to the application of engineering principles to the design and operation of unit operations for the removal of traditional and “emerging” contaminants; (2) Challenges to providing water of appropriate quality for drinking, sanitation, and environmental sustainability in the face of population growth and climate change; and (3) Alternative approaches for meeting those challenges, particularly as related to the design and application of technological interventions.
Instructor(s): W. Ball.

This course considers the transport of solutes and sediments by water through terrestrial landscapes, with an emphasis on the movement of nutrients and contaminants from the landscape into receiving water bodies like rivers, lakes and estuaries. The course will cover the theoretical approaches (advection-diffusion/dispersion, transit time distributions), the use of active and passive tracers to infer transport processes, analysis of water quality time series, runoff generation and flow pathways in watersheds, and the effect of climate variability on transport. Assessment is based on a semester project and in-class presentations. Seniors interested in joining the class must have Hydrology 570.353 and should contact the instructor.
Area: Engineering, Natural Sciences.

EN.570.657. Air Pollution.
The course consists of an introduction to the fundamental concepts of air pollution. Major topics of concern are aspects of atmospheric motion near the earth’s surface; basic thermodynamics of the atmosphere; atmospheric stability and turbulence; equations of mean motion in turbulent flow, mean flow in the surface boundary layer; mean flow, turbulence in the friction layer; diffusion in the atmosphere; statistical theory of turbulence; plume rise. Emphasis is placed on the role and utility of such topics in a systems analysis context, e.g., development of large and mesoscale air pollution abatement strategies. Comparisons of the fundamental concepts common to both air and water pollution are discussed.
Instructor(s): J. Ellis.

EN.570.659. Environmental Policy Analysis.
Instructor(s): J. Ellis.

EN.570.661. Applied Math For Engineer.
Instructor(s): C. Norman.

EN.570.676. Stochastic Programming.
The course deals with computationally tractable methodologies for incorporating risk/uncertainty into mathematical programming (optimization) models. Focal topics include chance-constrained programming, stochastic linear programming, two-stage programming under uncertainty and stochastic dynamic programming. Some of these techniques may result in the creation of nonlinear models thus nonlinear/nonseparable optimization techniques are presented as well. Numerous applications are presented involving, for the most part, environmental (i.e., water and air resources) problems. Prerequisites: linear algebra, power series, Fourier series, separation of variables, integral transforms.
Instructor(s): M. Hilpert.

EN.570.680. Environment and Society.
This class addresses a range of questions, including: Why do we not act in our own best interests in the environment? How are environmental discourses developed and how do they relate to environmental policies? How do environmental politics and policy in the US compare with other countries?
Instructor(s): E. Schoenberger
Area: Social and Behavioral Sciences.

EN.570.800. Masters Independent Study.
Instructor(s): Staff.

EN.570.801. Doctoral Research.
Instructor(s): Staff.

EN.570.803. Master's Research.
Instructor(s): Staff.

EN.570.805. Jensen Internship.
Instructor(s): W. Ball.

EN.570.841. M. Gordon Wolman Seminar.
Instructor(s): K. Chen.

EN.570.850. Graduate Independent Study.
Instructor(s): M. Hilpert; S. Guikema; W. Ball.

Instructor(s): B. Hobbs; D. Gayme; J. Ellis; J. Williams.
Instructor(s): E. Bouwer.

Cross Listed Courses

Anthropology

This course combines anthropological perspectives with the discussion and examination of technology-based interventions in the field of development and aid policies, with particular focus on activities related to water resources, sanitation, and hygiene. Readings and discussions analyze some of the theoretical, historically rooted, and practical issues that challenge those who hope to provide effective aid. A key aim of this course is to provide students with better understanding of cultural, social, environmental and economic issues relevant to technical intervention in developing countries.
Instructor(s): E. Cervone; W. Ball
Area: Humanities, Social and Behavioral Sciences.

Public Policy

AS.195.477. Intro To Urban Policy.
Perm. Req’d. 195.477 & 195.478 must be taken together by undergraduates Cross-listed with Political Science, Sociology, Public Health Studies, and Geography and Environmental Engineering
Instructor(s): S. Newman
Area: Social and Behavioral Sciences.

195.478 & 195.477 must be taken together by undergraduates Cross-listed with Political Science, Sociology, Public Health Studies, and Geography and Environmental Engineering
Instructor(s): S. Newman.
Area: Social and Behavioral Sciences.

Earth Planetary Sciences

AS.270.205. Introduction to Geographic Information Systems and Geospatial Analysis.
The course provides a broad introduction to the principles and practice of Geographic Information Systems (GIS) and related tools of Geospatial Analysis. Topics will include history of GIS, GIS data structures, data acquisition and merging, database management, spatial analysis, and GIS applications. In addition, students will get hands-on experience working with GIS software.
Instructor(s): X. Chen
Area: Engineering, Natural Sciences.

Public Health Studies

AS.280.335. The Environment and Your Health.
This course surveys the basic concepts underlying environmental health sciences (toxicology, exposure assessment, risk assessment), current public health issues (hazardous waste, water- and food-borne diseases), and emerging global health threats (global warming, built environment, ozone depletion, sustainability). Public Health Studies, Global Environmental Change and Stability, and Earth and Planetary Science majors have 1st priority for enrollment. Your enrollment may be withdrawn at the discretion of the instructor if you are not a GECS, PHS, or EPS major.
Prerequisites: (Students may not have taken AS.270.320)
Instructor(s): J. Bressler; M. Trush
Area: Natural Sciences.

Interdepartmental

AS.360.147. Freshmen Seminar: Adam Smith and Karl Marx.
This freshmen seminar examines the ideas of Smith, the greatest proponent of the free market, and Marx, his most radical critic. Freshmen only.
Instructor(s): E. Schoenberger; P. Jelavich
Area: Humanities, Social and Behavioral Sciences.

AS.360.528. Problems in Applied Economics.
This course focuses on a monetary approach to national income determination and the balance of payments. Money and banking, as well as commodity and financial markets, are dealt with under both central banking, as well as alternative monetary regimes. Particular emphasis is placed on currency board systems. Students learn how to properly conduct substantive economic research, utilizing primary data sources, statistical techniques and lessons from economic history. Findings are presented in the form of either memoranda or working papers of publishable quality. Exceptional work may be suitable for publication through the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise. Advanced excel programming skills are required and students are expected to be pre-screened for research at the Library of Congress in Washington, D.C.. Bloomberg certification is a requisite.
Prerequisites: EN.660.203
Instructor(s): S. Hanke
Area: Quantitative and Mathematical Sciences, Social and Behavioral Sciences.