The Department of Earth and Planetary Sciences offers programs of study and research in a wide range of disciplines including atmospheric science, ecology, environmental science and studies, geology, geochemistry, geophysics, oceanography, and planetary science. The undergraduate major in Earth and Planetary Sciences is flexible and allows the student, in consultation with a faculty adviser, to devise a program of study that is both rigorous and individualized. The graduate program develops skills in research through independent investigation under the general guidance of one or more members of the faculty, backed up by relevant coursework. The department gives particular emphasis to the integration of experimental investigation, theoretical calculation, and quantitative field observations.

The Department also supports an interdisciplinary undergraduate program in Environmental Science and Studies (ENVS), which involves faculty from a range of departments across the university. The two ENVS majors and minor introduce students to Earth system science and the ways in which humans interact with and affect the Earth. ENVS is solution-focused and trains students to help solve the environmental and sustainability problems facing society today using the powerful tools of science and policy. Undergraduate degrees are typically specialized within traditional disciplines, but a primary goal of this program is to develop the ability of students to think outside of those boxes. Students learn theory, research, and practical applications of the natural and social sciences in their coursework, while also examining the relationship between humans and the environment through the lens of the humanities.

**Facilities**

The Department of Earth and Planetary Sciences is housed in Olin Hall, a modern building dedicated to the Earth sciences, nestled on a wooded knoll on the western edge of campus. Its facilities include state-of-the-art instrumentation, a departmental library, and modern computer equipment. There are laboratories for crystallography, evolutionary biology/ecology, stable isotope geochemistry, materials science, and fluid and solid mechanics. Olin Hall also contains equipment for modern petrographic work (including a computer-controlled image analysis system), darkroom facilities, and a laboratory for sectioning rocks. There is also a substantial collection of rocks, minerals, and fossils. Facilities are available for a wide spectrum of fluid mechanical experiments, including thermal convection and solidification.

A JEOL 8600 electron microprobe in Olin Hall is available to all members of the department. Crystallographic facilities include a modern specimen preparation laboratory for transmission electron microscopy and single-crystal X-ray diffraction studies. The transmission electron microscopy laboratory houses state-of-the-art instruments capable of both high-resolution imaging at the atomic scale and microanalysis at the nanometer scale.

The department contains several computer laboratories containing clusters of workstations and personal computers, together with printers and scanners. These computers are used for numerical simulations, graphics applications, data manipulation, and word processing.

Field studies and excursions form an integral part of the program of instruction and research in geology and are closely integrated with the laboratory and course work. Situated at the fall line between the Coastal Plain and the Piedmont and only an hour’s ride from the Blue Ridge and Appalachian Mountains, Baltimore is an excellent location for a department with a field-oriented program in geology. The department has a permanent field station for geological research, Camp Singewald, in the Bear Pond Mountains of Washington County, Maryland, and a vehicle for field use.

Supporting facilities on campus include the Milton S. Eisenhower Library, the Space Telescope Science Institute, and the Homewood High-Performance Computing Center. In addition, the JHU Applied Physics Laboratory, the facilities of the Smithsonian Institution and the Geophysical Laboratory and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington are available by special arrangement for students qualified to use them. For students whose research requires substantial computation, special arrangements can be made to use the supercomputers at the NASA Goddard Space Flight Center and the National Center for Atmospheric Research.

**Undergraduate Programs**

The Department of Earth and Planetary Sciences offers the following majors and minors:

- Earth and Planetary Sciences Major (p. )
- Earth and Planetary Science Minor (p. )
- Environmental Science Major (p. )
- Environmental Studies Major (p. )
- Environmental Studies Minor (p. )

The Earth and Planetary Sciences major focuses on the study of the Earth and other planets. It is designed primarily for science students who wish to have careers involving research and study of the Earth and planets, although it is also suitable for students planning careers in the health professions.

The interdisciplinary ENVS majors and minor introduce students to human-Earth interactions and processes, our complex relationship with the changing environment, and methods for solving environmental and sustainability problems. The Environmental Science major emphasizes the perspective of the natural sciences, while the Environmental Studies major emphasizes the social science perspective, but there is a set of common core courses shared by both these majors that create a strong interdisciplinary foundation. ENVS is designed to prepare students for a variety of potential career paths, including both graduate study and entry-level jobs in an environmentally related field.

In addition to major requirements, students are required to complete the university requirements for the bachelor’s degree. See Requirements for a Bachelor’s Degree (http://e-catalog.jhu.edu/academic-policies/requirements-for-a-bachelors-degree).

**Earth and Planetary Sciences (EPS) Major (B.A.)**

The Bachelor of Arts in Earth and Planetary Sciences is for undergraduates interested in the study of the physical, chemical, and biological processes that shape the Earth and the other planets, drawing
on the disciplines of geology, geochemistry, geophysics, hydrology, ecology, geobiology, oceanography, and atmospheric science.

Students should design a specific plan of appropriate courses in consultation with their adviser and the EPS Director of Undergraduate Studies (DUS). Those who wish to be majors may proceed directly to the introductory courses at the 200-level, but depending on the student’s background, it may be appropriate initially to take a freshman seminar or 100-level course designed for the non-major. Our courses provide a broad educational base in the Earth, planetary, and environmental sciences and enable exploration of a set of electives at the 300- and 400-level, depending on the area of interest.

The department requires a total of 9 credits at the 100- or 200-level and 12 credits at the 300-level or above within the department, as well as science and math foundation courses from other departments. All courses must be taken for a letter grade, and students must earn a grade of C- or better to apply the course to the major. Students should design a specific plan of appropriate courses in consultation with their adviser and the EPS Director of Undergraduate Studies (DUS). Those who wish to be majors may proceed directly to the introductory courses at the 200-level, but depending on the student’s background, it may be appropriate initially to take a freshman seminar or 100-level course designed for the non-major. Our courses provide a broad educational base in the Earth, planetary, and environmental sciences and enable exploration of a set of electives at the 300- and 400-level, depending on the area of interest.

The department requires a total of 9 credits at the 100- or 200-level and 12 credits at the 300-level or above within the department, as well as science and math foundation courses from other departments. All courses must be taken for a letter grade, and students must earn a grade of C- or better to apply the course to the major.

**EPS Core Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.270.224</td>
<td>Oceans &amp; Atmospheres</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.220</td>
<td>The Dynamic Earth: An Introduction to Geology</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.221</td>
<td>The Dynamic Earth Laboratory</td>
<td>2</td>
</tr>
</tbody>
</table>

**Other Science & Math Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>AS.110.106</td>
<td>Calculus I (Biology and Social Sciences)</td>
<td>4</td>
</tr>
<tr>
<td>or AS.110.108</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>AS.110.107</td>
<td>Calculus II (For Biological and Social Science)</td>
<td>4</td>
</tr>
<tr>
<td>or AS.110.109</td>
<td>Calculus II (For Physical Sciences and Engineering)</td>
<td>4</td>
</tr>
<tr>
<td>or AS.110.113</td>
<td>Honors Single Variable Calculus</td>
<td>4</td>
</tr>
<tr>
<td>AS.171.101</td>
<td>General Physics: Physical Science Major I</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.103</td>
<td>General Physics I for Biological Science Majors</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.107</td>
<td>General Physics for Physical Sciences Majors (AL)</td>
<td>4</td>
</tr>
<tr>
<td>AS.171.102</td>
<td>General Physics: Physical Science Major II</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.104</td>
<td>General Physics/Biology Majors II</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.108</td>
<td>General Physics for Physical Sciences Majors (AL)</td>
<td>4</td>
</tr>
</tbody>
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**EPS Elective Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.270.220</td>
<td>The Dynamic Earth: An Introduction to Geology</td>
<td>3</td>
</tr>
<tr>
<td>or AS.270.224</td>
<td>Oceans &amp; Atmospheres</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.270.3xx-4xx</td>
<td>General Physics/Physical Science Major II</td>
<td>3</td>
</tr>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
<td>3</td>
</tr>
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**Sample Program of Study for the EPS Major**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>AS.110.108</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Calculus I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS.110.109</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Calculus II</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS.270.220</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>The Dynamic Earth: An Introduction to Geology</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>AS.270.221</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The Dynamic Earth Laboratory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Credits</td>
<td>42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>Sophomore</td>
<td>AS.171.101</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>General Physics: Physical Science Major I</td>
<td>4</td>
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<tr>
<td></td>
<td>or AS.171.102</td>
<td>General Physics/Physical Science Major II</td>
</tr>
<tr>
<td></td>
<td>or AS.171.104</td>
<td>General Physics/Biology Majors II</td>
</tr>
<tr>
<td></td>
<td>or AS.171.108</td>
<td>General Physics for Physical Sciences Majors (AL)</td>
</tr>
<tr>
<td></td>
<td>AS.030.101</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Introductory Chemistry I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS.270.1xx-2xx or higher</td>
<td></td>
</tr>
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<td></td>
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<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>Junior</td>
<td>AS.270.3xx-4xx</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>General Physics: Physical Science Major II</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or AS.270.495 Senior Thesis</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or AS.270.496 Senior Thesis</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total Credits</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior</td>
<td>AS.270.3xx-4xx</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or AS.270.3xx-4xx</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total Credits</td>
<td>3</td>
</tr>
</tbody>
</table>

**Earth and Planetary Sciences Minor**

The Earth and Planetary Sciences minor is for science undergraduates interested in learning about Earth and other planets through geology, geochemistry, geophysics, hydrology, ecology, geobiology, oceanography, and atmospheric science. Students take 12 credits of EPS courses, at least six of which are at the 300-level, and at least 16 credits of other natural sciences, quantitative studies, or engineering. No ENVS AS.271.xxx courses may count toward the minor. All courses must be taken for a letter grade, and students must earn a grade of C- or better to apply the course towards the minor.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.270.220</td>
<td>The Dynamic Earth: An Introduction to Geology</td>
<td>3</td>
</tr>
<tr>
<td>or AS.270.224</td>
<td>Oceans &amp; Atmospheres</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.495 Senior Thesis</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>or AS.270.496 Senior Thesis</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>AS.270.3xx-4xx</td>
<td>General Physics/Physical Science Major II</td>
<td>3</td>
</tr>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.1xx-2xx or higher</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.270.3xx-4xx</td>
<td>General Physics/Physical Science Major II</td>
<td>3</td>
</tr>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.1xx-2xx or higher</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sixteen credits of natural science, quantitative, or engineering courses not from the EPS Department, preferably biology, chemistry, physics, or mathematics.

Environmental Science Major (B.S.)
The Bachelor of Science in Environmental Science is an interdisciplinary major that introduces students to Earth system science and the ways in which humans interact with the environment. It equips students to use a variety of tools, such as policy, science, communication, and individual and societal behavior change, to solve environmental and sustainability problems but focuses on the perspectives and tools of the natural sciences. Environmental Science majors must complete a set of core courses common to both ENVS majors, including a senior capstone course and an applied experience involving either research or an internship, plus several additional natural science core courses and a suite of electives selected to form an adviser-approved focus area.

The ENVS senior capstone seminar involves the planning and execution of a tangible, group sustainability project on or off-campus. All ENVS majors must enroll in the capstone course in the fall semester of their senior year. The applied experience can be completed during any semester including summers and involves at least 80 hours of supervised, hands-on experience working with environmental or sustainability issues through a research project, internship, or study abroad program with a research or internship component. Synthesizing assignments reflecting on the experience are also required. The goal of the applied experience requirement is to ensure that students have practical experience in a research, workplace, or community setting that will help prepare them for the next step in their education and career. Consult the ENVS advising guide on the program's website for additional information: http://krieger.jhu.edu/envs/requirements/major/

The Environmental Science major requires a total of 71-77.5 credits to complete. All courses must be taken for a letter grade, and students must earn a grade of C- or better to apply the course to the major. All ENVS majors are encouraged to consider studying abroad at some point during their undergraduate years to develop a more global, culturally sensitive perspective on environmental and sustainability issues. Appropriate transfer or study abroad courses may be counted toward the major at the discretion of the ENVS Director of Undergraduate Studies (DUS). Students are not permitted to double-major in both Environmental Science and Environmental Studies.

Common ENVS Core

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.270.103</td>
<td>Introduction to Global Environmental Change</td>
<td>3</td>
</tr>
<tr>
<td>AS.271.107</td>
<td>Introduction to Sustainability</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.205</td>
<td>Introduction to Geographic Information Systems and Geospatial Analysis</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.336</td>
<td>Freshwater Systems</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.308</td>
<td>Population/Community Ecology</td>
<td>3</td>
</tr>
<tr>
<td>or EN.570.205</td>
<td>Ecology</td>
<td></td>
</tr>
<tr>
<td>or EN.570.403</td>
<td>Ecology</td>
<td></td>
</tr>
<tr>
<td>AS.271.401</td>
<td>Environmental Ethics</td>
<td>3</td>
</tr>
<tr>
<td>AS.271.403</td>
<td>Environmental Policymaking and Policy Analysis</td>
<td>3</td>
</tr>
<tr>
<td>AS.271.505</td>
<td>Senior Capstone Experience</td>
<td>4</td>
</tr>
<tr>
<td>AS.271.509</td>
<td>Applied Experience</td>
<td>1</td>
</tr>
<tr>
<td>AS.180.102</td>
<td>Elements of Microeconomics</td>
<td>3</td>
</tr>
<tr>
<td>AS.190.102</td>
<td>Introduction To Comparative Politics</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credits 28

Environmental Science Major (B.S.)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.190.111</td>
<td>Introduction to Global Studies</td>
<td></td>
</tr>
<tr>
<td>or AS.190.209</td>
<td>Contemporary International Politics</td>
<td></td>
</tr>
<tr>
<td>or AS.190.226</td>
<td>Global Governance</td>
<td></td>
</tr>
<tr>
<td>AS.030.101</td>
<td>Introductory Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>or AS.030.103</td>
<td>Applied Chemical Equilibrium and Reactivity w/lab</td>
<td></td>
</tr>
<tr>
<td>AS.110.106</td>
<td>Calculus I (Biology and Social Sciences)</td>
<td>4</td>
</tr>
<tr>
<td>or AS.110.108</td>
<td>Calculus I</td>
<td></td>
</tr>
<tr>
<td>AS.230.205</td>
<td>Introduction to Social Statistics</td>
<td>4</td>
</tr>
<tr>
<td>or AS.280.345</td>
<td>Public Health Biostatistics</td>
<td></td>
</tr>
<tr>
<td>or EN.553.111</td>
<td>Statistical Analysis I</td>
<td></td>
</tr>
<tr>
<td>or EN.553.211</td>
<td>Probability and Statistics for the Life Sciences</td>
<td></td>
</tr>
<tr>
<td>or EN.553.310</td>
<td>Probability &amp; Statistics</td>
<td></td>
</tr>
<tr>
<td>or EN.553.311</td>
<td>Probability and Statistics for the Biological Sciences and Engineering</td>
<td></td>
</tr>
</tbody>
</table>

Total Credits 43

Natural Sciences Core

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.110.107</td>
<td>Calculus II (For Biological and Social Science)</td>
<td>4</td>
</tr>
<tr>
<td>or AS.110.109</td>
<td>Calculus II (For Physical Sciences and Engineering)</td>
<td></td>
</tr>
<tr>
<td>If AS.030.103 was not taken:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS.030.102</td>
<td>Introductory Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>Choose 2 of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS.020.151</td>
<td>General Biology I</td>
<td>3</td>
</tr>
<tr>
<td>AS.020.152</td>
<td>General Biology II</td>
<td>3</td>
</tr>
<tr>
<td>AS.171.101</td>
<td>General Physics/Physical Science Major I</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.103</td>
<td>General Physics I for Biological Science Majors</td>
<td></td>
</tr>
<tr>
<td>or AS.171.107</td>
<td>General Physics for Physical Sciences Majors (AL)</td>
<td></td>
</tr>
<tr>
<td>AS.171.102</td>
<td>General Physics: Physical Science Major II</td>
<td>4</td>
</tr>
<tr>
<td>or AS.171.104</td>
<td>General Physics/Biology Majors II</td>
<td></td>
</tr>
<tr>
<td>or AS.171.108</td>
<td>General Physics for Physical Science Majors (AL)</td>
<td></td>
</tr>
<tr>
<td>Lab Experiences: 3 approved science lab courses are required, either as separate 1-2-credit lab courses or as part of 4-5-credit lecture courses that include a lab section. Approved labs include but are not limited to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS.020.153</td>
<td>General Biology Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>AS.020.154</td>
<td>General Biology Lab II</td>
<td>1</td>
</tr>
<tr>
<td>AS.030.105</td>
<td>Introductory Chemistry Laboratory I</td>
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</tr>
<tr>
<td>AS.030.106</td>
<td>Introductory Chemistry Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>AS.173.111</td>
<td>General Physics Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>AS.173.112</td>
<td>General Physics Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>AS.270.221</td>
<td>The Dynamic Earth Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>AS.270.337</td>
<td>Freshwater Systems Lab</td>
<td>1</td>
</tr>
</tbody>
</table>

Total Credits 43

Focus Area
Each student should work with their adviser to choose a coherent suite of elective courses totaling at least 15 credits, 12 of which are at the 300-level or above. These courses should be related to a focus area of relevance to the student's individual interests and career plans. The focus area can center around a particular environmental or sustainability topic or a particular disciplinary lens through which a variety of environmental issues can be viewed. Suggested topical focus areas include but are not limited to: climate change, oceans, and energy; water and soil; ecology and conservation; and environmental health. Appropriate focus area courses are those that concentrate directly on environmental or...
sustainability issues. The ENVS Director of Undergraduate Studies (DUS) distributes a list of approved focus area courses prior to the registration period for each semester, and approval for other courses can be sought by emailing the major adviser and DUS. Consult the ENVS advising guide on the program’s website for additional information: http://krieger.jhu.edu/envs/requirements/major/.

With the adviser approval, choose 15 credits of course work related to a focus area, at least 12 credits of which are at the 300-level or above.

**Total Credits**

### Sample Program of Study for the Environmental Science Major

#### Freshman

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AS.270.103 Introduction to Global Environmental Change</td>
<td>3</td>
<td>AS.271.403 Environmental Policymaking and Policy Analysis</td>
<td>4</td>
</tr>
<tr>
<td>AS.030.101 Introductory Chemistry I</td>
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<td>AS.030.102 Introductory Chemistry II</td>
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<td>AS.110.108 Calculus I</td>
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<td>AS.110.109 Calculus II (For Physical Sciences and Engineering)</td>
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**Total Credits: 15**

#### Sophomore

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<th>Fall</th>
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<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>AS.270.336 Freshwater Systems</td>
<td>3</td>
<td>AS.270.205 Introduction to Geographic Information Systems and Geospatial Analysis</td>
<td>3</td>
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<tr>
<td>AS.270.337 Freshwater Systems Lab</td>
<td>1</td>
<td>AS.020.152 General Biology II</td>
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<tr>
<td>AS.020.151 General Biology I</td>
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<td>AS.020.154 General Biology Lab II</td>
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</tr>
<tr>
<td>AS.020.153 General Biology Laboratory I</td>
<td>1</td>
<td>AS.180.102 Elements of Microeconomics</td>
<td>3</td>
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<tr>
<td>EN.553.111 Statistical Analysis I</td>
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**Total Credits: 10**

#### Junior

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<tbody>
<tr>
<td>AS.270.308 Population/Community Ecology</td>
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<td>AS.271.401 Environmental Ethics</td>
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<tr>
<td>Focus area course</td>
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<td>AS.271.509 Applied Experience</td>
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**Total Credits: 9**

#### Senior

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<th>Fall</th>
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<th>Spring</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>AS.271.505 Senior Capstone Experience</td>
<td>4</td>
<td>AS.271.403 Environmental Policymaking and Policy Analysis</td>
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</tr>
<tr>
<td>Focus area course</td>
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<td>Focus area course</td>
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**Total Credits: 71**

### Environmental Studies Major (B.A.)

The Bachelor of Arts in Environmental Studies is an interdisciplinary major that introduces students to Earth system science and the ways in which humans interact with the environment. It equips students to use a variety of tools, such as policy, science, communication, and individual and societal behavior change, to solve environmental and sustainability problems but focuses on the perspectives and tools of the social sciences. Environmental Studies majors must complete a set of core courses common to both ENVS majors, including a senior capstone course and an applied experience involving either research or an internship, plus three additional social science core courses and a suite of electives selected to form an adviser-approved focus area.

The ENVS senior capstone seminar involves the planning and execution of a tangible, group sustainability project on or off-campus. All ENVS majors must enroll in the capstone course in the fall semester of their senior year. The applied experience can be completed during any semester including summers and involves at least 80 hours of supervised, hands-on experience working with environmental or sustainability issues through a research project, internship, or study abroad program with a research or internship component. Synthesizing assignments reflecting on the experience are also required. The goal of the applied experience requirement is to ensure that students have practical experience in a research, workplace, or community setting that will help prepare them for the next step in their education and career. Consult the ENVS advising guide on the program’s website for additional information: http://krieger.jhu.edu/envs/requirements/major/.

The Environmental Studies major requires a total of 64-66.5 credits to complete. All courses must be taken for a letter grade, and students must earn a grade of C- or better to apply the course to the major. All ENVS majors are encouraged to consider studying abroad at some point during their undergraduate years to develop a more global, culturally sensitive perspective on environmental and sustainability issues. Appropriate transfer courses taken abroad may be counted toward the major at the discretion of the ENVS Director of Undergraduate Studies (DUS). Students are not permitted to double-major in both Environmental Studies and Environmental Science.

### Common ENVS Core

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS.270.103 Introduction to Global Environmental Change</td>
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<tr>
<td>AS.271.107 Introduction to Sustainability</td>
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<tr>
<td>AS.270.205 Introduction to Geographic Information Systems and Geospatial Analysis</td>
<td>3</td>
</tr>
<tr>
<td>AS.270.336 Freshwater Systems</td>
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</tr>
<tr>
<td>AS.270.308 Population/Community Ecology or EN.570.205 Ecology or EN.570.403 Ecology</td>
<td>3</td>
</tr>
<tr>
<td>AS.271.401 Environmental Ethics</td>
<td>3</td>
</tr>
<tr>
<td>AS.271.403 Environmental Policymaking and Policy Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>
Sample Program of Study for the Environmental Studies Major

**Focus Area**
Each student should work with their adviser to choose a coherent suite of elective courses totaling at least 12 credits, 9 of which are at the 300-level or above. These courses should be related to a focus area of relevance to the student's individual interests and career plans. The focus area can center around a particular environmental or sustainability topic or a particular disciplinary lens through which a variety of environmental issues can be viewed. Suggested topical focus areas include but are not limited to: sustainable development; environmental policy and governance; ecology and conservation; and environmental health. Appropriate focus area courses are those that concentrate directly on environmental or sustainability issues. The ENVS Director of Undergraduate Studies (DUS) distributes a list of approved focus area courses prior to the registration period for each semester, and approval for other courses can be sought by emailing the major adviser and DUS. Consult the ENVS advising guide on the program's website for additional information: [http://krieger.jhu.edu/envs/requirements/major/](http://krieger.jhu.edu/envs/requirements/major/).

With adviser approval, choose 12 credits of coursework related to a focus area, at least 9 credits of which are at the 300-level or above.

**Total Credits:** 12

**Sample Program of Study for the Environmental Studies Major**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
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<td>AS.271.107 Introduction to Sustainability</td>
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<tr>
<td>AS.180.101 Elements of Macroeconomics</td>
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<td>AS.180.102 Elements of Microeconomics</td>
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<th>Fall</th>
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<th>Spring</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>AS.270.336 Freshwater Systems</td>
<td>3</td>
<td>AS.270.205 Introduction to Geographic Information Systems and Geospatial Analysis</td>
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</tbody>
</table>

**Sophomore**

**Fall** | Credits | Spring | Credits |
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<tr>
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</thead>
<tbody>
<tr>
<td>AS.270.308 Population/Community Ecology</td>
<td>3</td>
<td>AS.271.509 Applied Experience</td>
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<tr>
<td>AS.271.302 Exploring Nature</td>
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<td>AS.270.202 Research Methods for the Social Sciences</td>
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**Focus area course** | 3 | Focus area course | 3 |

**Total Credits:** 9

**Junior**

**Fall** | Credits | Spring | Credits |
<table>
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<tbody>
<tr>
<td>AS.271.505 Senior Capstone Experience</td>
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<td>AS.271.403 Environmental Policymaking and Policy Analysis</td>
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<td>AS.271.401 Environmental Ethics</td>
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**Focus area course** | 3 | Focus area course | 3 |

**Total Credits:** 7

**Senior**

**Fall** | Credits | Spring | Credits |
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<td>AS.230.205 Introduction to Social Statistics</td>
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<td>AS.110.106 Calculus I (Biology and Social Sciences)</td>
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</table>

**Focus area course** | 3 | Focus area course | 3 |

**Total Credits:** 64

**Honors in the ENVS Majors**
To qualify for honors in an ENVS major, a student must:

- Earn a cumulative GPA of 3.5 in the courses taken to fulfill the major requirements, as determined at the end of the second-to-last semester of the student's enrollment.
- Successfully complete 3 or more credits of independent research or senior thesis involving an environmental or sustainability-related project.
- Earn a rating of good or excellent on the final product of the research project, as determined by the faculty research adviser.
- Present the results of the research orally in an appropriate JHU department.

**Environmental Studies Minor**
The Environmental Studies minor is designed to allow students majoring in other disciplines to develop additional expertise in environmental issues and sustainability. It consists of 18 credits of environmental or sustainability-related courses, including two introductory core courses.
At least 6 credits must be at the 300-level or above. Students are encouraged to select electives from relevant courses in both the social and natural sciences but can tailor their coursework to fit their particular interests and career goals. Appropriate elective courses are those focused directly on environmental or sustainability issues. The ENVS Director of Undergraduate Studies (DUS) distributes a list of approved courses for the minor prior to the registration period for each semester, and approval for other courses can be sought by emailing the DUS. All courses must be taken for a letter grade, and students must earn a grade of C- or better to apply the course to the minor.

AS.270.103 Introduction to Global Environmental Change 3
AS.271.107 Introduction to Sustainability 3
Take 12 credits of approved elective courses, at least 6 credits of which are at the 300-level or above.

Appropriate elective courses focus directly on environmental or sustainability issues. Contact the ENVS DUS for a list of approved courses.

Total Credits 18

B.A./M.S. Option for Johns Hopkins ENVS Majors

Undergraduates majoring in Environmental Science or Environmental Studies (ENVS) may apply for accelerated status toward an M.S. in Environmental Science and Policy (ESP) through the JHU Krieger School of Arts & Sciences’ Advanced Academic Programs. Students should refer to the Graduate tab for more information.

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Graduate Programs

Requirements for Admission

Applicants must submit transcripts, Graduate Record Examination scores (aptitude exam only), and supporting letters to show their ability to do advanced study. The applicant should have his/her GRE scores, verbal and quantitative aptitude, sent to the department before the January 1 deadline for filing applications for admission.

The department expects applicants for advanced degrees to have completed undergraduate training in the basic sciences and mathematics. Normally this includes mathematics through at least integral calculus and a year’s course each in physics, chemistry, and biology. Further undergraduate study in one or more of these subjects or in mathematics is highly desirable for all programs in the Earth sciences; additional mathematics is essential for geophysics, atmospheric sciences, and dynamical oceanography. Extensive undergraduate work in Earth sciences is not a requirement for admission. If students lack formal training in this area or have deficiencies in the other related sciences, they may be admitted but will have to allow additional time in the graduate program to make up for deficiencies in their preparation.

JUMP to Requirements for the B.A./M.S. Option for Johns Hopkins Undergraduate ENVS Majors. (p. 8)

Requirements for Advanced Degrees

Candidates for the Ph.D. must take courses and meet requirements specified by their advisory committee; must pass a comprehensive examination before a departmental committee and an oral examination administered by the Graduate Board of the university; and must submit an acceptable dissertation involving significant original research. A minimum of two consecutive terms registered as a full-time student is required.

The department rarely accepts candidates for the M.A. degree alone, but Ph.D. students can, with the consent of their advisors, complete a program that will qualify them for the M.A. degree at the end of the second year. Candidates for this degree must pass a comprehensive examination before a departmental committee, and must satisfy the residency requirement specified above for the Ph.D. degree. A student’s advisor may require an essay demonstrating research capability.

For further information about graduate study in the Earth and planetary sciences contact the Chair, Department of Earth and Planetary Sciences.

Fields of Graduate Study and Research

The department offers a range of fields of study covering Earth, Space and Environmental Sciences. In recent years we have invested in hiring new faculty in Planetary Sciences, Geosciences and Environmental Science, with seven new assistant professors and two new full professors. What links all of our fields of research together is a focus on treating individual processes—ranging from the formation of rocks to the distribution of organisms—as part of a system, with implications for and feedbacks from other parts of the system. The description below provides a rough grouping of the research areas involved and the faculty associated with each one. Interested applicants are urged to consult individual group web sites for more detail as well as to view presentations made as part of the department’s 50th Anniversary celebration (http://eps.jhu.edu/events/50th-anniversary-symposium/). Prospective students should contact individual faculty members with whom they are interested in working. Students with interests that cross disciplinary boundaries or who use techniques found in different groups are strongly encouraged to apply as we believe that the most exciting questions to pursue in science today involve interdisciplinary research.

Planetary Sciences

In the last four years the department has hired four new faculty members in the Planetary Sciences who study bodies ranging from Mercury to Pluto to exoplanets. Key questions include: What role do planetary atmospheres play in the habitability of planets and the origin and/or evolution of life? (Hörst) What can we learn from the sedimentary record on Mars about what processes have shaped the evolution of that planet? (Lewis) How do planetary dynamos work? (Stanley) How can we use the wealth of spectra coming to us from new sensors to learn about planetary atmospheres? (Sing) A common thread across all of this work is the question of habitability—what sort of things need to happen in order for a planet to be able to support life, and for us to detect it? These questions are addressed using a combination of observation (ground-based telescopes and robotic spacecraft), laboratory experimentation, theoretical modeling, and Earth-analog field studies. The program requires an interdisciplinary focus, drawing from a wide variety of fields including astronomy, geosciences, physics and chemistry. Research often includes data from active planetary exploration missions. EPS faculty include members of the Cassini mission to the Saturn system, New Horizons mission to the Pluto system, and Mars Science Laboratory Rover teams, along with a number of proposed future missions to Venus, and Titan, and other worlds.

Students are encouraged to take courses in astrophysics, chemistry, physics, applied mathematics, computer science, and engineering to gain the comprehensive background necessary for interdisciplinary research. The best undergraduate preparation is a broad background in physics, applied mathematics, chemistry, or earth science. Advanced undergraduate courses in these fields (including differential equations, linear algebra, classical mechanics, electricity and magnetism, thermodynamics, organic, and physical chemistry) are strongly
recommended. The EPS Planetary Science research program has close ties with the Space Department of the JHU Applied Physics Laboratory (APL), and students may be co-advised by APL researchers. Students in the department additionally benefit from the local availability of outside institutions including the Space Telescope Science Institute (co-located on the JHU campus), NASA Goddard Space Flight Center, the Carnegie Institution for Science, and the Smithsonian Institution.

Deep Earth Geosciences
This area focuses on understanding chemical and physical processes deep within the Earth and other planetary bodies. Key questions include: How do materials behave at very high temperatures and pressures, and what are the implications of this behavior for the whole planet system? (Wicks, Sverjensky) By what processes and at what rates do petrologic and tectonic systems evolve, and what are the feedbacks with the biosphere? (Viete). How is the Earth’s geodynamo changing with time - and why? (Stanley) The interdisciplinary techniques used to study these questions include X-ray scattering and laser studies of planet-building minerals at extreme conditions (Wicks), geological field work and observation, and spatially-resolved geochemical and geochronological analysis of crystalline rocks (Viete) and theoretical and laboratory studies of mineral-fluid interactions (Sverjensky).

Aqueous geochemical studies centered in the Sverjensky group focus on the role of water in the evolution of Earth through deep time, particularly the linkages between water in the deep Earth and the near-surface environment. It involves quantitative geochemical modeling of the chemistry of water-rock interactions from Earth’s surface into the upper mantle. Students participate in research involving the interpretation of experimental studies of water-rock interactions in terms of fundamental properties of aqueous inorganic and organic species over extreme ranges of pressure and temperature. Developing a thermodynamic characterization of the behavior of fluids at elevated pressures and temperatures enables exciting research into topics such as the origins of diamonds, the development and evolution of the continents and the potential roles of abiogenic hydrocarbons in Earth’s deep carbon cycle. Collaborations with experimental laboratories enable a wide range of training in combined theoretical and experimental studies of the role of fluids in the history of Earth and other planets.

Students applying in this area will come from a wide variety of backgrounds, including class and research experience in chemistry, mechanical engineering, material science and condensed matter physics. Recommended classes, depending on the research track, include crystallography, mineralogy, petrology, and field geology, thermodynamics, quantum mechanics, continuum mechanics, and mineral physics.

Research within the fields of petrology and tectonics centered in the Viete group focus on questions of length scales, time scales and drivers. It seeks to understand the tectonic processes that operate at plate margins, the nature and utility of the rock record, and interactions between the solid Earth and biosphere. Current foci include crustal heating and the tectonic significance of metamorphic rocks, scales of tectonic organization and episodicity, and petrologic records of seismicity. Student projects begin in the field, first involving mapping, measurement, observation and sampling. With field context established, geological questions are further interrogated through micro-scale structural, geochemical and geochronological analysis of sampled materials. Simple analytical and numerical modeling of processes of deformation and heat and material transfer are used to reproduce observed features and constrain processes recorded in landscapes and rocks.

Students applying in this area should enjoy field work and the outdoors and will preferably have some background and interest in chemistry, physics and/or mathematics. Recommended classes, depending on research track, may include field geology, petrology and petrography, structural geology, sedimentology, transport phenomena, thermodynamics, and rock mechanics.

Geoscience in the Surface Environment
This area focuses on what the geological record can tell us about the evolution of life on Earth and its interaction with climate. A particular focus of this group is the use of isotope geochemistry to examine the carbon, nitrogen, oxygen and sulfur cycles, and to link changes in the rock record to the actual organisms present at the time. Key questions include: What was the physical and chemical context in which the earliest complex life formed? (Smith) How do environmental conditions and/or biological communities influence geochemical signatures found in the rock record? (Gomes)

Students working in this area will learn a range of skills - including the field geology methods necessary to put samples in context, how to make isotopic measurements necessary to characterize the large-scale chemical environment, and how to use this information in conjunction with quantitative and modeling tools to investigate the coevolution of life and the Earth surface. Additionally, the Smith group has expertise in the paleontology of Ediacaran organisms and the Gomes group uses the tools of microbial ecology. Using multi-disciplinary tools, researchers in this area seek to use insight about the coevolution of life and the Earth surface to provide context to understand modern climate change and investigate the tools that can be used to search for life on other planets.

Oceans, Atmospheres and Climate
The Oceans, Atmospheres and Climate area focuses on understanding planetary-scale and regional dynamics with implications for planetary climates, including anthropogenic climate change. The philosophy underlying the department's program is a rigorous and thorough process-based understanding of the climate system, with a grounding in fluid dynamics, energy exchange, and relevant chemical and biological interactions. Researchers in the department address these processes with theory, laboratory and numerical experiments, and study both remotely sensed and in situ field observations. Johns Hopkins is a member of the University Corporation for Atmospheric Research.

The best preparation for graduate study in this program is an undergraduate degree in physics, applied mathematics, mechanical engineering, or another parent science such as chemistry, oceanography, meteorology, or geology/geophysics. Prior course work in fluid dynamics, while highly desirable, is not mandatory to pursue graduate study in this area. It is strongly recommended to have a broad background in the parent sciences, specialization in one of them, and at least three years of undergraduate mathematics. Research experience is also desirable.

Research in physical oceanography (involving Profs. Haine, Gnanadesikan and Waugh) focuses on the processes that maintain the global ocean circulation and the ocean's role in climate and global biogeochemical cycling. In particular, attention is on the role of waves, eddies, and small-scale mixing in controlling the ocean's part in Earth's heat and freshwater balances. We also study advection, stirring, and mixing processes in the interior ocean and their roles in dispersing atmospheric trace gases and nutrients. The research program also
includes computational oceanography, with links to other Hopkins departments and centers.

Research in atmospheric dynamics, (involving Prof. Waugh) focuses on large-scale dynamics, the transport of trace constituents, and understanding the composition of the global atmosphere (e.g., distributions of stratospheric ozone and tropospheric water vapor). Current interests include stratospheric vortex dynamics, troposphere-stratosphere couplings, transport and mixing processes, and global modeling of chemical constituents.

Research in hydroclimate, including atmospheric processes that drive precipitation and terrestrial hydrology, is a focus of Prof. Zaichik’s group. This research employs satellite image analysis, numerical modeling, and field observation to build a process-based understanding of the ways in which climate shapes landscape and vice versa. Current interests include drivers of rainfall variability in the tropics, coupled natural-human systems, seasonal forecast, and the application of hydroclimate analysis to studies of water resources, agriculture, and human health.

Research on climate and radiation is found across all of the research groups in this area and includes study of the global climate system and its response to radiative forcing due to changes in greenhouse gases and solar luminosity, the feedback effects of water vapor and clouds, and the radiative and hydrological effects of aerosols. These studies involve global and regional scale modeling, and the analysis and interpretation of satellite observations.

Additionally Prof. Gnanadesikan’s group conducts research in global biogeochemical cycling, focusing on applying and developing large-scale computational models that can be combined with observations remotely sensed data to characterize cycling of key elements (including carbon, nitrogen, and oxygen) in the earth system. Opportunities exist to link this work to the observational and theoretical geochemistry work done in the department as well as to simulate key periods and transitions in Earth History.

Ecology: Organisms, Ecosystems and Environmental Change

This area of research involves understanding how organisms interact with each other and with the physical world, and how humans affect ecological processes and ecosystems. Questions include: How does past and present land use change affect species distribution, community assembly and biogeochemical cycles? (Avolio, Szlavecz) How does biodiversity, especially invasive species, affect the rates of soil biogeochemical cycling the production of greenhouse gasses (Szlavecz)? How do urban environments shape the ecology and evolution of plants and soil organisms within these systems (Avolio, Szlavecz)? What are the linkages between plant community composition and ecosystem function and/or services in grasslands and cities (Avolio)? How resistant or resilient are grasslands to global change drivers and what is their capacity to adapt to new environmental conditions (Avolio)? Students are invited to participate in ongoing collaborations at two Long Term Ecological Research Sites (Baltimore Ecosystem Study and Konza Prairie Biological Station), the Smithsonian Environmental Research Center, the Beltsville Agricultural Research Center, or to design an original research project under the advisement of our faculty.

All Ph.D. students are expected to have a background of general biology, physics, chemistry and calculus. Deficiencies can be made up in the first semesters at Hopkins. Students take a core program of statistics, Earth history, stable isotope geochemistry, and ecology. In conjunction with the Department of Environmental Health and Engineering, Earth and Planetary Sciences offers course work opportunities in aquatic chemistry, microbial ecology, geospatial analysis, and analytical environmental chemistry.

Financial Aid

The university makes available to the department a number of Gilman Fellowships, which provide for complete payment of tuition, together with Johns Hopkins’ fellowships and graduate assistantships that carry a nine-month stipend. Graduate assistantships cannot require more than 10 hours a week of service to the department, and all recipients of financial aid carry a full program of study. In addition, a number of special and endowed fellowships pay as much or more. In many areas of study, summer support is also available.

Applications for admission to graduate study and financial aid (including all supporting documents and GRE scores) should be submitted to the department before January 1.

B.A./M.S. Option for Johns Hopkins ENVS Majors

Undergraduates majoring in Environmental Science or Environmental Studies (ENVS) may apply for accelerated status toward an M.S. in Environmental Science and Policy (ESP) through the JHU Krieger School of Arts & Sciences’ Advanced Academic Programs. These students should declare their intention to pursue the M.S. during their junior year or early in their senior year to their adviser and to the Director of the ESP Program, Jerry Burgess (jerry.burgess@jhu.edu). ENVS students may apply up to three courses taken as undergraduates toward the M.S. in Environmental Science and Policy thereby leaving only seven more courses to complete the M.S. following receipt of their bachelor’s degree.

Application

ENVS students may apply for the B.A./M.S. anytime during the senior year or after conferral of their undergraduate degree. The application procedure is the same as that of other AAP applicants and details are found online at: http://advanced.jhu.edu/. Students admitted to the B.A./M.S. program will be assigned a graduate adviser but will also continue to be advised by their ENVS adviser for all matters concerning the bachelor’s degree.

Course Requirements For B.A./M.S.

ENVS students will receive two separate degrees, so the requirements of both degrees must be fulfilled. Students cannot earn the M.S. degree without completion of the B.A. or B.S., however, students who do not complete the M.S. retain their B.A. or B.S. ENVS students pursuing the M.S. may opt for either the general ESP degree or a concentration. Up to three courses completed while an undergraduate can count toward the ten courses required for the M.S. Two of the following courses can be used to satisfy the corresponding core course requirements for the M.S. in Environmental Science and Policy.

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<td>Oceans &amp; Atmospheres</td>
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<td>AS.270.308</td>
<td>Population/Community Ecology</td>
<td>3</td>
</tr>
<tr>
<td>AS.271.403</td>
<td>Environmental Policymaking and Policy Analysis</td>
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</table>

(Note that the Environmental Policymaking and Policy Analysis course is a combined ENVS undergraduate and ESP masters class.)

If a student wishes to apply a third course to both their ENVS B.A. or B.S. and their ESP M.S., the course must be approved by the graduate adviser and must be at the 300- to 600- level with content germane to environmental science and policy.
Faculty

Chair
Anand Gnanadesikan
biogeochemical oceanography, geophysical fluid dynamics.

Professors

Thomas Haine
physical oceanography.

Sabine Stanley
planetary magnetism, planetary interiors, geophysics.

Darrell F. Strobel
planetary atmospheres and astrophysics.

Dimitri Sverjensky
molecular surface geochemistry and environmental geochemistry.

Darryn W. Waugh
atmospheric dynamics.

Associate Professor

Benjamin Zaitchik
climate dynamics, surface hydrology.

Assistant Professors

Meghan Avolio
plant and urban ecology.

Maya Gomes
stable isotope geochemistry, geobiology.

Sarah Horst
atmospheric chemistry, planetary atmospheres.

Kevin Lewis
planetary geology and geophysics.

Emmy Smith
sedimentary geology, biostratigraphy and Earth history.

Daniel Viete
metamorphic petrology, structural geology and tectonics.

June Wicks
mineral physics, planetary interiors.

Professors Emeriti

John M. Ferry
metamorphic geology.

George W. Fisher
global earth systems and religious ethics.

Bruce D. Marsh
igneous petrology and geophysics.

Peter I. Olson
geophysical fluid dynamics.

David R. Veblen
crystallography.

Research/Teaching Faculty

Jerry Burgess
Lecturer: environmental science and studies.

Xin Chen
Lecturer: civil engineering.

Rebecca Kelly
Associate Teaching Professor: environmental science and studies.

Jomar Malodano
Lecturer: environmental science and studies.

Alexios Monopolis
Senior Lecturer: environmental science and studies.

Richard Stolarski
Research Professor: atmospheric chemistry.

Katalin Szlavecz
Research Professor: soil ecology.

Joint Appointments

Andrew W. Beck
Adjunct Assistant Professor, Earth and Planetary Sciences; Senior Staff Scientist, Applied Physics Lab

Gabriel Bever
Assistant Professor, Functional Anatomy and Evolution, School of Medicine

Siobhan Cooke
Assistant Professor, Functional Anatomy and Evolution, School of Medicine

Jocelyne DiRuggiero
Associate Research Professor, Biology.

Ciaran Harman
Assistant Professor, Environmental Health and Engineering.

Michael Harrower
Assistant Professor, Near Eastern Studies.

Kevin J. Hemker
Professor, Mechanical Engineering.

Takeru Igusa
Professor, Civil Engineering.

Scot Miller
Assistant Professor, Environmental Health and Engineering

K.T. Ramesh
Professor, Mechanical Engineering.

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

AS.270.102. Freshman Seminar: Conversations with the Earth. 3.0 Credits.
A discussion of topics on Earth's origin, evolution, and habitability. Students will be introduced to the role that scientific thinking and process play in research and our understanding of Earth systems. We will cover a broad foundation of knowledge of Earth sciences, including solid earth, atmospheric, and oceanic systems, as well as topics concerning the origin of life, evolution, ecosystems, and mass extinctions. And we will discuss the relation of these systems to societal concerns such as climate change, energy resources, mineral and ore needs in industry, and nuclear waste storage and risk assessment. We are returning to the original seminar format for this class, with a limit of 15 students. We are looking for students who are willing to engage in frequent class discussion with instructors and classmates to ensure they acquire a broad understanding of the subject matter. This will be a 3 credit course with homework to be completed each week and a term paper submitted at the end of the semester.
Instructor(s): A. Charrier De Assis
Area: Natural Sciences.

AS.270.103. Introduction to Global Environmental Change. 3.0 Credits.
A broad survey of the Earth as a planet, with emphasis on the processes that control global changes. Topics include: the structure, formation, and evolution of the Earth, the atmosphere, oceans, continents, and biosphere. Special attention is given to present-day issues, such as global climate change, natural hazards, air pollution, resource depletion, human population growth, habitat destruction, and loss of biodiversity. Open to all undergraduates.
Instructor(s): D. Waugh; K. Szlavecz
Area: Natural Sciences.

AS.270.110. Freshman Seminar: Sustainable + Non-Sustainable Resources. 1.0 Credit.
An introduction to the important resources involved in the origin and production of oil, natural gas, coal, cement, metals and geothermal fluids.
Instructor(s): D. Sverjensky
Area: Natural Sciences.

AS.270.111. Freshman Seminar: The Story of Earth. 1.0 Credit.
The four and a half billion year story of Earth's global changes focusing on the co-evolution of Earth and Life.
Instructor(s): D. Sverjensky
Area: Natural Sciences.

AS.270.112. The Changing Arctic Environment: Problem or Opportunity?. 3.0 Credits.
The Arctic is warming three times faster than the global-mean rate. In this course we will be studying this phenomenon and its consequences by looking at the interconnected parts of the Arctic climate system (ocean, atmosphere, and ice), how they are changing, and which socio-economic opportunities and environmental challenges arise from these changes.
Instructor(s): R. Gelderloos
Area: Natural Sciences.

AS.270.113. Freshman Seminar: Environmental Poisons. 1.0 Credit.
An exploration of the occurrence and potential effects of poisons in the environment, from naturally occurring ones such as arsenic to those that may be introduced by mankind such as nuclear waste.
Instructor(s): D. Sverjensky
Area: Natural Sciences.

AS.270.114. Guided Tour: The Planets. 3.0 Credits.
An introduction to planetary science and planetary exploration primarily for non-science majors. A survey of concepts from astronomy, chemistry, geology, and physics applied to the study of the solar system.
Instructor(s): S. Stanley
Area: Natural Sciences.

AS.270.116. Freshman Seminar: An Introduction to Climate Change. 3.0 Credits.
This course introduces the main physical components of the Earth's climate systems and their documented and forecasted changes. The first part of the course presents evidences of climate change in Earth's history, and introduces the main natural and anthropogenic drivers of climate change. The second part of the course focuses on future climates, and includes modules about climate modeling, building of emission scenarios, geoengineering, emission reductions and adaptability. The course is highly interdisciplinary, exploring the relationships among climate science, policy, ecology, economy and ethics. Freshmen Only. No prerequisites required.
Instructor(s): V. Aquila
Area: Natural Sciences.

AS.270.119. Climate Science and Policy. 3.0 Credits.
This course is designed to introduce non-science students to the ways in which humans and the Earth interact. These interactions go in both directions, with Earth processes and materials affecting human society, and human activities altering the Earth. Topics include natural disasters, natural resources, and environmental issues rooted in geology; and they are examined from both a historical perspective and in the context of current events. Class time involves active learning and hands-on experiences. Course open to freshmen, sophomores, and juniors. Seniors by instructor permission only.
Instructor(s): R. Kelly
Area: Natural Sciences.

AS.270.205. Introduction to Geographic Information Systems and Geospatial Analysis. 3.0 Credits.
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.

AS.270.220. The Dynamic Earth: An Introduction to Geology. 3.0 Credits.
Basic concepts in geology, including plate tectonics; Earth's internal structure; geologic time; minerals; formation of igneous, sedimentary, and metamorphic rocks; development of faults, folds and earthquakes; geomagnetism. Corequisite (for EPS Majors): AS.270.221; optional for others. The course is introductory and open to undergraduates at all levels; freshmen are encouraged to enroll.
Prerequisites: AS.030.101 OR (AS.171.101 AND AS.171.102) or equivalent.
Instructor(s): D. Viete; E. Smith
Area: Natural Sciences.
AS.270.221. The Dynamic Earth Laboratory. 2.0 Credits.
This course is a hands-on learning experience for introductory geological concepts and techniques using geological tools, such as mineral/rock samples, microscopes, and maps. Field trips are its essential part. The course is open to undergraduates at all levels; freshmen who wish to get their hands (and boots) dirty are encouraged to enroll.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.
Corequisites: AS.270.220
Instructor(s): D. Viete; E. Smith
Area: Natural Sciences.

AS.270.222. Mineralogy. 4.0 Credits.
An introduction to the properties, occurrence, and origin of the basic constituents of the Earth, including minerals and rocks. Introductory training in the recognition of minerals and rocks in the laboratory and the field.
Prerequisites: Students must have completed Lab Safety training prior to registering for this class.
Instructor(s): J. Wicks
Area: Natural Sciences.

AS.270.224. Oceans & Atmospheres. 3.0 Credits.
A broad survey of the Earth's oceans and atmospheres, and their role in the environment and climate. Topics covered include waves, tides, ocean and atmosphere circulation, weather systems, tornades and hurricanes, El Niño, and climate change. For science and engineering majors
Instructor(s): A. Gnanadesikan; T. Haine
Area: Natural Sciences.

AS.270.302. Aqueous Geochemistry. 3.0 Credits.
Modeling the chemistry of water-rock interactions from weathering and riverine development at Earth’s surface to hot springs at depth, fluids in subduction zones in Earth’s interior, and the ancient fluids preserved in fluid inclusions. Thermodynamic basis for the calculation of equilibria and irreversible chemical mass transfer involving minerals and aqueous species at low and high temperatures and pressures. The course culminates with practical examples of research interest to individual participants.
Prerequisites: (AS.030.101 AND AS.030.102) AND (AS.270.220 AND AS.270.221) or equivalents.
Instructor(s): D. Sverjensky
Area: Natural Sciences.

AS.270.303. Earth History. 3.0 Credits.
This course will explore the evolution of life in the context of environmental, ecological, and geological changes to the Earth surface system. The goal of the class is to provide students with an understanding of how geological and paleontological records provide insight into the origin(s) of life, oxygenation of the atmosphere, the evolution of multicellularity, evolutionary radiations and extinctions, and modern global change.
Prerequisites: AS.270.103 OR AS.270.220 OR AS.270.224; or permission of the instructor.
Instructor(s): M. Gomes
Area: Natural Sciences.

AS.270.304. Igneous Geology and Volcanology. 3.0 Credits.
This course provides an introduction to igneous and volcanic processes on Earth and other planetary bodies. Focus is placed on linking observations made on rocks in hand sample and outcrop to Earth/planetary processes. The course will review crystal chemistry of major rock-forming minerals and progress through how igneous rocks form. Volcanism, including eruption processes, landforms and tectonic settings, will be reviewed. Labs will include rock identification, study of thin sections under microscope and field trips. Teaching is geared toward the graduate and advanced undergraduate level. Recommended course background: AS.270.220 and AS.270.221, or instructor permission.
Instructor(s): A. Beck
Area: Natural Sciences.

AS.270.305. Energy Resources in the Modern World. 3.0 Credits.
This in-depth survey will inform students on the non-renewable and renewable energy resources of the world and the future prospects. Topics include petroleum, natural gas, coal, nuclear, hydroelectric, geothermal, solar, wind, biomass, and ocean energy. Global production, distribution, usage, and impacts of these resources will be discussed.
Instructor(s): J. Burgess
Area: Natural Sciences.

AS.270.306. Urban Ecology. 3.0 Credits.
Urban ecology has been called the ecology in, of, and for cities. In this course, we will explore how ecological concepts are applied to urban ecosystems and the different approaches to urban ecological research. Topics will include: Biodiversity, water dynamics, energy and heat island effects, and nutrient cycling, urban metabolism, design of greenspace, and sustainability of cities. We will use Baltimore as a case study for studying cities.
Prerequisites: AS.270.308 OR EN.570.205 OR EN.570.403
Instructor(s): M. Avolio
Area: Natural Sciences.

AS.270.307. Geoscience Modeling. 4.0 Credits.
An introduction to modern ways to interpret observations in the context of a conceptual model. Topics include model building, hypothesis testing, and inverse methods. Practical examples from geophysics, engineering, and medical physics will be featured.
Instructor(s): T. Haine
Area: Natural Sciences.

AS.270.308. Population/Community Ecology. 3.0 Credits.
This course explores the distribution and abundance of organisms and their interactions. Topics include dynamics and regulation of populations, population interactions (competition, predation, mutualism, parasitism, herbivory), biodiversity, organization of equilibrium and non-equilibrium communities, energy flow, and nutrient cycles in ecosystems. Field trip included. Permission of instructor.
Instructor(s): K. Szlavecz
Area: Natural Sciences.

AS.270.310. Evolution and Development of the Vertebrates. 3.0 Credits.
Modern vertebrates (animals with backbones) are the products of a more than 500-million-year evolutionary history. This course surveys that history and uses it to explore such core evolutionary concepts as adaptive radiation, convergence, extinction, homology, phylogenetic taxonomy, and tree thinking. Emphasis will be placed on the origins of the modern vertebrate fauna and how fossils are being integrated with developmental biology to better understand major transitions in the vertebrate body plan.
Instructor(s): G. Bever
Area: Natural Sciences.
AS.270.311. Geobiology. 3.0 Credits.
A survey of the interactions between geological and biological processes at and near the Earth's surface, covering topics such as biogeochemistry and nutrient cycles, soil chemistry, biomarkers, archives of paleobiology, and the evolution of life, with an emphasis on terrestrial systems. Recommended Course Background: AS.270.220
Instructor(s): N. Levin
Area: Natural Sciences.

AS.270.312. Mammalian Evolution. 3.0 Credits.
An introduction to the evolutionary history and diversity of mammals, with emphasis on the first half of the Cenozoic - the beginning of the Age of Mammals. The course will focus primarily on the adaptive radiation of mammals (including our own order primates) that followed the extinction of the dinosaurs, exploring the origins and relationships of the major groups of mammals as well as the anatomical and ecological reasons for their success. Lectures will be supplemented with relevant fossils and recent specimens.
Instructor(s): S. Cooke
Area: Natural Sciences.

AS.270.313. Isotope Geochemistry. 3.0 Credits.
Instructor(s): B. Passey
Area: Natural Sciences.

AS.270.315. Natural Catastrophes. 3.0 Credits.
A survey of naturally occurring catastrophic phenomena, with emphasis on the underlying physical processes. Topics include hurricanes, tornadoes, lightning, earthquakes, tsunamis, landslides, and volcanic eruptions and climate change. Intended for students in science and engineering.
Instructor(s): A. Charrier De Assis
Area: Natural Sciences.

AS.270.316. Planets. 3.0 Credits.
This course will serve as an introduction to planetary science at a more advanced level than AS.270.114. Topics covered will include formation of the solar system, planetary interiors, surfaces and atmospheres, solar system exploration, and extrasolar planets. Recommended Course Background: AS.270.220 and AS.270.224.
Instructor(s): S. Horst
Area: Natural Sciences.

AS.270.317. Conservation Biology. 3.0 Credits.
In this course, students examine the meaning and implications of biodiversity with a focus on disciplines associated with conservation biology, wildlife conservation and wildlife management, including taxonomy, genetics, small population biology, chemical and restoration ecology, and marine biology. This includes exploring how conservation biology differs from other natural sciences in theory and in application. Students learn the major threats to biodiversity and what natural and social science methods and alternatives are used to mitigate, stop, or reverse these threats. The course also includes the economic and cultural tradeoffs associated with each conservation measure at the global, national, regional, and local levels. One required field trip.
Instructor(s): J. Burgess
Area: Natural Sciences.

AS.270.318. Remote Sensing of the Environment. 3.0 Credits.
This course is an introduction to the use of remote sensing technology to study Earth's physical and biochemical processes. Topics covered include remote sensing of the atmosphere, land and oceans, as well as remote sensing as a tool for policy makers. Also offered as 270.618
Instructor(s): B. Zaitchik; K. Lewis
Area: Natural Sciences.

AS.270.319. Geochronology and High-Temperature Isotope Geochemistry. 3.0 Credits.
Introduction to radioisotope geo/thermochronology and mantle stable and radioisotope geochemistry. Course covers: (1) methods for dating of rocks and geologic processes using long-half-life radioisotope systems, including the various isotope systems available and their applicability; (2) radioisotope techniques for investigation of the geochemical evolution of the crust and mantle; (3) isotope fractionation and utility of traditional and novel stable isotope geochemistry for interrogating high-temperature processes, and (4) thermochronology and methods for interrogating upper-crustal processes. Recommended course background: AS.270.220 and AS.270.221, or instructor permission.
Instructor(s): D. Viete.

AS.270.320. Seminar in Planetary Science. 1.0 Credit.
Major problems of current interest in planetary science are critically discussed in depth.
Instructor(s): S. Horst
Area: Natural Sciences.

AS.270.323. Ocean Biogeochemical Cycles. 3.0 Credits.
This course will examine the cycling of trace chemicals in the ocean, consider what we can learn from the distributions of these chemicals about the ocean circulation, and ocean ecosystems. Topics covered will include oceanic biological productivity, open water cycling of nutrients and oxygen, ocean acidification and sediment cycling.
Instructor(s): A. Gnanadesikan
Area: Natural Sciences.

AS.270.324. Climate variability with python. 1.0 Credit.
Seasonal-to-decadal climate variability is important for various fields from agriculture to reinsurance, and it is challenging dynamically as the fluctuations often include coupled ocean-atmosphere mechanisms. This summer course covers mechanism for seasonal-to-decadal climate variability, and we will use python to build simple models to understand them. Students will learn the basics of python, numerical integration, and climate modelling. The course is S/U but will require a student report on a chosen mechanism of climate variability.
Instructor(s): A. Nummedalin
Area: Natural Sciences.

AS.270.325. Introductory Oceanography. 3.0 Credits.
This class is an introduction to a wide range of physical, chemical, and biological phenomena in the world’s oceans. Underlying basic principles are exposed wherever possible. Topics covered include: seawater, waves, tides, ocean circulation, chemical oceanography, biogeochemical ocean processes, and remote sensing of the oceans. Recommended Course Background: freshman Physics, Chemistry, Calculus through ordinary differential equations.
Instructor(s): A. Gnanadesikan
Area: Natural Sciences.
AS.270.326. Cosmochemistry. 4.0 Credits.
Students in this course will gain an understanding of the origin of various forms of matter in our Solar System and beyond, along with its evolution through geologic processes. Beginning with the concepts of nucleosynthesis and stellar evolution, this course will then cover the condensation of matter, meteorites, and petrogenetic evolution of differentiated, rocky bodies (i.e. asteroids, the Moon, Mars). Evolution of matter in extra-Solar planetary systems (i.e. exoplanets) will also be broached. In lab we will examine thin sections of meteorites, lunar material, and terrestrial analogs - a field trip to the Smithsonian Meteorite Collection is planned. Graduate and advanced undergraduate-level students are encouraged, as are interdisciplinary students with an interest in planetary science.
Instructor(s): A. Beck; J. Wicks
Area: Natural Sciences, Social and Behavioral Sciences.

AS.270.328. Planetary Exploration: Techniques and Data Analysis. 3.0 Credits.
Have you ever wondered what it would be like if you could visit other planets and travel through the space? Students in this course will use state-of-the-art observational techniques in planetary exploration and actual spacecraft data from the Cassini mission to Saturn and the Mars Rover mission to solve problems in planetary science and design a space exploration mission. Important planetary properties, such as atmospheric composition and interior composition of a planet, will be studied using remote sensing and in situ data. Recent discoveries about exoplanets will be integrated into course activities. Recommended Course Background: One semester of Introductory Chemistry (AS.030.101).
Instructor(s): X. Yu
Area: Natural Sciences, Social and Behavioral Sciences.

AS.270.332. Soil Ecology. 3.0 Credits.
The course introduces basic aspects of cycles and flows in the soil ecosystem, and provides students with an overview of the higher groups of soil organisms. Laboratory and field surveying methods are also covered.
Instructor(s): K. Szlavecz
Area: Natural Sciences.

AS.270.336. Freshwater Systems. 3.0 Credits.
A study of streams, lakes, and groundwater with a focus on aspects of water quality, hydrology, geomorphology, and aquatic ecology that are relevant to human impacts on freshwater systems. US environmental policies and water resource management agencies will also be examined in the context of issues such as dams, cattle grazing, climate change, and water allocation.
Prerequisites: AS.270.103 OR AS.271.107 or permission of the instructor.
Instructor(s): R. Kelly
Area: Natural Sciences.

AS.270.337. Freshwater Systems Lab. 1.0 Credit.
A hands-on investigation of the water quality, hydrology, geomorphology, and aquatic ecology of streams and other freshwater bodies. Includes field trips to water-related facilities such as drinking water and wastewater treatment plants.
Instructor(s): R. Kelly
Area: Natural Sciences.

AS.270.350. Sedimentary Geology. 4.0 Credits.
Sedimentary rocks are the historical records of the Earth, documenting climate change, mass extinctions, and the evolution of life. This course will provide an introduction to sedimentary processes and sedimentary rocks. Focus is placed on linking physical observations to the ancient environments in which sedimentary rocks once formed. Fundamental tools for interpreting the sedimentary rock record, such as depositional models, geochronology, and chemostratigraphy will be reviewed. Two 1-day weekend field trips will occur over the course of the semester. There will also be weekly 1-hour labs. Lab and field trip times will be determined in the first week of class. Graduate and advanced undergraduate level.
Recomended Course Background: AS.270.220 or instructor permission.
Instructor(s): K. Lewis; M. Gomes
Area: Natural Sciences.

AS.270.366. Spacecraft Instrumentation Project. 3.0 Credits.
Co-Listed with EN.530.366 Investigation into the content relevant to an ongoing spacecraft instrumentation project. An interdisciplinary team will enhance the skills and knowledge of science and engineering students. Topics include mission background, planetary science, sensor design, spacecraft systems, and mission planning, and sensor fabrication, calibration, integration, and testing, data analysis and interpretation, scientific/technical writing and publication.
Instructor(s): S. Horst
Area: Engineering, Natural Sciences.

AS.270.369. Geochem Earth/Environment. 3.0 Credits.
An introduction to all aspects of Geochemistry: theoretical, experimental, and observational, including the application of geochemistry to issues such as the migration of toxic metals and nuclear waste.
Prerequisites: AS.270.220
Instructor(s): D. Sverjensky
Area: Natural Sciences.

AS.270.378. Present and Future Climate. 3.0 Credits.
Intended for majors who are interested in the science that underlies the current debate on global warming, the focus is on recent observations one can glean from model simulations. Meets with AS.270.641.
Recommended Course Background: AS.110.108-AS.110.109 and AS.171.101-AS.171.102
Prerequisites: Student may not receive credit for both AS.270.378 and AS.270.641.
Instructor(s): B. Zaitchik; D. Waugh
Area: Natural Sciences.

AS.270.379. Atmospheric Science. 3.0 Credits.
A survey of core topics in atmospheric science, including dynamics, thermodynamics, radiative transfer, and chemistry. The course addresses both basic principles and applications to weather and climate.
Prerequisites: (AS.110.108 AND AS.110.109) AND (AS.171.101 AND AS.171.102)
Instructor(s): B. Zaitchik; D. Waugh
Area: Natural Sciences.
AS.270.380. Seminar in Regional Field Geology. 3.0 Credits.
Introduction to the regional geology and geological history of the Appalachian system (from Alabama to Newfoundland). Key papers on regional bedrock geology and Mesoproterozoic through Phanerozoic tectonics are reviewed in weekly seminar classes. Two three-day field trips are made on weekends negotiated at the beginning of the semester. Fieldwork will be designed with student input to test ideas and models from the literature. Techniques in sedimentary, metamorphic, igneous and structural field geology are introduced and developed in the field. Recommended course background: AS.270.220 and AS.270.221, or instructor permission.
Instructor(s): D. Viete; E. Smith
Area: Natural Sciences, Social and Behavioral Sciences.

AS.270.395. Planetary Physics and Chemistry. 3.0 Credits.
The fundamental principles governing the dynamic processes within and around the planets are treated in some detail. Core equations are developed and used to analyze nebula condensation, planetary accretion, convection in mantles and atmospheres, radiative and conductive heat transport, seismic waves, hurricanes, volcanism, and meteorite impacts, among others. Emphasis is on fundamentals and problem solving.
Prerequisites: AS.030.101; AS.171.101-102 or 103-104 or 105-106.
Instructor(s): D. Strobel
Area: Natural Sciences.

AS.270.396. Special Topics in Planetary Exploration. 3.0 Credits.
A selection of planetary research topics investigated by Prof. Strobel spanning the past 45 years covering the progress that has been made and remaining problems that still need to be addressed. The majority of topics will involve the outer solar system and the science discoveries made by the Voyager, Cassini-Huygens, and New Horizons Missions as well as observations by Earth orbiting satellites – IUE, HUT, HST, FUSE.
Instructor(s): D. Strobel
Area: Natural Sciences.

AS.270.400. The Carbon Cycle: Past, Present and Future. 3.0 Credits.
This course will explore how the carbon cycle shapes environmental conditions and influences other biogeochemical cycles through an investigation of the modern carbon cycle, major carbon cycle perturbations in the geological record, and projections of future global change. The majority of the class will be structured as a reading seminar, but students will also develop an understanding of how to use quantitative models to evaluate patterns of change associated with both modern and ancient carbon cycle perturbations with implications for predicting future environmental changes. Recommended Prerequisites: AS.270.103 or AS.270.220 or AS.270.224
Instructor(s): E. Smith; M. Gomes
Area: Natural Sciences, Quantitative and Mathematical Sciences.

AS.270.401. Metamorphic Geology. 3.0 Credits.
Introduction to metamorphic geology and the concepts on which it is built. Ideas and techniques that underpin metamorphic petrology are introduced in the context of the development and evolution of metamorphic geology as a discipline. Focus is on utility of metamorphic geology in understanding crustal processes and the nature of plate tectonics. One-day, weekend field trips to explore the Baltimore Gneiss Domes. Recommended course background: AS.270.220 and AS.270.221, or instructor permission.
Prerequisites: AS.270.220 AND AS.270.221
Instructor(s): D. Viete
Area: Natural Sciences.

AS.270.404. Planetary Interiors. 3.0 Credits.
This course investigates the physical processes occurring in planetary interiors. Topics include formation and differentiation of planetary bodies, planetary structure, thermal evolution, convection, and dynamo generation of magnetic fields. Standard remote sensing methods used to investigate planetary interiors and results from recent planetary satellite missions will also be discussed. Recommended: Knowledge of vector calculus, PDEs and introductory physics.
Instructor(s): S. Stanley
Area: Natural Sciences.

AS.270.405. Modeling the Hydrological Cycle. 3.0 Credits.
Survey of modeling techniques for hydrological monitoring, analysis and prediction, including applied exercises with commonly used models. Topics include the terrestrial water balance, rivers and floods, groundwater, atmospheric transport, and precipitation processes. Focus is on numerical methods applicable at the large watershed to global scale.
Instructor(s): A. Dezfuli; B. Zaitchik.

AS.270.410. Planetary Surface Processes. 3.0 Credits.
This course explores processes that influence the evolution of planetary surfaces, including impact cratering, tectonics, volcanism, weathering, and sediment transport. These processes manifest themselves as structural deformation of planetary crusts due to loading by volcanoes, formation of crater by asteroid impacts, modification of surfaces by flowing landslides, rivers and glaciers, and the accumulation and transport of sand in dune fields on various planets. Emphasis is on the relationship to similar Earth processes, and the integrated geologic histories of the terrestrial planets, satellites, and asteroids. The focus will be on developing a physical understanding of these processes to interpret the surface characteristics and evolution of planets, satellites, asteroids, and comets from both qualitative assessments and quantitative measurements obtained from spacecraft data. A key component of the class will be the interpretation of these observations from recent and current planetary missions to the Moon, Mars, and other terrestrial bodies. Recommended Course Background: A sound knowledge of Calculus and Introductory Physics, and some prior knowledge of Earth and/or Planetary Science.
Instructor(s): K. Lewis
Area: Natural Sciences.

AS.270.423. Planetary Atmospheres. 3.0 Credits.
Instructor(s): S. Horst
Area: Natural Sciences.
AS.270.425. Earth and Planetary Fluids. 3.0 Credits.
An introductory course on the properties, flow, and transport characteristics of fluids throughout the Earth and planets. Topics covered include: constitutive relationships, fluid rheology, hydrostatics, dimensional analysis, low Reynolds number flow, porous media, waves, stratified and rotating fluids, plus heat, mass, and tracer transport. Illustrative examples and problems are drawn from the atmosphere, ocean, crust, mantle, and core of the Earth and other Planets. Open to graduate and advanced undergraduate students. Recommended Course Background: Basic Physics, Calculus, and familiarity with ordinary differential equations.
Instructor(s): S. Stanley
Area: Natural Sciences.

AS.270.431. Tectonics Seminar. 3.0 Credits.
Introduction to plate tectonics and its "framework" role in understanding the Earth. Kay papers will be discussed in a weekly seminar class. Focus will be on early works that helped establish the theory, in addition to recent breakthrough contributions that have led to modifications and improvements to the theory of plate tectonics.
Instructor(s): D. Vite.

AS.270.495. Senior Thesis. 3.0 Credits.
Preparation of a substantial thesis based upon independent student research, supervised by at least one faculty member in Earth and Planetary Sciences. Open to Sr. departmental majors only. Required for department honors.
Instructor(s): A. Gnanadesikan; T. Haine
Area: Natural Sciences
Writing Intensive.

AS.270.496. Senior Thesis. 4.0 Credits.
Preparation of a substantial thesis based upon independent student research, supervised by at least one faculty member in Earth and Planetary Sciences. Open to Sr. departmental majors only. Required for department honors.
Instructor(s): A. Gnanadesikan; B. Passey; T. Haine
Area: Natural Sciences
Writing Intensive.

AS.270.501. Independent Study. 3.0 Credits.
An independent course of study may be pursued under the direction of an adviser on those topics not specifically listed in the form of regular courses.
Instructor(s): B. Marsh; B. Zaitchik; C. Parker; K. Szelavecz.

AS.270.503. Independent Research. 3.0 Credits.
Instructor(s): G. Ball; K. Lewis.

AS.270.504. Independent Research. 0.0 - 3.0 Credits.
Research under the direction of members of the Earth & Planetary Sciences Faculty.
Instructor(s): E. Smith; M. Gomes; S. Horst.

AS.270.595. Internship. 1.0 Credit.
Instructor(s): C. Parker; D. Sverjensky; D. Veblen; D. Waugh.

AS.270.599. Independent Study. 3.0 Credits.
Instructor(s): Staff.

AS.270.603. Geochemistry Seminar.
A variety of topics of current interest involving mineral-fluid interactions will be reviewed.
Instructor(s): D. Sverjensky.

AS.270.605. EPS Colloquium.
A weekly seminar series in which graduate students present their latest research results and attend Departmental seminars. This course is required for all graduate students in the Department of Earth and Planetary Sciences.
Instructor(s): S. Stanley.

AS.270.606. EPS Colloquium.
A weekly seminar series in which graduate students present their latest research results and attend Departmental seminars. This course is required for all graduate students in the Department of Earth and Planetary Sciences.
Instructor(s): T. Wright.

AS.270.611. Global Atmospheric Dynamics.
This course will examine the fluid dynamics that determine large-scale atmospheric circulation and variability using Ian James' "Introduction to Circulating Atmospheres." Topics covered will include the dynamics of Hadley cells, mid-latitude jets, baroclinic instability, monsoon circulations, and low-frequency variability of the circulation.
Instructor(s): A. Gnanadesikan.

Transitioning from graduate school to a postdoc to a "permanent" job in the natural sciences requires a set of essential skills that are not covered as a formal component of most Ph.D. programs. This seminar will be a weekly discussion of career issues relevant to new scientists. Topics will include elements of good presentations, conferences, scientific writing and peer-review, employment trends, job interviews, and grant proposals. The class will conclude with a mock grant proposal review panel, conducted by the students. This seminar is aimed at graduate and advanced undergraduate students in the natural sciences planning careers in academia or industry.
Instructor(s): J. Roberts.

AS.270.615. Inversion Modeling & Data Assimilation.
This graduate class will introduce modern inverse modeling and data assimilation techniques. These powerful methods are used in atmospheric science, oceanography, and geophysics and are growing more widespread. Topics will include: singular value decomposition, Green's function inversions, Kalman filtering, and variational data assimilation. The class will include lectures on concepts and theory, and practical experience in the computer laboratory. Permission of Instructor Required
Instructor(s): T. Haine.

Also offered as 270.318
Instructor(s): B. Zaitchik; K. Lewis
Area: Natural Sciences.

AS.270.619. Regional Climate Analysis.
This seminar style course will address advanced topics in regional climate, including dynamic mesoscale models, climate change downscaling, seasonal forecasts, and statistical methods. Students will review relevant literature and collaborate to address modeling and analysis challenges.
Instructor(s): B. Zaitchik
Area: Natural Sciences.
AS.270.620. Seminar in Geophysical Turbulence and Transport.
Turbulence plays an important role in setting the structure of both atmospheres and oceans by transporting heat and momentum. It also plays a key role in mobilizing chemical species such as nutrients and aerosols that play key roles in the Earth System. This seminar will cover how we measure and model turbulence and its effects. For the Fall of 2015 the course will center around Planetary Boundary Layers, including topics such as scaling theories, large eddies in boundary layers and their simulation, and interactions with small-scale topographic features. Instructor(s): A. Gnanadesikan.

Discussion of the physical principles that underlie earth remote sensing. Topics to include radiative transfer in Earth's atmosphere, operating principles of active and passive remote sensing systems, and advanced methods for image analysis. Instructor(s): K. Szlavecz.

AS.270.626. Ocean General Circulation.
The aim of this course is to achieve conceptual understanding of the large scale low frequency ocean general circulation. The role of the ocean circulation in earth's climate is emphasized throughout. Instructor(s): T. Haine.

Discussion of current research topics in soil ecology and biogeochemistry. Instructor(s): K. Szlavecz.

AS.270.628. Field Seminar.
Weekend field trip to explore regional geology. Students are required to prepare short presentations on field trip stops in advance of weekend trip. Attendance at organizational meetings is required. Open to E & PS graduate students and upper level E & PS undergraduate majors and minors. Two meetings to be scheduled prior to trip. Trip dates are 4/15-4/17/2016. Consult instructors for details. Instructor(s): D. Viete.

AS.270.629. Tracer Transport in Geophysical Flows.
This course examines the transport of substances in geophysical flows. Topics covered include fundamental transport processes, transport in simple flows, and use of chemical tracers to infer transport properties. These concepts will be illustrated by case studies in a variety of geophysical flows, including the flow in atmospheres, oceans, lakes, and groundwater. Instructor(s): D. Waugh.

AS.270.630. Physics and Chemistry of Aerosols.
This course will cover fundamentals of aerosol physics and chemistry. Topics covered will include aerodynamics and diffusion of aerosol particles, condensation and evaporation, particle size distributions, optics of small particles, characterization of particle composition, and the diversity of aerosols found in planetary atmospheres. Recommended Course Background: Basic Physics and Chemistry. Calculus. Instructor(s): S. Horst.

AS.270.631. Tectonics Seminar.
Introduction to plate tectonics and its "framework" role in understanding the Earth. Kay papers will be discussed in a weekly seminar class. Focus will be on early works that helped establish the theory, in addition to recent breakthrough contributions that have led to modifications and improvements to the theory of plate tectonics. Instructor(s): D. Viete.

AS.270.633. Advanced Topics in Isotopic Geochemistry.
Consent of instructor required In depth exploration of selected systems in stable isotope geochemistry, and examination of the physical basis of stable isotope fractionation. Topics vary annually. Instructor(s): N. Levin
Area: Natural Sciences.

AS.270.641. Present and Future Climate.
Meets with AS.270.378.
Prerequisites: Student may not receive credit for both AS.270.378 and AS.270.641.
Instructor(s): B. Zaitchik; D. Waugh
Area: Natural Sciences.

AS.270.642. Surface Geochemistry.
Instructor(s): D. Sverjensky.

AS.270.644. Physics of Climate Variability.
This course is an advanced-level review of the ways in which climate varies on time scales of seasons to decades, including El Nino, the Pacific Decadal Oscillation, the Indian Ocean Dipole Mode, the North Atlantic Oscillation and others. Topics covered will include, depending on class's interest: 1) Methods for isolating climate modes. (2) Key dynamic and thermodynamic processes involved in causing such fluctuations, including atmospheric and oceanic wave propagation, air-sea interaction and changes in the thermohaline circulation. (3) Impacts of climate modes on biogeochemical cycling, including some that are used by paleoclimatologists to reconstruct past variability. Geophysical understanding and links to fundamental mechanisms are emphasized. Format will consist of a mix of lectures and paper discussions. Instructor(s): A. Gnanadesikan
Area: Natural Sciences.

AS.270.647. Earth's Interior.
Mechanical processes in Earth's core and mantle with applications to plate tectonics, the thermal and chemical evolution of the Earth, and generation of Earth's magnetic field. Instructor(s): P. Olson.

AS.270.653. Earth and Planetary Fluids II.
A sequel to AS.270.425 concentrating on planetary-scale atmospheric and oceanic circulation. Physical understanding of the underlying fluid dynamics will be emphasized. Instructor(s): D. Waugh; T. Haine.

AS.270.654. Environmental Data Analysis.
Environmental data is often messy-contaminated with noise, fundamental nonlinear, potentially stationary. This course will build on Menke and menke's Environmental Data Analysis with Matlab to examine methods of analyzing environmental data that don't lead us to confuse noise with signal. Topics covered will include significance testing, spectral estimation, nonparametric methods, multivariate data analysis. Applications will be tailored to the student interest. Instructor(s): A. Gnanadesikan.

Instructor(s): N. Izenberg.

Instructor(s): K. Szlavecz
Area: Natural Sciences.
AS.270.668. Geobiology Seminar. Geobiology is the study of interactions between life and rocks. In this class we will explore how organisms impact sedimentary rocks both directly, by leaving behind biosignatures, or indirectly, by affecting their surroundings in a way that promotes formation of certain types of minerals. This will serve as a guide for interpreting geological records during the early evolution of life on Earth, the rise of animals, and major mass extinctions. Instructor(s): E. Smith; M. Gomes. Area: Natural Sciences.

AS.270.679. Atmospheric Science. A survey of core topics in atmospheric science, including dynamics, thermodynamics, radiative transfer, and chemistry. The course addresses both basic principles and applications to weather and climate. Prerequisites: (AS.110.108 AND AS.110.109) AND (AS.171.101 AND AS.171.102) or permission of instructor. Instructor(s): B. Zaitchik; D. Waugh. Area: Natural Sciences.

AS.270.680. Seminar in Regional Field Geology. Introduction to the regional geology and geological history of the Appalachian system (from Alabama to Newfoundland). Key papers on regional bedrock geology and Mesoproterozoic through Phanerozoic tectonics are reviewed in weekly seminar classes. Two three-day field trips are made on weekends negotiated at the beginning of the semester. Fieldwork will be designed with student input to test ideas and models from the literature. Techniques in sedimentary, metamorphic, igneous and structural field geology are introduced and developed in the field. Recommended course background: AS.270.220 and AS.270.221, or instructor permission. Instructor(s): D. Viete; E. Smith. Area: Natural Sciences.

AS.270.696. Special Topics in Planetary Exploration. A selection of planetary research topics investigated by Prof. Strobel spanning the past 45 years covering the progress that has been made and remaining problems that still need to be addressed. The majority of topics will involve the outer solar system and the science discoveries made by the Voyager, Cassini-Huygens, and New Horizons Missions as well as observations by Earth orbiting satellites – IUE, HUT, HST, FUSE. Instructor(s): D. Strobel. Area: Natural Sciences.

AS.270.807. Research. Instructor(s): Staff.

AS.270.808. Research. Instructor(s): B. Zaitchik.

AS.271.107. Introduction to Sustainability. 3.0 Credits. Humans are having such a massive impact on Earth systems that some call this the Anthropocene epoch. Should we consider this state of affairs progress or catastrophe? How to we find a sustainable path to the future? This course provides an interdisciplinary introduction to the principles and practice of sustainability, exploring such issues as population, pollution, energy and natural resources, biodiversity, food, justice, and climate change through the lens of systems thinking. Course open to freshmen, sophomores, and juniors. Seniors by instructor permission only. Instructor(s): R. Kelly.

AS.271.120. Environmental Photojournalism. 3.0 Credits. Environmental cognition, consciousness and communication are produced, reproduced, interpreted and remembered with the support of visual representations and, in particular, photography. Images increasingly structure our experience of nature, environmental problems, human-environmental relations, and ecological awareness. Students will review critical literature focusing on visual representation theory, the relationship between images and social change, and the history and typology of environmental photography. An understanding of modern environmental history, environmental issues and sustainability is required. Students will identify and investigate environmental issues facing Baltimore, participate in photographic critiques, and develop a final documentary project focusing on a specific environmental narrative. The class is designed with an emphasis on independent research and practice, interdisciplinary analysis, and application. Instructor(s): A. Monopolis. Area: Humanities, Social and Behavioral Sciences. Writing Intensive.

AS.271.301. Climate Change Adaptation in the Developing World. 3.0 Credits. This course considers the way in which people and their livelihoods are adapting to climate change in sensitive regions of the developing world. The course will include an overview of climate systems and climate change science, although it will emphasize vulnerability assessment from an ecosystem and livelihood perspective. Using a case-study approach, the focus will be on key economic sectors of agriculture, water resources, forest systems and tourism. A focus of the course is how to develop an informed approach to climate change adaptation that can drive both national policy and international development and donor efforts to create sustainable responses that serve both the local country and global needs. Students will consider adaptive capacity in specific countries, evaluating the feasibility and sustainability of current adaptation strategies, differentiate national and international efforts and effects of adaptation; learn key tools for climate change assessment, review and critique climate data sources for developing countries, and compare climate change adaptation to the developed world. GECS Majors Only. Prerequisites: Intro to Sustainability, Intro to Global Environmental Change, or Climate Change: Science and Policy. Prerequisites: AS.270.107 OR AS.271.107. Instructor(s): A. Monopolis; C. Parker. Area: Social and Behavioral Sciences.

AS.271.302. Exploring Nature. 3.0 Credits. This course integrates environmental media analysis and production with weekly outdoor excursions. Environmental media increasingly structures our experience of nature, environmental problems, human-environmental relations, and ecological awareness. Students will survey a range of authors, photographers and filmmakers that have written about or documented nature and environmental issues. Field trips to Baltimore's parks and green spaces will encourage students to discover their own sense of place and environmental worldview through careful exploration, observation and reflection. Using a mixed media journal, students will reflect on their experiences, perspectives, and insights. A background in photography or film is not required. Instructor(s): A. Monopolis. Area: Humanities, Social and Behavioral Sciences. Writing Intensive.
AS.271.304. Sustainable Food Systems. 3.0 Credits.
Where does your food come from? What impact does food production have on the environment and human societies? How can food systems become more sustainable as the human population increases? This seminar-style course examines the past, present, and future of agriculture, including topics such as the foodways of indigenous people, modern “factory farming” versus organic agriculture, genetically modified foods, and the interplay among science, economics, policy, and agriculture. Involves hands-on experiences.
Instructor(s): A. Monopolis
Area: Social and Behavioral Sciences.

AS.271.305. Special Topics in Environmental Studies. 3.0 Credits.
Environmental Policy in the Age of Trump. This course will analyze the effects of the current administration’s actions on environmental issues by assessing the policies in question and estimating the potential impacts on climate change, human health, and ecology. Policies that have been overturned or are under review represent a number of environmental issues, including climate change and greenhouse gas emissions, offshore drilling, national monuments, mining pollution, toxic discharge into public waterways, the development of oil pipelines, public land use planning, coal leases, a harmful insecticide, hunting in wildlife refuges, airborne mercury emissions, protection of tributaries and wetlands under the Clean Water Act, energy and fuel-efficiency standards, and resource extraction from federal lands. Students will examine the historical roles environmental organizations and government agencies have played in advocating for, creating and enforcing U.S. environmental policy and will discuss the future roles of these actors and other stakeholders in implementing effective environmental policy.
Instructor(s): R. Kelly
Area: Social and Behavioral Sciences.

AS.271.309. Designing Sustainable Wellness. 3.0 Credits.
This course examines the convergence of social and environmental sustainability within the built environment. The built environment refers to the space, structures and systems humans generate for living, working and playing. This includes everything from homes and office buildings, to neighborhoods and cities, to green spaces and parks. It also includes hard infrastructure, such as energy, transportation and water systems, and soft infrastructure, such as formal human services (e.g. health, education, recreation). More recently, the term has expanded to include conditions related to public health, such as walkability, bikability, and access to healthy foods. This course will examine the conceptual frameworks that support the creation of built environments, assess their impact on environmental and social well-being, and re-imagine methodologies and designs that may better promote “sustainable wellness” or, socio-ecological sustainability, in the future. Through case studies and a final design-based project, students will learn and apply the fundamental principles behind socio-ecologically sustainable design. The course is designed with an emphasis on interdisciplinary analysis and systems thinking. The course is geared towards GECS majors, in addition to students interested in psychology, design, architecture and urban planning.
Instructor(s): A. Monopolis
Area: Engineering, Social and Behavioral Sciences.

AS.271.360. Climate Change: Science & Policy. 3.0 Credits.
Prereq: 270.103 or permission of instructor. This course will investigate the policy and scientific debate over global warming. It will review the current state of scientific knowledge about climate change, examine the potential impacts and implications of climate change, explore our options for responding to climate change, and discuss the present political debate over global warming.
Instructor(s): B. Zaitchik, D. Waugh
Area: Natural Sciences.

AS.271.401. Environmental Ethics. 3.0 Credits.
Environmental Ethics is a philosophical discipline that examines the moral relationship between humans and the natural environment. For individuals and societies, it can help structure our experience of nature, environmental problems, human-environmental relations, and ecological awareness. Beginning with a comprehensive analysis of their own values, students will explore complex ethical questions, philosophical paradigms and real-life case studies through readings, films and seminar discussions. Traditional ethical theories, including consequentialism, deontology, and virtue ethics will be examined and applied. Environmental moral worldviews, ranging from anthropocentric to eco-centric perspectives, will be critically evaluated. Organized debates will help students strengthen their ability to deconstruct and assess ethical arguments and to communicate viewpoints rooted in ethical principles. Students will apply ethical reasoning skills to an examination of contemporary environmental issues including, among others, biodiversity conservation, environmental justice, climate change, and overpopulation. Students will also develop, defend and apply their own personal environmental ethical framework. A basic understanding of modern environmental history and contemporary environmental issues is required. Prior experience with philosophy and ethics is not required.
Instructor(s): A. Monopolis
Area: Humanities, Social and Behavioral Sciences
Writing Intensive.

AS.271.402. Water, Energy, and Food. 3.0 Credits.
The water, energy and food (WEF) nexus is a topic of growing interest in the research and policy communities. This course will survey WEF concepts and principles, introduce tools of analysis, and engage students in case studies of critical WEF issues in the United States and internationally.
Instructor(s): B. Zaitchik.

AS.271.403. Environmental Policymaking and Policy Analysis. 3.0 Credits.
This course provides students with a broad introduction to US environmental policymaking and policy analysis. Included are a historical perspective as well as an analysis of future policymaking strategies. Students examine the political and legal framework, become familiar with precedent-setting statutes such as NEPA, RCRA, and the Clean Air and Clean Water Acts, and study models for environmental policy analysis. Cost benefit studies, the limits of science in policymaking, and the potential impacts and implications of climate change, explore our options for responding to climate change, and discuss the present political debate over global warming.
Instructor(s): J. Maldonado
Area: Social and Behavioral Sciences.
AS.271.404. GIS Workshop. 1.0 Credit.
An accompaniment to the GECS Senior Capstone Seminar for students whose research project involves a GIS component. Designed to enable beginner to advanced GIS users to acquire the data and skills needed to accomplish their research goals.
Corequisites: AS.271.506
Instructor(s): R. Kelly
Area: Natural Sciences.

AS.271.501. Independent Study. 3.0 Credits.
Instructor(s): A. Monopolis.

AS.271.502. Independent Study. 1.0 - 3.0 Credits.
Instructor(s): A. Monopolis; S. Horst.

AS.271.505. Senior Capstone Experience. 4.0 Credits.
This seminar will provide the academic space, time, and mentoring for students to integrate, synthesize and apply the knowledge and skills obtained through GECS curriculum into a tangible environmental filed project.
Instructor(s): A. Monopolis
Writing Intensive.

AS.271.506. GECS Senior Capstone Seminar Part I. 3.0 Credits.
The GECS Senior Capstone Seminar will provide the intellectual time and space to bring together the knowledge and tools acquired during the four years of interdisciplinary work on the GECS curriculum into a coherent framework in preparation for careers, and/or graduate work. Part I of this module will include the initial, research and planning phase of the capstone project. Part II, during the Spring semester, will involve the application and implementation phase.
Instructor(s): A. Monopolis.

AS.271.507. Internship. 1.0 Credit.
Instructor(s): R. Kelly.

AS.271.508. Internship. 1.0 - 3.0 Credits.
Instructor(s): C. Parker; R. Kelly.

AS.271.509. Applied Experience. 1.0 Credit.
This course is designed to accompany a supervised, hands-on experience working on an environmental or sustainability-related research project or internship. While completing 80 hours of applied work, students will prepare a reflective journal, paper, and poster presentation about their experience. Graded S/U only.
Instructor(s): R. Kelly
Area: Natural Sciences.

Cross Listed Courses
Near Eastern Studies
AS.130.378. Geoarchaeology: Applications of Earth Science to Archaeology. 3.0 Credits.
Geoarchaeology is a multidisciplinary subfield that applies the tools and techniques of earth science to understand ancient humans and their interactions with environments. This course examines basic topics and concepts, including archaeological site formation, paleo-environmental reconstruction, raw materials and resources, soil science, deposition and erosion of wind and water-borne sediments in different environments such as along rivers, lakes and coastlines, radiocarbon and other chronometric dating methods, and ground-based remote sensing, including ground penetrating radar.
Instructor(s): M. Harrower
Area: Natural Sciences, Social and Behavioral Sciences.

AS.131.678. Geoarchaeology: Applications of Earth Science to Archaeology.
Geoarchaeology is a multidisciplinary subfield that applies the tools and techniques of earth science to understand ancient humans and their interactions with environments. This course examines basic topics and concepts, including archaeological site formation, paleo-environmental reconstruction, raw materials and resources, soil science, deposition and erosion of wind and water-borne sediments in different environments such as along rivers, lakes and coastlines, radiocarbon and other chronometric dating methods, and ground-based remote sensing, including ground penetrating radar.
Instructor(s): M. Harrower
Area: Natural Sciences, Social and Behavioral Sciences.