The department offers courses in geology and meteorology. Majors can be earned in earth science (B.A., B.S.), geology (B.S.), and meteorology (B.S.). Candidates for all degrees must satisfy the requirements established by the College of Liberal Arts and Sciences (see Liberal Arts and Sciences, Curriculum). In addition, the department has requirements for each major. A minimum of 120 credits are required.

The bachelor of science in Geology prepares the student for a professional career and/or graduate study in the geological sciences. Students selecting geology as a major will elect an option in traditional geology or environmental geology/hydrogeology. The traditional option prepares a student for employment in state and U.S. geological surveys, regulatory agencies, and graduate study in the environmental aspects of geology. Required courses in this option include:

**GEOLOGY**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 100</td>
<td>The Earth</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 100L</td>
<td>The Earth: Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 102</td>
<td>History of the Earth</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 102L</td>
<td>History of the Earth: Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 302</td>
<td>Summer Field Studies</td>
<td>6</td>
</tr>
<tr>
<td>GEOL 315</td>
<td>Mineralogy and Earth Materials</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 315L</td>
<td>Laboratory in Mineralogy and Earth Materials</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 316</td>
<td>Optical Mineralogy</td>
<td>2</td>
</tr>
<tr>
<td>GEOL 356</td>
<td>Structural Geology</td>
<td>5</td>
</tr>
<tr>
<td>GEOL 365</td>
<td>Igneous and Metamorphic Petrology</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 368</td>
<td>Sedimentary Geology</td>
<td>4</td>
</tr>
<tr>
<td>GEOL 479</td>
<td>Surficial Processes</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>And 9 credits of geology electives</td>
<td>9</td>
</tr>
</tbody>
</table>

**Total Credits** 44

The environmental geology/hydrogeology option prepares a student for employment in environmental consulting, state and U.S. geological surveys, mineral and petroleum exploration, and graduate study in most aspects of geology. Required courses in this option include:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</tr>
</thead>
<tbody>
<tr>
<td>GEOL 100</td>
<td>The Earth</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 100L</td>
<td>The Earth: Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 102</td>
<td>History of the Earth</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 102L</td>
<td>History of the Earth: Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 302</td>
<td>Summer Field Studies</td>
<td>6</td>
</tr>
<tr>
<td>GEOL 315</td>
<td>Mineralogy and Earth Materials</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 315L</td>
<td>Laboratory in Mineralogy and Earth Materials</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 316</td>
<td>Optical Mineralogy</td>
<td>2</td>
</tr>
<tr>
<td>GEOL 356</td>
<td>Structural Geology</td>
<td>5</td>
</tr>
<tr>
<td>GEOL 368</td>
<td>Sedimentary Geology</td>
<td>4</td>
</tr>
<tr>
<td>GEOL 411</td>
<td>Hydrogeology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>One of the following</td>
<td></td>
</tr>
<tr>
<td>GEOL 419</td>
<td>Environmental Geochemistry</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 426</td>
<td>Stable Isotopes in the Environment</td>
<td></td>
</tr>
<tr>
<td>GEOL 479</td>
<td>Surficial Processes</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>And 6 credits of geology electives</td>
<td>6</td>
</tr>
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</table>

**Total Credits** 45

Required supporting courses include:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 177</td>
<td>General Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 177L</td>
<td>Laboratory in General Chemistry I</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 178</td>
<td>General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 178L</td>
<td>Laboratory in College Chemistry II</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 111</td>
<td>General Physics</td>
<td>5</td>
</tr>
<tr>
<td>PHYS 112</td>
<td>General Physics</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>One of the following</td>
<td></td>
</tr>
<tr>
<td>MATH 165</td>
<td>Calculus I</td>
<td></td>
</tr>
<tr>
<td>MATH 181</td>
<td>Calculus and Mathematical Modeling for the Life Sciences</td>
<td>6</td>
</tr>
</tbody>
</table>

**Total Credits** 44

No more than 9 credits in 490 may be counted toward a degree in Geology.

Graduates work to understand natural processes on Earth and other planets. They are able to apply their knowledge of forces and factors that shape the Earth to reconstruct the past and anticipate the future. Graduates provide essential information for solving problems for resource management, environmental protection, and public health, safety, and welfare. They work as consultants on engineering and environmental problems, explorers for new minerals and hydrocarbon resources, researchers, teachers, writers, editors, and museum curators. Graduates are able to integrate field and laboratory data and to prepare reports. They are able to make presentations that include maps and diagrams that illustrate the results of their studies.

**Communication Proficiency requirement:** The department requires a grade of C or better in:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 150</td>
<td>Critical Thinking and Communication</td>
<td>3</td>
</tr>
</tbody>
</table>
| ENGL 250  | Written, Oral, Visual, and Electronic Composition | 3-
| or ENGL 250H | Written, Oral, Visual, and Electronic Composition: Honors | 3 |
|           | One of the following                       |         |
| ENGL 309  | Proposal and Report Writing                | 3       |
| ENGL 314  | Technical Communication                    |         |
| ENGL 302  | Business Communication                     |         |
| JL MC 347 | Science Communication                      |         |

**Total Credits** 9

**Minor - Geology**

A minor in Geology may be earned by taking 15 credits of geology coursework, including:

3 credits:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 100</td>
<td>The Earth</td>
<td>3</td>
</tr>
<tr>
<td>&amp; 100L</td>
<td>and The Earth: Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>or GEOL 201</td>
<td>Geology for Engineers and Environmental Scientists</td>
<td></td>
</tr>
<tr>
<td>GEOL 102</td>
<td>History of the Earth</td>
<td>3</td>
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</table>
### Geology, B.S. - Env-Geol/Hydro Option

#### Freshman

<table>
<thead>
<tr>
<th>Course</th>
<th>Fall Credits</th>
<th>Spring Credits</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 150</td>
<td>3</td>
<td>GEOL 102</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 100</td>
<td>3</td>
<td>GEOL 102L</td>
<td>1</td>
</tr>
<tr>
<td>GEOL 100L</td>
<td>1</td>
<td>CHEM 178</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 177</td>
<td>4</td>
<td>CHEM 178L</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 177L</td>
<td>1</td>
<td>MATH 166</td>
<td>4</td>
</tr>
<tr>
<td>MATH 165</td>
<td>4</td>
<td>Social-Science</td>
<td>3</td>
</tr>
<tr>
<td>or 181</td>
<td></td>
<td>Choice</td>
<td></td>
</tr>
<tr>
<td>LIB 160</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Total Credits: 124-127</strong></td>
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</table>

#### Sophomore

<table>
<thead>
<tr>
<th>Course</th>
<th>Fall Credits</th>
<th>Spring Credits</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 250</td>
<td>3</td>
<td>Arts-and-Humanities</td>
<td>3</td>
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<tr>
<td>GEOL 315</td>
<td>3</td>
<td>Social-Science</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 315L</td>
<td>1</td>
<td>Phys 112</td>
<td>5</td>
</tr>
<tr>
<td>GEOL 316</td>
<td>2</td>
<td>Foreign</td>
<td>3-4</td>
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<tr>
<td>PHYS 111</td>
<td>5</td>
<td>Elective</td>
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<tr>
<td>Foreign Language/Elective</td>
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<td></td>
<td><strong>17-18</strong></td>
<td><strong>14-15</strong></td>
<td><strong>6</strong></td>
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</table>

#### Junior

<table>
<thead>
<tr>
<th>Course</th>
<th>Fall Credits</th>
<th>Spring Credits</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOL 411</td>
<td>4</td>
<td>GEOL 356</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 368</td>
<td>4</td>
<td>Arts-and-Humanities</td>
<td>3</td>
</tr>
<tr>
<td>Arts-and-Humanities Choice</td>
<td>3</td>
<td>Science/Engineering/Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 479</td>
<td>3</td>
<td>Elective</td>
<td>3-4</td>
</tr>
<tr>
<td></td>
<td><strong>17</strong></td>
<td><strong>15</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

#### Senior

<table>
<thead>
<tr>
<th>Course</th>
<th>Fall Credits</th>
<th>Spring Credits</th>
<th>Total Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology Choice</td>
<td>3</td>
<td>Elective</td>
<td>3</td>
</tr>
<tr>
<td>GEOL 419 or GEOL 426 or elective</td>
<td>3</td>
<td>GEOL 434 or elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>17</strong></td>
<td><strong>15</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>
in aerospace engineering, agronomy (soil science), chemistry, civil and
for each departmental major. Additional coursework is normally taken
with requirements of the Graduate College and established requirements
Programs of study are designed on an individual basis in accordance
their expressed goals.
also cooperates in the interdepartmental major in Water Resources (see
A strong undergraduate background in the physical and mathematical
Index). Students desiring a major in the above fields normally will have

Graduate Study

The department offers programs leading to the master of science
and doctor of philosophy with majors in Earth Science, Geology, and
Meteorology. Program options are available for the M.S. and Ph.D.
degrees in earth science leading to careers in teaching. The department
also cooperates in the interdepartmental major in Water Resources (see
Index). Students desiring a major in the above fields normally will have
a strong undergraduate background in the physical and mathematical
sciences. Individuals desiring to enter a graduate program are evaluated
by considering their undergraduate background and performance and
their expressed goals.

Programs of study are designed on an individual basis in accordance
with requirements of the Graduate College and established requirements
for each departmental major. Additional coursework is normally taken
in aerospace engineering, agronomy (soil science), chemistry, civil and
construction engineering, computer engineering, computer science,
engineering mechanics, materials engineering, mathematics, mechanical
engineering, microbiology, physics, or statistics. Departmental
requirements provide a strong, broad background in the major and allow
considerable flexibility in the program of each individual.

A dissertation is required of all Ph.D. candidates.

M.S. students in Geology are required to complete a thesis. The M.S. in
Earth Science is available to students electing the non-thesis (Creative
Component) option in Geology or Meteorology. A non-thesis option is
also offered for the M.S. degree in Meteorology.

Graduates in Geology specialize in a subdiscipline, but they comprehend
and can communicate the basic principles of geology and supporting
sciences. They possess the capacity for critical and independent
thinking. They are able to write a fundable research proposal, evaluate
current relevant literature, carry out the proposed research, and
communicate the results of their research to peers at national meetings
and to the general public. They work as consultants on engineering and
environmental problems, explorers for new minerals and hydrocarbon
resources, researchers, teachers, writers, editors, and museum curators.

Course requirements for the MS degree include MTEOR 542, 543, 507
or 518, 552 or 516x, and 502 or 504 or 505 or 605. In addition to the 5
required courses from this list, students must take at least 3 more credits
of graduate course work in Meteorology, Agricultural Meteorology, or
a field related to their research interests (students will work closely
with their POS committee to determine the exact amount of structured
course work required – typically this is 18-21 credits). Students without
prior synoptic meteorology course work must complete MTEOR 511 and
may substitute these credits in place of the required MTEOR 507 or 518
courses.

Graduates in Meteorology have a good comprehension of basic
principles, a capacity for critical and independent thought and an ability
to communicate effectively with scientific colleagues. They have an
appropriate breadth in their understanding of meteorology with a suitable
specialization. Graduates are able to undertake thorough research and
explain the results in a scientifically reasonable fashion.

Courses primarily for undergraduates:

GEOL 100: The Earth
(3-0) Cr. 3. F.S.SS.
How does the earth work, what is it made of, and how does it change
through time? Plate tectonics, Earth materials, landforms, structures,
climate, and natural resources. Emphasis on the observations and
hypotheses used to interpret earth system processes. Students may also
enroll in Geol 100L.

GEOL 100L: The Earth: Laboratory
(0-2) Cr. 1. F.S.
Prereq: Credit or enrollment in GEOL 100
Students will gain understanding of how Earth processes affect their lives
and how they affect the Earth, and of the complex nature of the Earth and
its processes. They will gain a deep knowledge of the methods used to
understand the time scales and rates of Earth processes also through an
applied research experience on groundwater and surface water.

Students in all ISU majors must complete a three-credit course in
U.S. diversity and a three-credit course in international perspectives.
Check (http://www.registrar.iastate.edu/courses/div-ip-guide.html)
for a list of approved courses. Discuss with your adviser how the two
courses that you select can be applied to your graduation plan.
LAS majors require a minimum of 120 credits, including a minimum
of 45 credits at the 300/400 level. At least 8 credits in the major from
300+ courses must earn grade C or better. The average grade of all
courses that you select can be applied to your graduation plan.

Courses primarily for undergraduates:

GEOL 100: The Earth
(3-0) Cr. 3. F.S.SS.
How does the earth work, what is it made of, and how does it change
through time? Plate tectonics, Earth materials, landforms, structures,
climate, and natural resources. Emphasis on the observations and
hypotheses used to interpret earth system processes. Students may also
enroll in Geol 100L.

GEOL 100L: The Earth: Laboratory
(0-2) Cr. 1. F.S.
Prereq: Credit or enrollment in GEOL 100
Students will gain understanding of how Earth processes affect their lives
and how they affect the Earth, and of the complex nature of the Earth and
its processes. They will gain a deep knowledge of the methods used to
understand the time scales and rates of Earth processes also through an
applied research experience on groundwater and surface water.
GEOL 101: Environmental Geology: Earth in Crisis
(Cross-listed with ENV S). (3-0) Cr. 3. F.S.
An introduction to geologic processes and the consequences of human activity from local to global scales. Discussion of human population growth, resource depletion, pollution and waste disposal, global warming and ozone depletion, desertification, and geologic hazards such as earthquakes, landslides, flooding, and volcanism.

GEOL 102: History of the Earth
(3-0) Cr. 3. S.
Prereq: GEOL 100 or GEOL 201
The Earth’s physical and biological evolution; concepts of global tectonics. Methods used to decipher earth history. Students majoring in geology must also enroll in Geol 102L.

GEOL 102L: History of the Earth: Laboratory
(0-2) Cr. 1. S.
Prereq: Credit or enrollment in GEOL 102
Introduction to the use of sedimentary rocks and fossils in reconstructing the Earth’s history.

GEOL 105: Gems and Gemstones
(2-0) Cr. 1. F.
Offered in second half of the semester. Introduction to gems and gemstones, physical and optical properties of gems and gemstones, explanation of where gems come from and how they are found, how to distinguish between synthetic and naturally occurring gems, how the value of gems are determined, and the history of famous gems.

GEOL 106: Earth and Space Science for Elementary Education Majors
(Cross-listed with ASTRO). (2-0) Cr. 2. F.S.
Prereq: Major in elementary or early childhood education.
Fundamental concepts of Earth and Space Science, including the solar system, weather and climate, water and soils, plate tectonics, and geologic hazards. Online course format.

GEOL 106L: Earth and Space Science for Elementary Education Majors: Laboratory
(Cross-listed with ASTRO). (0-2) Cr. 1. F.S.
Prereq: Restricted to elementary and early childhood education majors; to be taken concurrently with GEOL 106/ASTRO 106
Inquiry-based lab exploring fundamental concepts of Earth and Space Science, including the solar system, weather and climate, water and soils, plate tectonics, and geologic hazards. Must be taken concurrently with GEOL/ASTRO 106.

GEOL 108: Introduction to Oceanography
(Cross-listed with ENV S). (3-0) Cr. 3. F.

GEOL 111: Geological Disasters
(Cross-listed with ENV S). (1-0) Cr. 1. F.S.S.S.
Introduction to the catastrophic geologic processes that disrupt ecosystems and human activity. Includes a discussion on the role of plate tectonics, the hydrologic cycle, and humans as the driving forces behind selected case studies on volcanic eruptions, earthquakes, tsunamis, landslides, and floods. Summer - online only.

GEOL 112: Geoscience Orientation
(Cross-listed with MTEOR). (1-0) Cr. 1. F.
Orientation course for students enrolled in the Earth, Wind and Fire Learning Community. Provides an introduction to Iowa State University and meteorology, geology, and Earth science programs for students enrolled in the department’s learning community. Activities include academic and social activities, talks and presentations on academic success, resume writing, and study abroad, as well as research talks by faculty members.

GEOL 160: Water Resources of the World
(Cross-listed with AGRON, ENV S, MTEOR). (3-0) Cr. 3. S.
Study of the occurrence, history, development, and management of world water resources. Basic hydrologic principles including climate, surface water, groundwater, and water quality. Historical and current perspectives on water policy, use, and the role of water in society and the environment. Meets International Perspectives Requirement.

GEOL 201: Geology for Engineers and Environmental Scientists
(2-2) Cr. 3. F.
Introduction to Earth materials and processes with emphasis on engineering and environmental applications.

GEOL 290: Independent Study
Cr. 1-4. Repeatable.
Prereq: Permission of instructor
Independent study for freshman and sophomore students.

GEOL 298: Cooperative Education
Cr. R. F.S.S.
Prereq: GEOL 100 or GEOL 201, GEOL 100L, GEOL 102, GEOL 102L, and permission of the department cooperative education coordinator; sophomore classification
Required of all cooperative education students. Students must register for this course prior to commencing the work period.

GEOL 302: Summer Field Studies
Cr. 6. SS.
Prereq: GEOL 102, GEOL 356, GEOL 368
Geologic mapping; structural, stratigraphic, sedimentologic, metamorphic, geomorphic, and environmental analyses. Study areas in the Bighorn Basin and Wind River Range and excursions to Yellowstone and Grand Teton National Parks. A 6-week summer field course required of all geology majors.

GEOL 306: Geology Field Course
Cr. 1-2. Repeatable, maximum of 2 times. F.S.
Prereq: GEOL 100 or GEOL 201
Weekly seminar introduces students to a selected geological region or theme that is visited on a required ten-day field excursion. Introduction to field-safety leadership.

GEOL 315: Mineralogy and Earth Materials
(3-0) Cr. 3. F.
Prereq: GEOL 100 or GEOL 201, CHEM 177
Introduction to mineral classification, elementary crystal chemistry, crystal growth and morphology, mineral stability, and mineral associations.

GEOL 315L: Laboratory in Mineralogy and Earth Materials
(0-3) Cr. 1. F.
Prereq: GEOL 100 or GEOL 201
Mineral identification methods, especially hand-specimen identification.
GEOL 316: Optical Mineralogy  
(1-2) Cr. 2. F.  
Prereq: GEOL 100 or GEOL 201, CHEM 177, credit or enrollment in GEOL 315  
Laboratory problems in mineral-identification methods utilizing optical microscopic techniques.

GEOL 324: Energy and the Environment  
(Cross-listed with ENSCI, ENV S, MTEOR). (3-0) Cr. 3. S.  

GEOL 356: Structural Geology  
(3-6) Cr. 5. S.  
Prereq: GEOL 100 or GEOL 201, PHYS 111  
Principles of stress and strain. Brittle and ductile behavior of rocks. Description, classification, and mechanics of formation of fractures, faults, folds, foliation, and lineation. Plate tectonics and regional geology. Laboratory includes application of geometrical techniques to solve structural problems; emphasizes map interpretation and use of stereonet and computer methods.

GEOL 365: Igneous and Metamorphic Petrology  
(2-3) Cr. 3. S.  
Prereq: GEOL 315, GEOL 315L, GEOL 316  
Nature and origin of igneous and metamorphic rocks. Emphasis on important rock-forming environments and processes and their influence on rock characteristics. Laboratory includes thin section study of rock textures and mineralogy and the interpretation of these features.

GEOL 366: Sedimentary Geology  
(3-3) Cr. 4. F.  
Prereq: GEOL 102  
Exploration of the interplay between weathering, sedimentation, sea-level change, tectonics, and life through time that creates sedimentary rocks and stratigraphic packages. Understanding of the historical development of sedimentary geology through the development of petrography, paleontology, deep earth sampling, geophysical technologies, and geochemistry. Field and laboratory problem sets illuminate lecture material.

GEOL 398: Cooperative Education  
Cr. R. F.S.SS.  
Prereq: GEOL 100 or GEOL 201, GEOL 100L, GEOL 102, GEOL 102L, and permission of the department cooperative education coordinator; junior classification  
Required of all cooperative education students. Students must register for this course prior to commencing each work period.

GEOL 402: Watershed Hydrology  
(Dual-listed with GEOL 502). (Cross-listed with ENSCI, MTEOR, NREM). (2-3) Cr. 3. F.  
Prereq: Four courses in physical or biological sciences or engineering; junior standing  
Examination of watersheds as systems, emphasizing the surface components of the hydrologic cycle. Combines qualitative understanding of hydrological processes and uncertainty with quantitative representation. Laboratory emphasizes field investigation and measurement of watershed processes.

GEOL 409: Field Methods in Hydrogeology  
(Dual-listed with GEOL 509). (Cross-listed with ENSCI). (0-4) Cr. 3. Alt. SS., offered even-numbered years.  
Prereq: GEOL/ENSCI 402 or GEOL/ENSCI 411 or C E 473  
Introduction to field methods used in groundwater investigations. In-field implementation of pumping tests, slug tests, monitoring well installation and drilling techniques, geochemical and water quality sampling, seepage meters, minipiezometers, stream gaging, and electronic instrumentation for data collection. Field trips to investigate water resource, water quality, and remediation projects.

GEOL 411: Hydrogeology  
(Dual-listed with GEOL 511). (Cross-listed with ENSCI). (3-2) Cr. 4. F.  
Prereq: Four courses in biological or physical sciences  
Physical principles of groundwater flow, nature and origin of aquifers and confining units, well hydraulics, groundwater modeling, and contaminant transport. Lab emphasizes applied field and laboratory methods for hydrogeological investigations.

GEOL 414: Applied Groundwater Flow Modeling  
(Dual-listed with GEOL 514). (Cross-listed with ENSCI). (2-2) Cr. 3. Alt. S., offered even-numbered years.  
Prereq: GEOL 411 or C E 473; MATH 165 or MATH 181  
Introduction to the principles of modeling groundwater flow systems. Finite-difference and analytic-element methods, spreadsheet models, boundary conditions, calibration, sensitivity analysis, parameter estimation, particle tracking, and post-audit analysis. Application of MODFLOW to regional flow-system analysis. Computer laboratory emphasizes assigned problems that illustrate topics discussed in the course.

GEOL 415: Paleoclimatology  
(Dual-listed with GEOL 515). (Cross-listed with ENSCI). (2-3) Cr. 3. Alt. S., offered odd-numbered years.  
Prereq: Four courses in biological or physical science  
Introduction to mechanisms that drive climate, including the interplay between oceanic and atmospheric circulation and fluctuation in Earth’s orbital parameters. Examination and analysis of past climate records ranging from historical documentation to ecological and geochemical proxies (e.g. tree ring analysis; O and C isotopes of skeletal carbonates and soils). Dating methods used to constrain and correlate climatic periods; utility of computer models to reconstruct past climates and predict future climate change. Emphasis placed on paleoclimatology and paleoecology of the late Quaternary (last ~1 million years).
GEOL 416: Hydrologic Modeling and Analysis
(Dual-listed with GEOL 516). (Cross-listed with ENSCI, MTEOR). (2-3) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: Four courses in Earth science, meteorology, or engineering; junior standing
Study of the basic principles of hydrologic modeling, including rainfall-runoff analysis, lumped and distributed modeling, conceptual and physical models, parameter estimation and sensitivity analysis, input and validation data, uncertainty analysis, and the use of models in surface water hydrology. A range of common models are applied to study hydrologic topics such as flood forecasting and land use change impacts. Previous experience with Matlab or other programming language is needed.

GEOL 419: Environmental Geochemistry
(Dual-listed with GEOL 519). (Cross-listed with ENSCI). (2-2) Cr. 3. S.
Prereq: GEOL 402 or GEOL 411 or equivalent
Geochemistry of natural waters and water-rock interactions. Acid-base equilibria, carbonate chemistry and buffer systems, mineral dissolution and precipitation, sorption, ion exchange, and redox reactions. Introduction to thermodynamics and kinetics. Laboratory emphasizes chemical analysis of waters and computer modeling.

GEOL 420: Mineral Resources
(Dual-listed with GEOL 520). (2-3) Cr. 3. Alt. F., offered even-numbered years.
Prereq: GEOL 365
Geology and geochemistry of non-metallic and metallic ore deposits. Major processes that concentrate metals in the Earth. Geochemical conditions of ore formation using stable-isotope and fluid-inclusion studies. Laboratory emphasizes the study of metallic ores.

GEOL 426: Stable Isotopes in the Environment
(Dual-listed with GEOL 526). (Cross-listed with ENSCI). (3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: Four courses in biological or physical science
Introduction to the theory, methods and applications of stable isotopes. Primary focus on the origin, natural abundance, and fractionation of carbon, hydrogen, oxygen, nitrogen isotopes. Applications of isotopic occurrence for elucidation of physical, chemical, biological, and environmental processes. Effects of plant physiology, photosynthesis, trophic structure, diffusion, evaporation, chemical precipitation, soil and atmospheric processes, and environmental factors on isotope abundance.

GEOL 451: Applied and Environmental Geophysics
(Dual-listed with GEOL 551). (Cross-listed with ENSCI). (2-2) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: GEOL 100 or GEOL 201, college algebra and trigonometry
Seismic, gravity, magnetic, resistivity, electromagnetic, and ground-penetrating radar techniques for shallow subsurface investigations and imaging. Data interpretation methods. Lab emphasizes computer interpretation packages. Field work with seismic - and resistivity-imaging systems and radar.

GEOL 452: GIS for Geoscientists
(Dual-listed with GEOL 552). (Cross-listed with AGRON, ENSCI). (2-2) Cr. 3. F.
Prereq: GEOL 100, GEOL 201 or equivalent
Introduction to geographic information systems (GIS) with particular emphasis on geoscientific data. Uses ESRI's ArcGIS Desktop Software and extension modules. Emphasizes typical GIS operations and analyses in the geosciences to prepare students for advanced GIS courses.

GEOL 457: Seismic Methods in Geology, Engineering, and Petroleum Exploration
(Dual-listed with GEOL 557). (2-2) Cr. 3. Alt. S., offered even-numbered years.
Prereq: GEOL 100 or GEOL 201, college algebra and trigonometry
Physics of elastic-wave propagation. Seismic surveys in environmental imaging, engineering, and petroleum exploration. Reflection and refraction techniques. Data collection, processing, and geological interpretation. Field work with state-of-the-art equipment.

GEOL 474: Glacial and Quaternary Geology
(Dual-listed with GEOL 574). (2-2) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: GEOL 100 or GEOL 201 or equivalent experience
The study of glaciers and glacial processes. Discussion of glaciology, glacial sediment transport, glacial landforms, and Quaternary history. Laboratory emphasizes topographic map interpretation and the Quaternary landscapes of Iowa.

GEOL 479: Surficial Processes
(Dual-listed with GEOL 579). (Cross-listed with ENSCI). (2-2) Cr. 3. F.
Prereq: GEOL 100 or GEOL 201 or equivalent experience
The study of physical processes that shape Earth's surface. Topics include weathering, sediment transport, and landform genesis with emphasis on fluvial, glacial, hillslope, eolian, and coastal processes. Applications to engineering and environmental problems. Laboratory includes topographic map interpretation and local field trips.

GEOL 488: GIS for Geoscientists II
(Dual-listed with GEOL 588). (Cross-listed with AGRON, ENSCI). (2-2) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: GIS course, such as GEOL 452, CRP 451, CRP 452, NREM 345, NREM 446, AE 408 or equivalent
GIS course with focus on the spatial analysis and modeling of raster data and triangulated irregular network (TIN) data. Uses ArcGIS and various extensions, such as Spatial Analyst, 3D Analyst, and ArcScene. Includes practical exercises during lectures, lab exercises, homework assignments, and (for GEOL 588) a class project.

GEOL 489: Survey of Remote Sensing Technologies
(Dual-listed with GEOL 589). (Cross-listed with E E, MTEOR, NREM). (3-0) Cr. 3. S.
Prereq: Four courses in physical or biological sciences or engineering
Electromagnetic-radiation principles, active and passive sensors, multispectral and hyperspectral sensors, imaging radar, SAR, thermal imaging, lidar. Examples of applications. Also offered online S.

GEOL 489L: Satellite Remote Sensing Laboratory
(Dual-listed with GEOL 589L). (Cross-listed with E E, MTEOR, NREM). (0-3) Cr. 1. S.
Prereq: Completion or concurrent enrollment in MTEOR/GEOL/NREM/EE 489/589
Processing and analysis of satellite sensor data (optical and radar). Provides practical applications in an environmental context.
GEOL 490: Independent Study
Cr. 1-4. Repeatable, maximum of 9 credits.
PreReq: 6 credits in geology and permission of instructor
No more than 9 credits of Geol 490 may be counted toward graduation.

GEOL 495: Undergraduate Seminar
Cr. 1. F.S.
PreReq: Junior or senior classification
Weekly seminar on topics of current research interest.

GEOL 498: Cooperative Education
Cr. R. F.S.S.S.
PreReq: Geol 100 or GEOL 201, GEOL 100L, GEOL 102, GEOL 102L, and permission of the department cooperative education coordinator; senior classification
Required of all cooperative education students. Students must register for this course prior to commencing each work period.

Courses primarily for graduate students, open to qualified undergraduates:

GEOL 502: Watershed Hydrology
(Dual-listed with GEOL 402). (Cross-listed with ENSCI, MTEOR, NREM).
(2-3) Cr. 3. F.
PreReq: Four courses in physical or biological sciences or engineering; junior standing
Examination of watersheds as systems, emphasizing the surface components of the hydrologic cycle. Combines qualitative understanding of hydrological processes and uncertainty with quantitative representation. Laboratory emphasizes field investigation and measurement of watershed processes.

GEOL 506: Geology Field Course
Cr. 1-2. Repeatable, maximum of 2 times. F.S.
PreReq: Graduate classification
Weekly seminar introduces students to a selected geological region or theme that is visited on a required ten-day field excursion. Graduate students are expected to assist in field teaching and safety leadership.

GEOL 507: Midwestern Geology Field Trip
Cr. 1. Repeatable, maximum of 4 times. F.
PreReq: GEOL 365
On-site inspection of various ore deposits, mining operations, and terrains dominated by igneous or metamorphic rocks. Offered on a satisfactory-fail basis only.

GEOL 509: Field Methods in Hydrogeology
(Dual-listed with GEOL 409). (Cross-listed with ENSCI). (0-4) Cr. 3. Alt. SS., offered even-numbered years.
PreReq: GEOL/ENSCI 402 or GEOL/ENSCI 411 or C E 473
Introduction to field methods used in groundwater investigations. In-field implementation of pumping tests, slug tests, monitoring well installation and drilling techniques, geochemical and water quality sampling, seepage meters, minipiezometers, stream gaging, and electronic instrumentation for data collection. Field trips to investigate water resource, water quality, and remediation projects.

GEOL 511: Hydrogeology
(Dual-listed with GEOL 411). (Cross-listed with ENSCI). (3-2) Cr. 4. F.
PreReq: Four courses in biological or physical sciences
Physical principles of groundwater flow, nature and origin of aquifers and confining units, well hydraulics, groundwater modeling, and contaminant transport. Lab emphasizes applied field and laboratory methods for hydrogeological investigations.

GEOL 514: Applied Groundwater Flow Modeling
(Dual-listed with GEOL 414). (Cross-listed with ENSCI). (2-2) Cr. 3. Alt. S., offered even-numbered years.
PreReq: GEOL 411 or C E 473; MATH 165 or MATH 181
Introduction to the principles of modeling groundwater flow systems. Finite-difference and analytic-element methods, spreadsheet models, boundary conditions, calibration, sensitivity analysis, parameter estimation, particle tracking, and post-audit analysis. Application of MODFLOW to regional flow-system analysis. Computer laboratory emphasizes assigned problems that illustrate topics discussed in the course.

GEOL 515: Paleoclimatology
(Dual-listed with GEOL 415). (Cross-listed with ENSCI). (3-0) Cr. 3. Alt. S., offered odd-numbered years.
PreReq: Four courses in biological or physical science
Introduction to mechanisms that drive climate, including the interplay between oceanic and atmospheric circulation and fluctuation in Earth’s orbital parameters. Examination and analysis of past climate records ranging from historical documentation to ecological and geochemical proxies (e.g. tree ring analysis; O and C isotopes of skeletal carbonates and soils). Dating methods used to constrain and correlate climatic periods; utility of computer models to reconstruct past climates and predict future climate change. Emphasis placed on paleoclimatology and paleoecology of the late Quaternary (last ~ 1 million years). 

GEOL 516: Hydrologic Modeling and Analysis
(Dual-listed with GEOL 416). (Cross-listed with ENSCI, MTEOR). (2-3) Cr. 3. Alt. S., offered odd-numbered years.
PreReq: Four courses in earth science, meteorology, or engineering; junior standing
Study of the basic principles of hydrologic modeling, including rainfall-runoff analysis, lumped and distributed modeling, conceptual and physical models, parameter estimation and sensitivity analysis, input and validation data, uncertainty analysis, and the use of models in surface water hydrology. A range of common models are applied to study hydrologic topics such as flood forecasting and land use change impacts. Previous experience with Matlab or other programming language is needed.

GEOL 519: Environmental Geochemistry
(Dual-listed with GEOL 419). (Cross-listed with ENSCI). (2-2) Cr. 3. S.
PreReq: GEOL 402 or GEOL 411 or equivalent
Geochemistry of natural waters and water-rock interactions. Acid-base equilibria, carbonate chemistry and buffer systems, mineral dissolution and precipitation, sorption, ion exchange, and redox reactions. Introduction to thermodynamics and kinetics. Laboratory emphasizes chemical analysis of waters and computer modeling.
GEOL 520: Mineral Resources
(Dual-listed with GEOL 420). (2-3) Cr. 3. Alt. F., offered even-numbered years.
Prereq: GEOL 365
Geology and geochemistry of non-metallic and metallic ore deposits. Major processes that concentrate metals in the Earth. Geochemical conditions of ore formation using stable-isotope and fluid-inclusion studies. Laboratory emphasizes the study of metallic ores.

GEOL 526: Stable Isotopes in the Environment
(Dual-listed with GEOL 426). (Cross-listed with ENSCI). (3-0) Cr. 3. Alt. S., offered even-numbered years.
Prereq: Four courses in biological or physical science
Introduction to the theory, methods and applications of stable isotopes. Primary focus on the origin, natural abundance, and fractionation of carbon, hydrogen, oxygen, nitrogen isotopes. Applications of isotopic occurrence for elucidation of physical, chemical, biological, and environmental processes. Effects of plant physiology, photosynthesis, trophic structure, diffusion, evaporation, chemical precipitation, soil and atmospheric processes, and environmental factors on isotope abundance.

GEOL 551: Applied and Environmental Geophysics
(Dual-listed with GEOL 451). (Cross-listed with ENSCI). (2-2) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: GEOL 100 or GEOL 201, college algebra and trigonometry
Seismic, gravity, magnetic, resistivity, electromagnetic, and ground-penetrating radar techniques for shallow subsurface investigations and imaging. Data interpretation methods. Lab emphasizes computer interpretation packages. Field work with seismic - and resistivity-imaging and imaging. Data interpretation methods. Lab emphasizes computer interpretation packages. Field work with state-of-the-art equipment.

GEOL 552: GIS for Geoscientists
(Dual-listed with GEOL 452). (Cross-listed with AGRON, ENSCI). (2-2) Cr. 3. F.
Prereq: GEOL 100, GEOL 201 or equivalent
Introduction to geographic information systems (GIS) with particular emphasis on geoscientific data. Uses ESRI’s ArcGIS Desktop Software and extension modules. Emphasizes typical GIS operations and analyses in the geosciences to prepare students for advanced GIS courses.

GEOL 555: Environmental Soil Mineralogy
(Cross-listed with AGRON). (3-0) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: AGRON 473, CHEM 178. Recommend: GEOL 311
Structure and behavior of clay minerals, humic substances and biochar in soil environments, with emphasis on reactions and environmental implications.

GEOL 557: Seismic Methods in Geology, Engineering, and Petroleum Exploration
(Dual-listed with GEOL 457). (2-2) Cr. 3. Alt. S., offered even-numbered years.
Prereq: GEOL 100 or GEOL 201, college algebra and trigonometry
Physics of elastic-wave propagation. Seismic surveys in environmental imaging, engineering, and petroleum exploration. Reflection and refraction techniques. Data collection, processing, and geological interpretation. Field work with state-of-the-art equipment.

GEOL 558: Introduction to the 3D Visualization of Scientific Data
(Cross-listed with COM S, HCI). (2-2) Cr. 3. Alt. F., offered even-numbered years.
Prereq: Graduate-student standing in the mathematical or natural sciences or engineering, basic programming knowledge
Introduction to visualizing scientific information with 3D computer graphics and their foundation in human perception. Overview of different visualization techniques and examples of 3D visualization projects from different disciplines (natural sciences, medicine, and engineering). Class project in interactive 3D visualization using the ParaView, Mayavi, TVTK, VTK or a similar system.

GEOL 574: Glacial and Quaternary Geology
(Dual-listed with GEOL 474). (2-2) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: GEOL 100 or GEOL 201 or equivalent experience
The study of glaciers and glacial processes. Discussion of glaciology, glacial sediment transport, glacial landforms, and Quaternary history. Laboratory emphasizes topographic map interpretation and the Quaternary landscapes of Iowa.

GEOL 579: Surficial Processes
(Dual-listed with GEOL 479). (Cross-listed with ENSCI). (2-2) Cr. 3. F.
Prereq: GEOL 100 or GEOL 201 or equivalent experience
The study of physical processes that shape Earth’s surface. Topics include weathering, sediment transport, and landform genesis with emphasis on fluvial, glacial, hillslope, eolian, and coastal processes. Applications to engineering and environmental problems. Laboratory includes topographic map interpretation and local field trips.

GEOL 588: GIS for Geoscientists II
(Dual-listed with GEOL 488). (Cross-listed with AGRON, ENSCI). (2-2) Cr. 3. Alt. S., offered odd-numbered years.
Prereq: GIS course, such as GEOL 452, CRP 451, CRP 452, NREM 345, NREM 446, AE 408 or equivalent
GIS course with focus on the spatial analysis and modeling of raster data and triangulated irregular network (TIN) data. Uses ArcGIS and various extensions, such as Spatial Analyst, 3D Analyst, and ArcScene. Includes practical exercises during lectures, lab exercises, homework assignments, and (for GEOL 588) a class project.

GEOL 589: Survey of Remote Sensing Technologies
(Dual-listed with GEOL 489). (Cross-listed with E E, MTEOR, NREM). (3-0) Cr. 3. S.
Prereq: Four courses in physical or biological sciences or engineering
Electromagnetic-radiation principles, active and passive sensors, multispectral and hyperspectral sensors, imaging radar, SAR, thermal imaging, lidar. Examples of applications. Also offered online S.

GEOL 590: Special Topics
Cr. 1-3. Repeatable.
Prereq: Permission of instructor

GEOL 590A: Special Topics: Surficial Processes
Cr. 1-3. Repeatable.
Prereq: Permission of instructor

GEOL 590B: Special Topics: Stratigraphy
Cr. 1-3. Repeatable.
Prereq: Permission of instructor
GEOL 590C: Special Topics: Sedimentation  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590D: Special Topics: Paleontology  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590E: Special Topics: Petrology  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590F: Special Topics: Structural Geology  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590G: Special Topics: Geochemistry  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590H: Special Topics: Hydrogeology  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590I: Special Topics: Earth Science  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590J: Special Topics: Mineral Resources  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590K: Special Topics: Geophysics  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590L: Special Topics: Mineralogy  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590M: Special Topics: Tectonics  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590N: Special Topics: Paleooecology and Paleoclimatology  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590O: Special Topics: Isotope Geochemistry  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590P: Special Topics: Computational Methods and GIS  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590R: Special Topics: Surface Hydrology  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 590S: Special Topics: Oceanography  
Cr. 1-3. Repeatable.  
Prereq: Permission of instructor

GEOL 595: Graduate Seminar  
(Cross-listed with MTEOR). Cr. 1. Repeatable. F.S.  
Prereq: Senior or graduate classification  
Weekly seminar on topics of current research interest. All students seeking a graduate degree in geology must enroll during each semester of residence. Students pursuing a non-thesis option for the M.S. in Earth Science must enroll for one semester. Offered on a satisfactory-fail basis only.

GEOL 595A: Graduate Seminar: Presentation Required  
(Cross-listed with MTEOR). (1-0) Cr. 1. Repeatable. F.S.  
Prereq: Senior or graduate classification  
Weekly seminar on topics of current research interest. All students seeking a graduate degree in geology must enroll during each semester of residence. Students pursuing a non-thesis option for the M.S. in Earth Science must enroll for one semester. Offered on a satisfactory-fail basis only.

GEOL 595B: Graduate Seminar: Attendance Only  
(Cross-listed with MTEOR). Cr. R. Repeatable. F.S.  
Prereq: Senior or graduate classification  
Attendance only. Weekly seminar on topics of current research interest. All students seeking a graduate degree in geology must enroll during each semester of residence. Students pursuing a non-thesis option for the M.S. in Earth Science must enroll for one semester. Offered on a satisfactory-fail basis only.

GEOL 599: Creative Component  
Cr. arr. Repeatable.

Courses for graduate students:

GEOL 610: Advanced Seminar  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor

GEOL 610A: Advanced Seminar: Earth Materials  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor

GEOL 610B: Advanced Seminar: Economic Geology  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor

GEOL 610C: Advanced Seminar: Environmental Geochemistry  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor

GEOL 610D: Advanced Seminar: Geophysics  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor

GEOL 610E: Advanced Seminar: Geotectonics  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor

GEOL 610F: Advanced Seminar: Hydrogeology  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor

GEOL 610G: Advanced Seminar: Surficial Processes  
Cr. 1-3. Repeatable. F.S.  
Prereq: Graduate standing and permission of instructor
GEOL 610H: Advanced Seminar: Sedimentation and Stratigraphy
Cr. 1-3. Repeatable. F.S.
Prereq: Graduate standing and permission of instructor

GEOL 610I: Advanced Seminar: Paleoecology and Paleoclimatology
Cr. 1-3. Repeatable. F.S.
Prereq: Graduate standing and permission of instructor

GEOL 610J: Advanced Seminar: Isotope Geochemistry
Cr. 1-3. Repeatable. F.S.
Prereq: Graduate standing and permission of instructor

GEOL 610K: Advanced Seminar: Computational Methods and GIS
Cr. 1-3. Repeatable. F.S.
Prereq: Graduate standing and permission of instructor

GEOL 699: Research
Cr. arr. Repeatable.

GEOL 699A: Research: Surficial Processes
Cr. arr. Repeatable.

GEOL 699B: Research: Stratigraphy
Cr. arr. Repeatable.

GEOL 699C: Research: Sedimentation
Cr. arr. Repeatable.

GEOL 699D: Research: Paleontology
Cr. arr. Repeatable.

GEOL 699E: Research: Petrology
Cr. arr. Repeatable.

GEOL 699F: Research: Structural Geology
Cr. arr. Repeatable.

GEOL 699G: Research: Geochemistry
Cr. arr. Repeatable.

GEOL 699H: Research: Hydrogeology
Cr. arr. Repeatable.

GEOL 699I: Research: Earth Science
Cr. arr. Repeatable.

GEOL 699J: Research: Mineral Resources
Cr. arr. Repeatable.

GEOL 699K: Research: Geophysics
Cr. arr. Repeatable.

GEOL 699L: Research: Mineralogy
Cr. arr. Repeatable.

GEOL 699M: Research: Tectonics
Cr. arr. Repeatable.

GEOL 699N: Research: Paleoecology and Paleoclimatology
Cr. arr. Repeatable.

GEOL 699O: Research: Isotope Geochemistry
Cr. arr. Repeatable.

GEOL 699P: Research: Computational Methods and GIS
Cr. arr. Repeatable.

GEOL 699R: Research: Surface Hydrology
Cr. arr. Repeatable.