

Geological and Atmospheric Sciences

The Department of Geological and Atmospheric Sciences seeks to establish innovative teaching and outstanding research programs that apply fundamental principles of physics, chemistry, biology, and mathematics to cross-disciplinary problems related to the Earth sciences. As a basis for this mission, the Department maintains strength in fundamental topics of geology, meteorology, and hydrology that involve investigating the dynamic nature of the structure, composition, and interactive processes of the Earth and its component systems. Study of these systems includes the application of scientific principles to a wide range of environmental, agricultural, and natural-resource problems, so that through its teaching and research activities, the Department fosters a global perspective on the geosciences. Individual elements of study, such as atmospheric-circulation patterns, water cycling, geochemical interactions, glacier dynamics, or rock formation, are viewed not only in terms of their own intrinsic value, but also in terms of their role in the evolving Earth system. The Department recognizes that many fundamental advances in the geosciences are occurring at the interfaces with other disciplines and between subdisciplines in the field, so Department faculty strive to form mutually beneficial research and educational collaborations with other programs at Iowa State University and other institutions around the world by taking a leadership position in solving problems at these interfaces.

Undergraduate Study

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.

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, mineral and petroleum exploration, and graduate study in most aspects of geology. Required courses in this option include:

GEOL 100	The Earth	3
GEOL 100L	The Earth: Laboratory	1
GEOL 102	History of the Earth	3
GEOL 102L	History of the Earth: Laboratory	1
GEOL 302	Summer Field Studies	6
GEOL 315	Mineralogy and Earth Materials	3
GEOL 315L	Laboratory in Mineralogy and Earth Materials	1
GEOL 316	Optical Mineralogy	2
GEOL 356	Structural Geology	5
GEOL 365	Igneous and Metamorphic Petrology	3
GEOL 368	Stratigraphy and Sedimentation	4
GEOL 479	Surficial Processes	3
And 9 credits of geology electives		9
Total Credits		44

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

GEOL 100	The Earth	3
GEOL 100L	The Earth: Laboratory	1
GEOL 102	History of the Earth	3
GEOL 102L	History of the Earth: Laboratory	1
GEOL 302	Summer Field Studies	6
GEOL 315	Mineralogy and Earth Materials	3
GEOL 315L	Laboratory in Mineralogy and Earth Materials	1
GEOL 316	Optical Mineralogy	2
GEOL 356	Structural Geology	5
GEOL 368	Stratigraphy and Sedimentation	4

GEOL 411	Hydrogeology	4
One of the following		3
GEOL 419	Environmental Geochemistry	
GEOL 426	Stable Isotopes in the Environment	
GEOL 434	Contaminant Hydrogeology	
GEOL 479	Surficial Processes	3
And 6 credits of geology electives		6
Total Credits		45

Required supporting courses include:

CHEM 177	General Chemistry I	4
CHEM 177L	Laboratory in General Chemistry I	1
CHEM 178	General Chemistry II	3
CHEM 178L	Laboratory in College Chemistry II	1
PHYS 111	General Physics	5
PHYS 112	General Physics	5
One of the following		4
MATH 165	Calculus I	
MATH 181	Calculus and Mathematical Modeling for the Life Sciences I	
One of the following		4
MATH 166	Calculus II	
MATH 182	Calculus and Mathematical Modeling for the Life Sciences II	
And 6 additional credits from an approved departmental list of courses in the science, engineering, or mathematical disciplines outside of geology		6
Total Credits		33

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

See Four-Year Graduation Plan: B.S. in Geology - Traditional Option

See Four-Year Graduation Plan: B.S. in Geology - Environmental-Geology/Hydrogeology Option

Minor - Geology

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

GEOL 100	The Earth	3-4
& 100L	and The Earth: Laboratory	
or GEOL 201	Geology for Engineers and Environmental Scientists	
GEOL 102	History of the Earth	3
GEOL 102L	History of the Earth: Laboratory	1
Total Credits		7-8

The remainder should be at the 300 level or above.

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.

The study of Meteorology involves the description of the earth's atmosphere and the processes responsible for its behavior. Students majoring in Meteorology earn the bachelor of science. The major satisfies guidelines specified by the American Meteorological Society and meets education requirements for employment with the National Weather Service and the World Meteorological Organization. Successful preparation for professional or graduate work in Meteorology requires that the student develop and integrate a diverse range of skills and knowledge bases. These include weather observing, the physics and dynamics of the global atmosphere, application of new weather technologies, advanced mathematical tools, computer programming and modeling, and effective oral and written communication. The faculty view the senior thesis (MTEOR 499 Senior Research), in particular, as a capstone experience in which students demonstrate they have achieved this integration. Also, contemporary meteorology is an earth-system science with ties to a variety of human experiences. The electives and general education requirements of the college are further experiences that the

meteorology student must integrate with their core meteorology knowledge in order to function effectively in a globally-oriented profession. The program requires the following courses:

MTEOR 111	Synoptic Applications	1
MTEOR 201	Introductory Seminar	R
MTEOR 206	Introduction to Weather and Climate	3
MTEOR 301	General Meteorology	4
MTEOR 311	Introduction to Synoptic Meteorology	2
MTEOR 341	Atmospheric Physics I	3
MTEOR 342	Atmospheric Physics II	3
MTEOR 411	Synoptic Meteorology	3
MTEOR 417	Mesoscale Forecasting Laboratory	3
MTEOR 432	Instrumentation and Measurements	3
MTEOR 443	Dynamic Meteorology I	3
MTEOR 454	Dynamic Meteorology II	3
MTEOR 499	Senior Research	2
Total Credits		33

An additional 9 credits must be chosen from:

MTEOR 402	Watershed Hydrology	4
MTEOR 404	Global Change	3
MTEOR 405	Environmental Biophysics	3
MTEOR 406	World Climates	3
MTEOR 407	Mesoscale Meteorology	3
MTEOR 452	Climate Modeling	3
MTEOR 490	Independent Study	1-3
GEOL 415	Paleoclimatology	3
or C E 372	Engineering Hydrology and Hydraulics	

Supporting work is required in areas at least equivalent to:

One of the following sequences		4
CHEM 163 & 163L	College Chemistry and Laboratory in College Chemistry	
Or		
CHEM 177 & 177L	General Chemistry I and Laboratory in General Chemistry I	
COM S 207	Fundamentals of Computer Programming	3
PHYS 221	Introduction to Classical Physics I	5
PHYS 222	Introduction to Classical Physics II	5
MATH 165	Calculus I	4
MATH 166	Calculus II	4
MATH 265	Calculus III	4
MATH 266	Elementary Differential Equations	3
STAT 105	Introduction to Statistics for Engineers	3
SP CM 212	Fundamentals of Public Speaking	3
Total Credits		38

A grade of C or better (not C-) is required in each of the following courses to meet minimum graduation requirements for a bachelor of science degree in Meteorology:

MTEOR 206	Introduction to Weather and Climate	3
MTEOR 301	General Meteorology	4

Several co-op programs are available for upper division undergraduates. Although a range of opportunities exists for men and women who terminate their studies with a bachelor of science, students who meet the necessary academic standards are encouraged to continue their studies in a graduate program. For these students, additional coursework is recommended in a mathematical or physical science. Other students can choose a wide range of supporting courses that will contribute to their particular area of interest in meteorology.

Minor - Meteorology

The department offers a minor in Meteorology which may be earned by completing 15 credits including MTEOR 111 Synoptic Applications (only 1 credit may count toward the minor), MTEOR 206 Introduction to Weather and Climate and MTEOR 301 General Meteorology. Further information concerning programs of study, including sample degree programs, is available from the department.

Major - Earth Science

The **Earth Science major** is a broad program that typically emphasizes an interdisciplinary field. Programs leading to the bachelor of science may be individually designed but will include required courses in Geology and Meteorology, and required supporting work in chemistry, physics, and mathematics. Specific programs have been designed for students interested in a geology, meteorology, or an environmental earth science emphasis. Programs leading to the bachelor of arts for earth science teaching are available. The latter program must satisfy the requirements of the Teacher Education Program (see Index, Teacher Education).

See Four-Year Graduation Plan: B.S. in Earth Science

See Four-Year Graduation Plan: B.A. in Earth Science

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

ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
or ENGL 250H	Written, Oral, Visual, and Electronic Composition: Honors	
One of the following		3
ENGL 309	Report and Proposal Writing	
ENGL 314	Technical Communication	
ENGL 302	Business Communication	
JL MC 347	Science Communication	

Total Credits 9

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.

All candidates for an advanced degree in Meteorology are expected to complete:

MTEOR 542	Physical Meteorology	3
MTEOR 543	Advanced Dynamic Meteorology I	3
MTEOR 552	Climate Modeling	3

In addition, students without prior synoptic course-work must complete MTEOR 511 Synoptic Meteorology; other students must complete:

MTEOR 507	Mesoscale Meteorology	3
AGRON 507	Mesoscale Meteorology	3

MTEOR 504	Global Change	3
or AGRON 504	Global Change	
MTEOR 605	Boundary-Layer Meteorology	3
or AGRON 505	Environmental Biophysics	

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.

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.S.

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.

Introduction to study of the oceans. Ocean exploration. Waves and currents. Shape, structure, and origin of the ocean basins. Sedimentary record of oceanic life. Composition of seawater and its significance for life. Ocean circulation and its influence on climate. Life of the oceans, including coral reefs. Use and misuse of ocean resources. Anthropogenic impacts on the oceanic environment.

GEOL 109. Exploring Iowa Geology.

(1-0) Cr. 1. Repeatable, maximum of 2 times. F.

Introduction to Iowa geology through classroom lectures and up to four Saturday field trips to selected Iowa geological attractions. Students will learn basic geologic concepts such as geologic time, erosion and sedimentation, stratigraphy, glacial geology, and karst topography using Iowa examples.

GEOL 111. Geological Disasters.

(Cross-listed with ENV S). (1-0) Cr. 1. F.S.SS.

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 MTEOR, ENV S, AGRON). (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.

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. 2-4. Repeatable. *Prereq: Permission of instructor*

GEOL 298. 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; 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. Nonmajor graduate credit.

GEOL 306. Geology Field Trip.

Cr. 1-2. Repeatable. F.S. *Prereq: GEOL 100 or GEOL 201*

Geology of selected regions studied by correlated readings followed by a field trip to points of geologic interest. Ten-day field trip required.

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. Nonmajor graduate credit.

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. Nonmajor graduate credit.

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. Nonmajor graduate credit.

GEOL 324. Energy and the Environment.

(Cross-listed with ENV S, MTEOR). (3-0) Cr. 3. S. Renewable and non-renewable energy resources. Origin, occurrence, and extraction of fossil fuels. Nuclear, wind, geothermal, biomass, hydroelectric, and solar energy. Biofuels. Energy efficiency. Environmental effects of energy production and use, including air pollution, acid precipitation, coal ash, mountaintop removal mining, oil drilling, hydraulic fracturing, groundwater contamination, nuclear waste disposal, and global climate change. Carbon sequestration and geoengineering solutions for reducing atmospheric CO₂ concentrations. GEOL 324 does not count toward credits required in the Geology major.

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. Nonmajor graduate credit.

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. Nonmajor graduate credit.

GEOL 368. Stratigraphy and Sedimentation.

(3-2) Cr. 4. F. *Prereq:* GEOL 315, GEOL 315L, GEOL 316 Origin of sedimentary rocks and the characteristics of major depositional systems, geologic time, stratigraphic nomenclature, methods of correlation, facies and facies analysis, sequence stratigraphy, sedimentary tectonics and basin analysis. Required field and laboratory-based problem with a comprehensive written report. Nonmajor graduate credit.

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). (3-3) Cr. 4. 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. Nonmajor graduate credit.

GEOL 409. Field Methods in Hydrogeology.

(Dual-listed with GEOL 509). (Cross-listed with ENSCI). (0-4) Cr. 3. Alt. SS., offered 2012. *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. Nonmajor graduate credit.

GEOL 414. Applied Groundwater Flow Modeling.

(Dual-listed with GEOL 514). (Cross-listed with ENSCI). (2-2) Cr. 3. Alt. S., offered 2012. *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. Nonmajor graduate credit.

GEOL 415. Paleoclimatology.

(Dual-listed with GEOL 515). (Cross-listed with ENSCI). (3-0) Cr. 3. Alt. S., offered 2013. *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). Nonmajor graduate credit.

GEOL 416. Hydrologic Modeling and Analysis.

(Dual-listed with GEOL 516). (Cross-listed with MTEOR, ENSCI). (2-3) Cr. 3. Alt. S., offered 2013. *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. Nonmajor graduate credit.

GEOL 419. Environmental Geochemistry.

(Dual-listed with GEOL 519). (Cross-listed with ENSCI). (2-2) Cr. 3. F. *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. Nonmajor graduate credit.

GEOL 420. Mineral Resources.

(Dual-listed with GEOL 520). (2-3) Cr. 3. Alt. F., offered 2012. *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. F., offered 2011. *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. Nonmajor graduate credit.

GEOL 434. Contaminant Hydrogeology.

(Dual-listed with GEOL 534). (Cross-listed with ENSCI). (3-0) Cr. 3. S. *Prereq:* GEOL 411 or equivalent Theory and practical considerations of fate and transport of solutes through porous geologic materials. Organic and inorganic contaminants in industrial and agricultural settings. Subsurface microbiology and biodegradation of aromatic and chlorinated hydrocarbons. Investigation of coupled processes (diffusion, advection, dispersion, sorption, and biodegradation) using computer models. Soil and groundwater monitoring and remediation strategies. Nonmajor graduate credit.

GEOL 451. Applied and Environmental Geophysics.

(Dual-listed with GEOL 551). (Cross-listed with ENSCI). (2-2) Cr. 3. Alt. S., offered 2012. *Prereq:* GEOL 100 or GEOL 201, MATH 181 or equivalent experience 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. Nonmajor graduate credit.

GEOL 452. GIS for Geoscientists.

(Dual-listed with GEOL 552). (Cross-listed with AGRON). (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. Nonmajor graduate credit.

GEOL 457. Exploration Seismology.

(Dual-listed with GEOL 557). (2-2) Cr. 3. Alt. S., offered 2013. *Prereq:* GEOL 100 or GEOL 201, MATH 181 or equivalent experience or permission of instructor
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. Nonmajor graduate credit.

GEOL 474. Glacial and Quaternary Geology.

(Dual-listed with GEOL 574). (2-2) Cr. 3. Alt. S., offered 2013. *Prereq:* GEOL 100 or GEOL 201 or equivalent experience
The study of glacial 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. Nonmajor graduate credit.

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. Nonmajor graduate credit.

GEOL 488. GIS for Geoscientists II.

(Dual-listed with GEOL 588). (Cross-listed with AGRON, ENSCI). (2-2) Cr. 3. Alt. S., offered 2013. *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. Nonmajor graduate credit.

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.SS. *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). (3-3) Cr. 4. 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. Nonmajor graduate credit.

GEOL 506. Geology Field Trip.

Cr. 1-2. Repeatable. F.S. *Prereq:* Graduate classification
Geology of selected regions studied by correlated readings, followed by a field trip to points of geologic interest. Ten-day field trip.

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 2012. *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 2012. *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 2013. *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 MTEOR, ENSCI). (2-3) Cr. 3. Alt. S., offered 2013. *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. F. *Prereq:* GEOL 511 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 2012. *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. F., offered 2011. *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 534. Contaminant Hydrogeology.

(Dual-listed with GEOL 434). (Cross-listed with ENSCI). (3-0) Cr. 3. S. *Prereq:* GEOL 511 or equivalent

Theory and practical considerations of fate and transport of solutes through porous geologic materials. Organic and inorganic contaminants in industrial and agricultural settings. Subsurface microbiology and biodegradation of aromatic and chlorinated hydrocarbons. Investigation of coupled processes (diffusion, advection, dispersion, sorption, and biodegradation) using computer models. Soil and groundwater monitoring and remediation strategies.

GEOL 542. Optical Mineralogy.

(1-2) Cr. 2. F. *Prereq:* GEOL 311

Introduction to using the microscope for mineral identification. Optical properties of minerals in immersion oils and in thin section. Research project required.

GEOL 551. Applied and Environmental Geophysics.

(Dual-listed with GEOL 451). (Cross-listed with ENSCI). (2-2) Cr. 3. Alt. S., offered 2012. *Prereq:* GEOL 100 or GEOL 201, MATH 181 or equivalent experience

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. Nonmajor graduate credit.

GEOL 552. GIS for Geoscientists.

(Dual-listed with GEOL 452). (Cross-listed with AGRON). (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 2013. *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 555L. Soil Clay Mineralogy Laboratory.

(Cross-listed with AGRON). (0-3) Cr. 1. Alt. S., offered 2013. *Prereq:* Credit or enrollment in AGRON 555

Laird. Application of X-ray diffraction, thermal analysis, infrared spectroscopy, and chemical analyses to identification and behavior of clay minerals in soils.

GEOL 557. Exploration Seismology.

(Dual-listed with GEOL 457). (2-2) Cr. 3. Alt. S., offered 2013. *Prereq:* GEOL 100 or GEOL 201, MATH 181 or equivalent experience or permission of instructor

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 HCI, COM S). (2-2) Cr. 3. Alt. S., offered 2013. *Prereq:* Graduate-student standing in the mathematical or natural sciences

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, engineering). Class project in interactive 3D visualization using the OpenDX, VTK or a similar system.

GEOL 574. Glacial and Quaternary Geology.

(Dual-listed with GEOL 474). (2-2) Cr. 3. Alt. S., offered 2013. *Prereq:* GEOL 100 or GEOL 201

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 2013. *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 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: Paleocology 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: Paleocology 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: Paleocology 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.

Courses primarily for undergraduates:**MTEOR 107. Severe and Hazardous Weather.**

(2-0) Cr. 1. F.

Understanding of atmospheric processes that play a role in creating severe and hazardous weather. Focus on thunderstorms, tornadoes, hurricanes, floods, blizzards, ice storms, and temperature extremes. Impacts on lives and property.

MTEOR 111. Synoptic Applications.

(1-0) Cr. 1. Repeatable. F. *Prereq: Credit or enrollment in MATH 165*

Current weather discussions and introduction to synoptic-scale interpretation of meteorology. Application and use of calculus in meteorology. Course restricted to majors. Others with permission of instructor.

MTEOR 112. Geoscience Orientation.

(Cross-listed with GEOL). (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.

MTEOR 160. Water Resources of the World.

(Cross-listed with GEOL, ENV S, AGRON). (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.

MTEOR 201. Introductory Seminar.

(1-0) Cr. R. F. *Prereq: Credit or enrollment in PHYS 221*

An overview of the atmospheric sciences, the meteorology program at Iowa State, and the major research journals used in the discipline.

MTEOR 206. Introduction to Weather and Climate.

(Cross-listed with AGRON). (3-0) Cr. 3. F.S.

Basic concepts in weather and climate, including atmospheric measurements, radiation, stability, precipitation, winds, fronts, forecasting, and severe weather. Applied topics include global warming, ozone depletion, world climates and weather safety.

MTEOR 227. Computational Meteorology I.

(3-1) Cr. 3. F. *Prereq: Credit or concurrent enrollment in MTEOR 206, credit or concurrent enrollment in PHYS 221*

An introduction to computer programming using FORTRAN with focus on meteorological applications. Emphasis on basics of good programming techniques and style through extensive practice in top-down design, writing, running, and debugging small programs. Topics include operations and functions, selective execution, repetitive execution, arrays, input/output, file processing, and subprograms. This course is designed for majors.

MTEOR 265. Scientific Balloon Engineering and Operations.

(Cross-listed with AER E). (0-2) Cr. 1. Repeatable. F.

Engineering aspects of scientific balloon flights. Integration of science mission objectives with engineering requirements. Operations team certification. FAA and FCC regulations, communications, and command systems. Flight path prediction and control.

MTEOR 298. Cooperative Education.

Cr. R. F.S.SS. *Prereq: 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.

MTEOR 301. General Meteorology.

(4-0) Cr. 4. S. *Prereq: MATH 166, credit or enrollment in PHYS 222*

Global distribution of temperature, wind, and atmospheric constituents; atmospheric thermodynamics, radiative transfer, global energy balance, storms and clouds, introductory dynamics. Nonmajor graduate credit.

MTEOR 311. Introduction to Synoptic Meteorology.(1-2) Cr. 2. F. *Prereq: MTEOR 301*

Concepts of weather map plotting and analysis. Introduction to forecasting and to the use of real-time UNIDATA computer products. Nonmajor graduate credit.

MTEOR 321. Meteorology Internship.Cr. 1-2. Repeatable, maximum of 3 credits. F.S.SS. *Prereq: MTEOR 311; junior or senior standing; permission of co-op program coordinator; acceptance by sponsoring agency*

Supervised practical experience in a professional meteorological agency. Experiences may include providing weather information for radio, TV, utilities, government agencies, construction, or agribusiness.

MTEOR 324. Energy and the Environment.

(Cross-listed with ENV S, GEOL). (3-0) Cr. 3. S.

Renewable and non-renewable energy resources. Origin, occurrence, and extraction of fossil fuels. Nuclear, wind, geothermal, biomass, hydroelectric, and solar energy. Biofuels. Energy efficiency. Environmental effects of energy production and use, including air pollution, acid precipitation, coal ash, mountaintop removal mining, oil drilling, hydraulic fracturing, groundwater contamination, nuclear waste disposal, and global climate change. Carbon sequestration and geoengineering solutions for reducing atmospheric CO₂ concentrations. GEOL 324 does not count toward credits required in the Geology major.**MTEOR 341. Atmospheric Physics I.**(3-0) Cr. 3. F. *Prereq: PHYS 222, credit or enrollment in MATH 266*

Basic laws of thermodynamics, thermodynamics of water vapor, mixtures of gases, stability, hydrostatics, cloud physics. Nonmajor graduate credit.

MTEOR 342. Atmospheric Physics II.(3-0) Cr. 3. S. *Prereq: MTEOR 341*

Precipitation physics, radar, atmospheric radiation, atmospheric optics, atmospheric electricity. Nonmajor graduate credit.

MTEOR 398. Cooperative Education.Cr. R. F.S.SS. *Prereq: Permission of the department cooperative education coordinator; junior classification*

Required of all cooperative education students. Students must register for this course prior to commencing the work period.

MTEOR 402. Watershed Hydrology.

(Dual-listed with MTEOR 502). (Cross-listed with ENSCI, GEOL, NREM). (3-3) Cr.

4. 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. Nonmajor graduate credit.

MTEOR 404. Global Change.

(Dual-listed with MTEOR 504). (Cross-listed with AGRON, ENSCI, ENV S). (3-0)

Cr. 3. S. *Prereq: Four courses in physical or biological sciences or engineering; junior standing*

Recent changes in global biogeochemical cycles and climate; models of future changes in the climate system; impacts of global change on agriculture, water resources and human health; ethical issues of global environmental change. Nonmajor graduate credit.

MTEOR 405. Environmental Biophysics.

(Dual-listed with MTEOR 505). (Cross-listed with AGRON, ENSCI). (3-0) Cr. 3.

Alt. S., offered 2013. *Prereq: MATH 165 or MATH 182 or equivalent and some computer programming experience (any language)*

Hornbuckle. A description of the physical microenvironment in which organisms live. Emphasis on the movement of energy (heat and radiation) and mass (water and carbon) among organisms, the soil, and atmosphere. Applications to humans, other animals, plants, and plant communities. Nonmajor graduate credit.

MTEOR 406. World Climates.(Cross-listed with AGRON, ENSCI). (3-0) Cr. 3. F. *Prereq: AGRON 206/MTEOR 206*

Arritt. Distribution and causes of different climates around the world. Effects of climate and climate variations on human activities including society, economy and agriculture. Current issues such as climate change and international efforts to assess and mitigate the consequences of a changing climate. Semester project and in-class presentation required. Nonmajor graduate credit.

Meets International Perspectives Requirement.

MTEOR 407. Mesoscale Meteorology.(Dual-listed with MTEOR 507). (Cross-listed with AGRON). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: Math 166 and Mteor 443*

Gallus. Physical nature and practical consequences of mesoscale atmospheric phenomena. Mesoscale convective systems, fronts, terrain-forced circulations. Observation, analysis, and prediction of mesoscale atmospheric structure.

MTEOR 411. Synoptic Meteorology.(Dual-listed with MTEOR 511). (1-4) Cr. 3. F. *Prereq: MTEOR 311, Credit or enrollment in MTEOR 454*

Current weather forecasting and discussion. Applications of atmospheric physics and dynamics in real-time weather situations. Use of UNIDATA computer products.

MTEOR 416. Hydrologic Modeling and Analysis.(Dual-listed with MTEOR 516). (Cross-listed with GEOL, ENSCI). (2-3) Cr. 3. Alt. S., offered 2013. *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. Nonmajor graduate credit.

MTEOR 417. Mesoscale Forecasting Laboratory.(1-5) Cr. 3. S. *Prereq: Credit or enrollment in MTEOR 411*

Real-time computer analysis of current weather, with emphasis on small-scale features. Studies of severe weather, lake-effect snow, CSI, cold-air damming. Nonmajor graduate credit.

MTEOR 432. Instrumentation and Measurements.(2-2) Cr. 3. S. *Prereq: Credit or enrollment in STAT 105, MATH 266, PHYS 222*

Measurement of meteorological variables and instruments used, including surface, upper air, and remote sensors; measurement errors, signal processing, recording and archiving; quality assurance. Nonmajor graduate credit.

MTEOR 443. Dynamic Meteorology I.(3-0) Cr. 3. S. *Prereq: MTEOR 341*

Conservation laws, governing equations, circulation and vorticity. Development of quasi-geostrophic theory. Nonmajor graduate credit.

MTEOR 452. Climate Modeling.(Dual-listed with MTEOR 552). (3-0) Cr. 3. F. *Prereq: Mteor 301*

Developing and working with climate models based on fundamental physical principles that govern the climate systems of the Earth and other planets. Emphasis on coupled, nonlinear-system interactions of physical processes such as circulation dynamics, radiative transfer, and cloud/precipitation physics, starting with fairly simple 0- and 1-dimensional analytical and numerical models based on energy, mass, and momentum conservation. Observational study of seasonally evolving weather patterns that form climates around the world. Nonmajor graduate credit.

MTEOR 454. Dynamic Meteorology II.(3-0) Cr. 3. F. *Prereq: MTEOR 443*

Planetary boundary layer, linear perturbation theory, atmospheric wave motions, baroclinic and convective instability, mesoscale circulations. Nonmajor graduate credit.

MTEOR 471. History of Modern Meteorology.(Dual-listed with MTEOR 571). (1-0) Cr. 1. Alt. S., offered 2012. *Prereq: MTEOR 341, MTEOR 342, MTEOR 411, MTEOR 443, MTEOR 452*

Development of meteorological theories and numerical weather prediction, discoveries of important meteorological phenomena, and impact of weather and climate on important historical events.

MTEOR 490. Independent Study.Cr. 1-3. Repeatable, maximum of 9 credits. *Prereq: 6 credits in meteorology, permission of instructor*

No more than 9 credits in Mteor 490 may be counted toward graduation.

MTEOR 490A. Independent Study: Synoptic Meteorology..Cr. 1-3. Repeatable, maximum of 9 credits. *Prereq: 6 credits in meteorology, permission of instructor*

No more than 9 credits in Mteor 490 may be counted toward graduation.

MTEOR 490B. Independent Study: Dynamic Meteorology..Cr. 1-3. Repeatable, maximum of 9 credits. *Prereq: 6 credits in meteorology, permission of instructor*

No more than 9 credits in Mteor 490 may be counted toward graduation.

MTEOR 490C. Independent Study: Physical Meteorology..

Cr. 1-3. Repeatable, maximum of 9 credits. *Prereq: 6 credits in meteorology, permission of instructor*

No more than 9 credits in Mteor 490 may be counted toward graduation.

MTEOR 490D. Independent Study: Instrumentation..

Cr. 1-3. Repeatable, maximum of 9 credits. *Prereq: 6 credits in meteorology, permission of instructor*

No more than 9 credits in Mteor 490 may be counted toward graduation.

MTEOR 490E. Independent Study: Hydrology..

Cr. 1-3. Repeatable, maximum of 9 credits. *Prereq: 6 credits in meteorology, permission of instructor*

No more than 9 credits in Mteor 490 may be counted toward graduation.

MTEOR 498. Cooperative Education.

Cr. R. F.S.SS. *Prereq: 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.

MTEOR 499. Senior Research.

(2-0) Cr. 2. F.

Required of all senior meteorology majors. Research projects in collaboration with faculty. Written and oral presentations of results at the end of the semester.

Courses primarily for graduate students, open to qualified undergraduates:**MTEOR 502. Watershed Hydrology.**

(Dual-listed with MTEOR 402). (Cross-listed with ENSCI, GEOL, NREM). (3-3) Cr. 4. 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. Nonmajor graduate credit.

MTEOR 504. Global Change.

(Dual-listed with MTEOR 404). (Cross-listed with AGRON, ENSCI, ENV S). (3-0) Cr. 3. S. *Prereq: Four courses in physical or biological sciences or engineering; junior, senior, or graduate standing*

Recent changes in global biogeochemical cycles and climate; models of future changes in the climate system; impacts of global change on agriculture, water resources and human health; ethical issues of global environmental change.

MTEOR 505. Environmental Biophysics.

(Dual-listed with MTEOR 405). (Cross-listed with AGRON, ENSCI). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: MATH 165 or MATH 182 or equivalent and some computer programming experience (any language)*

Hornbuckle. A description of the physical microenvironment in which organisms live. Emphasis on the movement of energy (heat and radiation) and mass (water and carbon) among organisms, the soil, and atmosphere. Applications to humans, other animals, plants, and plant communities. Nonmajor graduate credit.

MTEOR 507. Mesoscale Meteorology.

(Dual-listed with MTEOR 407). (Cross-listed with AGRON). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: Math 166 and Mteor 443*

Gallus. Physical nature and practical consequences of mesoscale atmospheric phenomena. Mesoscale convective systems, fronts, terrain-forced circulations. Observation, analysis, and prediction of mesoscale atmospheric structure.

MTEOR 511. Synoptic Meteorology.

(Dual-listed with MTEOR 411). (1-4) Cr. 3. F. *Prereq: MTEOR 311, Credit or enrollment in MTEOR 454*

Current weather forecasting and discussion. Applications of atmospheric physics and dynamics in real-time weather situations. Use of UNIDATA computer products.

MTEOR 516. Hydrologic Modeling and Analysis.

(Dual-listed with MTEOR 416). (Cross-listed with GEOL, ENSCI). (2-3) Cr. 3. Alt. S., offered 2013. *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.

MTEOR 518. Microwave Remote Sensing.

(Cross-listed with AGRON, E E). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: Math 265 or equivalent*

Microwave remote sensing of Earth's surface and atmosphere using satellite-based or ground-based instruments. Specific examples include remote sensing of atmospheric temperature and water vapor, precipitation, ocean salinity, and soil moisture.

MTEOR 542. Physical Meteorology.

(3-0) Cr. 3. F. *Prereq: MTEOR 342, MATH 266, PHYS 222*

Planetary atmospheres, radiative equilibrium models, radiative transfer, the upper atmosphere, remote sounding from satellites.

MTEOR 543. Advanced Dynamic Meteorology I.

(3-0) Cr. 3. Alt. F., offered 2012. *Prereq: MTEOR 455*

The first half of a two semester sequence. Governing equations, scale analysis, simple types of wave motion in the atmosphere, instability theory.

MTEOR 544. Advanced Dynamic Meteorology II.

(3-0) Cr. 3. Alt. S., offered 2012. *Prereq: MTEOR 543*

Continuation of 543. General circulation and dynamics of zonally symmetric circulations, atmospheric energetics, nonlinear dynamics of planetary waves.

MTEOR 552. Climate Modeling.

(Dual-listed with MTEOR 452). (3-0) Cr. 3. F. *Prereq: Mteor 301*

Developing and working with climate models based on fundamental physical principles that govern the climate systems of the Earth and other planets. Emphasis on coupled, nonlinear-system interactions of physical processes such as circulation dynamics, radiative transfer, and cloud/precipitation physics, starting with fairly simple 0- and 1-dimensional analytical and numerical models based on energy, mass, and momentum conservation. Observational study of seasonally evolving weather patterns that form climates around the world.

MTEOR 571. History of Modern Meteorology.

(Dual-listed with MTEOR 471). (1-0) Cr. 1. Alt. S., offered 2012. *Prereq: MTEOR 341, MTEOR 342, MTEOR 411, MTEOR 443, MTEOR 452*

Development of meteorological theories and numerical weather prediction, discoveries of important meteorological phenomena, and impact of weather and climate on important historical events.

MTEOR 590. Special Topics.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590A. Special Topics: Boundary-layer Meteorology.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590B. Special Topics: Tropical Meteorology.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590C. Special Topics: Mesoscale Meteorology.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590D. Special Topics: Global Climate Systems.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590E. Special Topics: Climate Modeling.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590F. Special Topics: Numerical Weather Prediction.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590G. Special Topics: Satellite Observations.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590H. Special Topics: Statistical Methods in Meteorology.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590I. Special Topics: Field Observations.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590J. Special Topics: Low Frequency Modes.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590K. Special Topics: Cloud Physics.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590L. Special Topics: Atmospheric Radiation.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590M. Special Topics: Hydrology.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 590N. Special Topics: Geophysical Fluid Dynamics.

Cr. 1-3. Repeatable. *Prereq: Permission of instructor*
Topics of current interest.

MTEOR 595. Graduate Seminar.

(Cross-listed with GEOL). 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.

MTEOR 595A. Graduate Seminar: Presentation Required.

(Cross-listed with GEOL). (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.

MTEOR 595B. Graduate Seminar: Attendance Only.

(Cross-listed with GEOL). 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.

Courses for graduate students:

MTEOR 605. Boundary-Layer Meteorology.

(3-0) Cr. 3. Alt. F., offered 2012. *Prereq: MTEOR 443 or equivalent-level course in engineering fluids*

Atmospheric boundary-layer structure and dynamics. Diurnal and seasonal variations, turbulent fluxes and turbulence kinetic energy. Measurements and empirical relations for wind and temperature near the ground. Numerical simulation and applications to wind energy.

MTEOR 699. Research.

Cr. arr. Repeatable.