

# EARTH AND PLANETARY SCIENCES (EARTH)

**EARTH 101-0 Earth Science for the 21st Century (1 Unit)** Introduction to earth science through topical issues facing contemporary society. Evolution of the earth, geologic hazards, natural resources, peak oil, climate change, the water cycle, nuclear fuel cycle, geology of US national parks. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 102-7 College Seminar (1 Unit)** Small, writing and discussion-oriented course exploring a specific topic or theme, and introducing skills necessary to thriving at Northwestern. Not eligible to be applied towards a WCAS major or minor except where specifically indicated.

**EARTH 102-8 First-Year Writing Seminar (1 Unit)** Small, writing and discussion-oriented course exploring a specific topic or theme, and focused on the fundamentals of effective, college-level written communication. Not eligible to be applied towards a WCAS major or minor except where specifically indicated.

**EARTH 105-0 Climate Catastrophes in Earth History (1 Unit)** Introduction to fundamental components of the earth system that control climate. Exploration of present-day climate change and how climate has changed (sometimes catastrophically) in the geologic past. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 106-0 The Ocean, the Atmosphere & Our Climate (1 Unit)** The role of the world's oceans in the earth's climate system. Properties of the oceans and marine life. Interaction of oceans, atmosphere, and land. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 114-0 Evolution and the Scientific Method (1 Unit)** Review of evolutionary theory and its scientific, philosophical, social, and religious impacts. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 180-0 Fantasy Worlds – How to Build Your Own Planet (1 Unit)** The formation and evolution of rocky planets. Introduction of physical concepts common in the lives of planets as they are in our everyday lives: gravity, heat transport, magnetism, and others. Students will apply these concepts to build their own unique planet, and will present their creation at a culminating poster presentation. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 203-0 Earth System History (1 Unit)** Evolution of the earth system and its record through geological time. Interactions among the atmosphere, hydrosphere, sediments, and life on earth. Recommended Background: At least one credit in math, chemistry, biology or physics. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 210-0 Earth Systems Science and Climate Change (1 Unit)** This course covers Earth systems: atmosphere, biosphere, hydrosphere, and geosphere, and their interactions at local and global scales. Topics include an introduction to systems thinking, how Earth processes formed and modify surface environments and climate, the planetary history of Earth systems, and modern human impacts on Earth and climate. Students may not enroll if they have previously completed EARTH 203-0 or ENVR\_SCI 201-0. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 211-0 Data Analysis in Earth and Environmental Sciences (1 Unit)** Overview of data analysis and modeling approaches used in earth, environmental, and planetary sciences, including data standards, environmental statistics, box modeling, geospatial and geo-temporal analyses. Assessments focus on skill-mastery, and include small group

mini-projects. The data sets used span sub-disciplines of earth and environmental sciences, such as population, climate, solid earth, and water science. *Empirical and Deductive Reasoning Foundational Dis Formal Studies Distro Area*

**EARTH 212-0 Ecology & Environmental Change (1 Unit)** Dimensions of the ecological niche; growth and regulation of populations; interactions among populations; community structure and diversity; conservation. Students may not enroll if they have previously completed ENVR\_SCI 202. *Natural Sciences Distro Area*

**EARTH 213-0 Decision-Making in the Anthropocene (1 Unit)** Introduction to human interactions with the environment. Topics may include but are not limited to energy, sustainability, pollution, and climate change. Students may not enroll if they have previously completed ENVR\_SCI 203. *Natural Sciences Distro Area*

**EARTH 214-0 Physical Earth Science (1 Unit)** Physical Earth Science synthesizes physical geology and historical geology. Physical geology examines the creation, modification, and characterization of rocks and minerals, as well as internal and external processes that shape the planet. Historical geology examines the origin and evolution of Earth and life through time. The course includes required laboratory sections and culminates with a required weekend field trip. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 215-0 Physics of the Earth's Interior (1 Unit)** The earth as a planet: origin, composition, and evolution of the solar system and the earth; internal structure of the earth; plate tectonics. Recommended Background: At least one credit in math, chemistry, biology or physics. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 300-0 Earth and Planetary Materials (1 Unit)**

Mineralogy of the earth and planets from atomic to continental scales, focusing on structure, composition, identification, and physical properties of minerals as they pertain to geological and societal applications. Recommended Background: At least one course in each of chemistry, physics, and math. *Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 301-0 Petrology: Evolution of Crustal and Mantle Rocks (1 Unit)**

Origin, composition, and classification of igneous, metamorphic, and sedimentary rocks. Application of laboratory characterization and basic thermodynamics to interpreting observed rock textures and mineral assemblages in terms of geological processes. *Natural Sciences Distro Area*

**EARTH 310-0 Aqueous Geochemistry (1 Unit)**

The geochemistry of rivers, groundwater, lakes, and seawater. Topics include thermodynamics, kinetics, acids and bases, pH and alkalinity, carbonate equilibria, chemical weathering, and numerical modeling. Recommended Background: At least one year of chemistry coursework. *Natural Sciences Distro Area*

**EARTH 312-0 Stable Isotope Geochemistry (1 Unit)**

Fractionation and distribution of stable isotopes (C, H, N, O, S) in the biosphere, hydrosphere, atmosphere, and geosphere. Isotopic biogeochemistry, environmental problems, and global climate change. Recommended Background: One of EARTH 201-0, EARTH 203-0, EARTH 210-0, EARTH 214-0, ENVR\_SCI 201-0, or equivalent.

**EARTH 313-0 Radiogenic Isotope Geochemistry (1 Unit)**

Application of radiogenic isotopes to problems in geochemistry, petrology, hydrology, oceanography, ecology, and environmental science. Includes radioactive decay, nucleosynthesis, cosmochemistry, geochronology, mixing processes, and numerical modeling. Recommended Background: CHEM 132-0, or equivalent.

**EARTH 314-0 Organic Geochemistry (1 Unit)**

The sources and fates of organic matter in the natural environment; global cycling of organic carbon; applications to the study of modern and ancient environments. Recommended Background: at least one quarter of earth or environmental science, and one quarter of chemistry. Taught with CIV\_ENV 314-0; may not receive credit for both courses.

*Natural Sciences Distro Area*

**EARTH 323-0 Seismology and Earth Structure (1 Unit)**

Elastic theory, seismic waves, seismometers and seismograms, ray paths, travel times; internal structure of the earth; field seismology. Recommended Background: EARTH 202-0 or EARTH 215-0, calculus, ordinary differential equations, and some exposure to complex numbers. No prior earth science experience required.

*Natural Sciences Distro Area*

**EARTH 324-0 Earthquakes and Tectonics (1 Unit)**

Earthquakes: location, characteristics, origin, mechanism, and relation to plate motions; seismic hazard. Recommended Background: Calculus, ordinary differential equations, and some exposure to complex numbers. No prior earth science experience required.

*Natural Sciences Distro Area*

**EARTH 327-0 Geophysical Time Series Analysis (1 Unit)**

Analysis of seismic and other geophysical data. Sampling, windowing, discrete and fast Fourier transforms, z-transforms, deconvolution, and filtering. Recommended Background: EARTH 202-0 or EARTH 215-0, and calculus differential equations; or consent of instructor.

**EARTH 330-0 Sedimentary Geology (1 Unit)**

Sedimentary rocks; stratigraphy; local, regional, and global correlation. Ancient depositional systems; facies analysis in context of tectonic, eustatic, and climatic controls on deposition. Recommended Background: One of EARTH 201-0, EARTH 203-0, EARTH 210-0, EARTH 214-0, ENVR\_SCI 201-0, or consent of instructor.

**EARTH 331-0 Field Problems in Sedimentary Geology (1 Unit)**

Field methods in stratigraphy and sedimentology; interpretation of depositional systems, facies models, and sequence stratigraphy based on field observations. Includes 3½-week late-summer field trip to Colorado and Utah.

Prerequisite: EARTH 330-0.

**EARTH 340-0 Physics of Weather & Climate (1 Unit)**

An investigation of atmospheric processes and the physical laws that govern them. Topics covered include atmospheric composition and structure, radiative transfer, thermodynamics, convection, precipitation, and the general circulation of the three-dimensional atmosphere. When possible, course content will engage with contemporaneous atmospheric conditions, and provide students with a better understanding of their meteorological and climatic environments. Recommended Background: Completion of full year of calculus Math and Physics.

*Natural Sciences Distro Area Natural Sciences Foundational Discipline*

**EARTH 341-0 Quaternary Climate Change: Ice Ages to the Age of Oil (1 Unit)**

Methods for reconstructing and dating past environmental changes, causes of natural climate change, and major climate events of the Quaternary through the present. Their relevance for understanding current climate change.

Prerequisite: At least one 200-level EARTH course; or consent of instructor.

*Natural Sciences Distro Area*

**EARTH 342-0 Contemporary Energy and Climate Change (1 Unit)**

Interdisciplinary course examining global energy use and associated challenges, including the history of energy use, the science of climate

change, and technological, economic, and environmental aspects of various energy sources. Registration reserved for seniors majoring in math, science, or engineering, and graduate students in all disciplines. Taught with ISEN 410-0; may not receive credit for both courses.

*Natural Sciences Distro Area*

**EARTH 343-0 Earth System Modeling (1 Unit)**

Introduction to the art and science of reducing Earth's complex systems into simple numerical models to build a better understanding of how components interact and evolve. Recommended Background: At least one 200-level course in EARTH or ENVR\_SCI, one course in each of calculus and physics.

*Natural Sciences Distro Area*

**EARTH 344-0 The Scientific Foundations of Decarbonization (1 Unit)**

Review of Earth climate controls, the carbon cycle and global warming, and the geoengineering strategies under consideration for mitigation of global climate change.

Prerequisite: one course in Chemistry (e.g. CHEM 131-0 or higher) or Geochemistry (e.g. EARTH 310-0 or higher).

**EARTH 350-0 Physics of the Earth for ISP (1 Unit)**

Solid-earth geophysics: the earth's gravity field, the earth's magnetic field, interior of the earth, heat flow, elementary wave propagation, plate tectonics.

Prerequisites: second-year standing in ISP; or comparable background in mathematics and physics and consent of both instructor and ISP director.

**EARTH 353-0 Mathematical Inverse Methods in Earth and Environmental Sciences (1 Unit)**

Theory and application of inverse methods to gravity, magnetotelluric, seismic, and other data. Nonlinear, linearized, underdetermined, and mixed-determined problems and solution methods, including regularized least-squares and neighborhood algorithms. Recommended Background: Linear algebra and differential calculus of multivariable functions.

**EARTH 354-0 Physics of Rock Deformation in Planetary Interiors (1 Unit)**

Rock deformation, through mobility of crystalline defects, shapes the evolution of terrestrial planets, including mantle convection, plate tectonics, earthquake cycles, and volcanism. Within interdisciplinary treatment of planetary-scale deformation, we emphasize microscopic mechanisms on various time scales, including elastic, viscoelastic, and plastic responses. Special attention is given to high-temperature creep of olivine, the main constituent of the lithosphere and upper mantle. Recommended Background: Students need background in linear algebra and multivariable calculus.

**EARTH 360-0 Instrumentation and Field Methods (1 Unit)**

Theory and practicum on electronic instrumentation for monitoring and measurement in earth sciences, including data loggers, conceptual design and construction of electronic sensors, signal processing, data management, and network design. Recommended Background: 3 EARTH or ENVR SCI courses.

**EARTH 361-0 Scientific Programming in Python (1 Unit)**

Introduction to coding, scientific computing, and visualization for analyzing data in the physical sciences. Emphasis on Python, but Unix, shell scripting, and Generic Mapping Tools are also introduced. Students undertake a significant final coding project individually or in pairs.

*Empirical and Deductive Reasoning Foundational Dis Formal Studies Distro Area*

**EARTH 370-0 Geobiology (1 Unit)**

A technical overview of the major topics of geo(micro)biology highlighting the fossil record, biogeochemical cycling, biomineralization,

key tools of the field, historical geobiology, and astrobiology.

Recommended Background: EARTH 201-0 or EARTH 214-0 (concurrent enrollment acceptable) and first-year chemistry.

*Natural Sciences Distro Area*

**EARTH 371-0 Biogeochemistry (1 Unit)**

The cycling of biogenic elements (C, N, S, Fe, Mn) in surficial environments. Emphasis on microbial processes and isotopic signatures.

Taught with CIV\_ENV 317-0; may not receive credit for both courses.

Recommended Background: At least One course in biology, chemistry, and earth or environmental science. Taught with CIV\_ENV 317-0; may not receive credit for both courses.

*Natural Sciences Distro Area*

**EARTH 373-0 Microbial Ecology (1 Unit)**

This course will provide a framework for understanding the role of microbes in natural environments in terms of cell numbers, metabolisms, and interactions with geochemical cycles. We will delve deeply into the interactions between microbial populations, higher organisms, and even our own bodies. The course will finish on a survey of microbial composition and dynamics in key settings across the planet.

Recommended Background: Basic understanding of chemistry, biology, and earth science.

**EARTH 390-0 Special Topics in Earth, Environmental and Planetary Science (1 Unit)**

Topics of current interest to students and faculty. May be repeated for credit with different topic. Some topics may be approved to be directed to specific requirements of the major or minor in Earth and Planetary Science, or the major in Environmental Science (including Advanced Studies, Sub-Discipline List, or Skills Lists). Prerequisites vary.

**EARTH 397-0 Scientific Communication (1 Unit)**

This course teaches how to speak the language of scientists. Students hone their scientific reading, writing, and presentation skills, breaking manuscripts and proposals down into components, detailing the approach, style, and content required for each. Verbal and visual scientific communication styles including posters and talks are also included. This course includes hands-on daily assignments, peer review, and classroom engagement.

*Advanced Expression*

**EARTH 399-0 Independent Study (1 Unit)** Special problems under direct faculty supervision. Comprehensive report required. Consent of instructor required.