

# GEOSCIENCE (GEO)

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## **GEO 101N - Introduction to Physical Geology. 3 Credits.**

Offered autumn and spring. Broad introduction to physical earth systems including the work of wind, flowing water, glacial ice, gravity, earthquakes, volcanoes and plate tectonics in shaping the earth's environment.

Gen Ed Attributes: Natural Science

## **GEO 102N - Introduction to Physical Geology Lab. 1 Credit.**

Offered autumn and spring. Prereq. or coreq., GEO 101N. A series of laboratory and field experiences designed around basic geologic processes and materials. Familiarization with common minerals, rocks, land forms, and structures. Intended to provide laboratory experience primarily with GEO 101N, but can be taken with or following any of the other freshman GEO courses listed above. Gen Ed Attributes: Natural Science Lab Course (N)

Gen Ed Attributes: Natural Science Lab Course, Natural Science

## **GEO 103N - Introduction to Environmental Geology. 3 Credits.**

Offered autumn and spring. General principles of environmental geology, including the spatial and temporal frameworks involved, Earth's materials (minerals, rocks, water, air), natural hazards, water and air pollution, energy, water, and soil resources, flooding, coastal erosion, and climate.

Gen Ed Attributes: Natural Science

## **GEO 104N - Introduction to Environmental Geology Laboratory. 1 Credit.**

Offered autumn and spring. Prereq. or coreq., GEO 103N. A series of laboratory exercises designed around the investigation of environmental geology problems, including natural hazards, water and air pollution, energy, water, and soil resources, flooding, coastal erosion, and climate.

Gen Ed Attributes: Natural Science Lab Course (N)

Gen Ed Attributes: Natural Science Lab Course, Natural Science

## **GEO 105N - Oceanography. 3 Credits.**

Offered spring. The ocean covers 70 % of the globe, and yet vast regions remain unexplored. Interactions between the atmosphere and the sea moderate and control our climate. Nearly 40 % of the world's population lives within 100 kilometers of the coast. The oceans are geographically, environmentally, culturally, and economically critical to society. This course introduces oceanography, including the origin of water and ocean basins; marine resources; atmospheric circulation; air-sea interaction; ocean-climate feedback; currents, tides, and coastal processes; marine ecology; and use and misuse of the oceans.

Gen Ed Attributes: Natural Science

## **GEO 107N - Natural Disasters. 3 Credits.**

Offered intermittently. This course introduces the scientific context and latest research on natural hazards and disasters, including storms, flood, drought, mass wasting (landslides and avalanches), earthquakes and tsunamis, volcanic eruptions, and wildfires.

Gen Ed Attributes: Natural Science

## **GEO 191 - Special Topics. 1-6 Credits.**

(R-6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

## **GEO 195 - Field Geosciences Methods. 1-6 Credits.**

Field-based instruction of basic geosciences principles. Geosciences field trips around Missoula and classroom meetings to integrate field observations.

## **GEO 201 - Geologic Evolution of North America. 4 Credits.**

Offered autumn and spring. Prereq., EARTH 101N, GEO 101N, GEO 103N, GEO 105N or GEO 107N. Presents scientific evidence and interpretations as to Earth's evolution and history as preserved in the global rock record, including the development of the oceans, atmosphere, climate and biota. Traces Earth's geologic history through time.

## **GEO 202 - The Water Planet. 4 Credits.**

Offered spring. Prereq., GEO 101N or EARTH 101N or GEO 103N or GEO 105N or GEO 107N; and GEO 102N or EARTH 103N or GEO 104N. The Water Planet will introduce students to the study of the hydrologic cycle and associated earth-surface processes. The course will describe the mechanisms that control the movement of water and the influence of water fluxes on landscapes, ecosystems, and humans.

## **GEO 224N - General Science: Physics & Geoscience. 5 Credits.**

Offered autumn. Prereq., M 095 or ALEKS placement  $\geq 4$  or M02-Maplesoft Algebra score  $\geq 12$ . Integrated lectures, discussions, laboratory exercises, and demonstrations on topics in chemical and physical science for prospective elementary school teachers and the non-scientist. A two-hour laboratory session is required each week. Gen Ed Attributes: Natural Science Lab Course (N)

Gen Ed Attributes: Natural Science Lab Course, Natural Science

## **GEO 291 - Special Topics. 1-6 Credits.**

(R-6) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

## **GEO 302 - Mineralogy and Optical Mineralogy. 4 Credits.**

Offered autumn. Prereq., GEO 201 and either CHMY 121N or CHMY 141N. Identification, properties, occurrence, and associations of the rock-forming minerals; introduction to crystallography (crystal classes, lattice types, and external morphology) and crystal chemistry (bonding and crystal structure types); analytical techniques including mineral optics, x-ray, and SEM analysis. \$50.00 field trip and lab fee.

## **GEO 304E - Science and Society. 3 Credits.**

Offered autumn. Role of scientific knowledge in human societies from the pre-Classical to the present. Discussion of tools for integrating science into ethical, political, and social decisions, including analyses of modern case studies from physical sciences.

Gen Ed Attributes: Ethical & Human Values

## **GEO 305 - Igneous & Metamorph Petrology. 4 Credits.**

Offered spring. Prereq., GEO 302. Characteristics, phase relations, and origin of igneous and metamorphic rocks. Classification and interpretation of igneous and metamorphic rocks in hand specimen and thin section. Plate tectonic settings of magmatism and metamorphism.

## **GEO 309 - Sedimentation/Stratigraphy. 4 Credits.**

Offered spring. Prereq. GEO 201, 302. Origins of sediments and sedimentary rocks; climate, weathering, and weathering products; transport, deposition, and depositional environments of sediments; concepts and methods of stratigraphy including correlation of sedimentary rocks and an introduction to basin analysis.

## **GEO 315 - Structural Geology. 4 Credits.**

Offered autumn. Prereq., GEO 201, 302. Structures of deformed rocks; mechanical principles; graphical interpretation of structural problems, tectonic principles.

**GEO 316 - Getting Started in Research. 2 Credits.**

This course introduces students to the process of research and creative inquiry, including how to formulate a research question, how to navigate academic literature, how to develop a research plan, how to connect with faculty mentors, and how to discover opportunities for internships and graduate school. The course prepares students to participate and thrive in undergraduate research experiences, such as a senior thesis, capstone project, or internship. Students may be new to research or already involved in research.

**GEO 318 - Earth's Changing Climate. 3 Credits.**

Offered autumn and/or summer. Prereq., junior standing and M 151 preferred. The future of our climate from the perspective of climate system dynamics. The course has three five-week modules. The first covers the processes and time scales governing Earth's heat balance, the basic rules of changing climate. The second module explores climate variability stemming from internal dynamics of the climate system. The final module examines the grand challenge in climate science: constraining projections of future change with regards to feedbacks and uncertainties in climate system processes. Emerging research is highlighted throughout the course on unsettled scientific problems in climate science and the approaches taken by scientists to solve them.

**GEO 319 - Surface Processes. 3 Credits.**

Offered spring. Prereq. GEO 101N/GEO 102N or EARTH 101N/103N or GEO 103N/GEO 104N, M 122 or M 151. Study of the earth's surface and near surface using the laws and principles of physics. Mechanisms underlying the processes that shape the earth's surface and drive its evolution, including climate, hydrology, geomorphology, and geochemistry.

**GEO 320 - Global Water. 3 Credits.**

Offered autumn. Prereq., CHMY 121N or CHMY 141N/CHMY 142N and WRIT 121, 201, 325, or consent of instructor. Water is necessary for life. Without it, life as we know it cannot exist. This course discusses the chemistry of water as it moves through the hydrological cycle. We discuss how water chemistry evolves through atmospheric water, rain water, ground water, surface water, and sea water. Students will have an understanding of the chemical attributes of water in major water reservoirs. The course is evaluated based on discussions, formal and informal writing assignments and an evidence-based project. Students will use excel to solve problems and will learn citation conventions relevant for scientific writing.

Gen Ed Attributes: Advanced Writing

**GEO 321 - Earth Resources and Sustainability. 3 Credits.**

Prereq., GEO 101N, EARTH 101N, GEO 103N, or GEO 107N. This course explores the nature and critical issues of major types of Earth resources - energy, metallic, non-metallic, water, soil - and the impacts that resource usage has on the Earth environment from both geologic and societal perspectives. Content will include timescales and geological processes of formation and distribution of resource materials and the scope for environmental and climatic change at the Earth's surface. The course will bring together the science of Earth resources with the broader human context of resource exploitation.

**GEO 322 - Energy and the Environment. 3 Credits.**

This course examines all forms of energy used by humans historically and today including renewable and conventional forms. Each energy form will be examined in terms of the technology behind it, sustainability pros/cons particularly as regards the environment, and the potential role of each for stabilizing atmospheric carbon dioxide levels.

**GEO 323 - Computational Methods for Earth and Environmental Scientists. 3 Credits.**

Prereq., M 121. In this course, students obtain a panoramic and practical understanding of computational methods commonly used in the field of Earth and Environmental Sciences and learn how to use the Python programming language to apply these methods for environmental data analysis. The course covers topics in statistical inference, hypotheses testing, solution of linear and nonlinear system and solution of ordinary differential equations.

**GEO 327 - Geochemistry. 3 Credits.**

Offered alternate years. Prereq., CHMY 121N or CHMY 141N/142N, M 171/M 172, and GEO 101N/GEO 102N or EARTH 101N/103N or GEO 103N/GEO 104N, or consent of instructor. The chemical properties of elements control their geological distribution and underlie the basic physical properties of rocks. An understanding of geochemistry will help students understand water chemistry, sediment geochemistry, and igneous petrology. The course covers chemical principles applied to geologic materials and processes, including the origin and chemical composition of earth, atmosphere, and hydrosphere. Principles of stable and radiogenic isotope geochemistry are discussed. Students will use excel to solve problems. Class discussions, problems sets, written assignments, and exams are used to assess student performance.

**GEO 390 - Research. 1-6 Credits.**

Offered intermittently. Directed individual research and study appropriate to the background and objectives of the student. Level: Undergraduate

**GEO 391 - Special Topics. 1-9 Credits.**

(R-9) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics.

**GEO 392 - Independent Study. 1-6 Credits.**

(R-6) Offered every term. Specific topics of particular interest to individual students.

**GEO 394 - Seminar/Workshop. 1-9 Credits.**

(R-9) Offered intermittently. A review and discussion of current research. Topics vary.

**GEO 398 - Internship. 1-6 Credits.**

Offered every term. Prereq., 12 credits in geosciences. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office. No more than 3 credits of GEO 398 may be applied to the geosciences minor. A maximum of 6 credits of Internship may count toward graduation.

**GEO 409 - Careers in Geosciences. 1 Credit.**

Geoscience graduates have a rich portfolio of career options. This course explores the spectrum of career available to Geoscience students and the tools to ensure a successful career. Invited speakers, mostly alumni of the Geosciences program at UM, describe their career, the skills required by their profession, and provide advice on how to maximize education for success in their field. Speakers are chosen to represent the broad spectrum of career paths and employer opportunities in the Geosciences. Level: Undergraduate-Graduate

**GEO 420 - Hydrogeology. 4 Credits.**

Offered spring. Prereq., GEO 101N/GEO 102N or EARTH 101N/103N or GEO 103N/GEO 104N; PHSX 205N/PHSX 206N or PHSX 215N/PHSX 216N ; M 171 strongly recommended or consent of instr. Occurrence, movement, quality, and methods of quantification of groundwater. Geological framework and physics of groundwater flow. Supply, contamination, and management problems. Level: Undergraduate-Graduate

**GEO 421 - Hydrology. 3 Credits.**

Offered autumn. Prereq. one semester college calculus and physics or consent of instructor. Introduction to the physical mechanisms that drive the water cycle at different scales. The course covers heat, momentum and mass transfer and storage mechanisms in turbulent systems and their role in the global and local climates. At the local scale, the equations that govern surface and subsurface water flows are studied. Along with the overarching goals, students will improve their quantitative skills, will gain experience accessing and reading the professional literature and will improve their capabilities to acquire knowledge independently. Level: Undergraduate-Graduate

**GEO 428 - Field Methods: Earth, Water, and Climate Science. 3 Credits.**

In this class students will develop basic knowledge required to perform field work in remote locations across a broad range of disciplines in the earth, water, and climate sciences. Students will be introduced to a wide variety of field skills from backcountry navigation to understanding instrumentation and measurement principles, sources of uncertainty error, and data reduction. Students will make a variety of different measurements and learn to interpret their collected data. Level: Undergraduate

**GEO 433 - Global Tectonics. 3 Credits.**

Offered autumn. Prereq., GEO 315 and M 171. Geodynamics and tectonics of the Earth and other planets. Course material includes methods of observing tectonic processes and tectonic phenomena, both at the surface and in the deep earth, over a wide range of time scales. Level: Undergraduate-Graduate

**GEO 439 - Geophysics. 3 Credits.**

Prereqs., GEO 101N/GEO 102N or EARTH 101N/103N or GEO 103N/GEO 104N, PHSX 207N or PHSX 217N, and M 171, or consent of instructor. We will explore a variety of fundamental topics in geophysics, including Earth formation, Earth structure, plate tectonics, gravity, seismology, heat flow and magnetics. The course will also cover modern geophysical surveying methods, including reflection seismology, refraction seismology, gravity surveying, and magnetic surveying. Level: Undergraduate-Graduate

**GEO 443 - Principles of Sedimentary Petrology . 4 Credits.**

Offered autumn. Prereq., GEO 302 or graduate standing. Field, hand specimen and thin section petrology of siliciclastic and carbonate rocks, emphasis on tectonic and diagenetic interpretation of siliciclastic rock and environments of deposition and diagenesis of carbonate rocks. Level: Undergraduate-Graduate

**GEO 460 - Process Geomorphology. 4 Credits.**

Offered autumn. Prereq., GEO 202 or NRS 210N and M 121 or M122 or M151; junior standing or consent of instructor. Quantitative examination of landforms, runoff generation, weathering, mechanics of soil erosion by water and wind, mass wasting, glacial processes and hillslope evolution. Level: Undergraduate-Graduate.

**GEO 488 - Snow, Ice and Climate Change. 3 Credits.**

Offered autumn. Prereq., junior standing and M 151 preferred. Frozen water (i.e., glaciers, ice sheets, seasonal snow, and sea ice) is a primary component of Earth's climate system that both drives and responds to climate change. This course examines the role of snow and ice in four pressing issues of climate change: 1) global sea level rise and stability of ice sheets; 2) Arctic amplification of climate change and sea ice processes; 3) climate system feedbacks revealed by ice cores; and, 4) water supply and mountain snowpack dynamics. Level: Undergraduate-Graduate

**GEO 491 - Special Topics. 1-8 Credits.**

(R-8) Offered intermittently. Experimental offerings of visiting professors, experimental offerings of new courses or one-time offerings of current topics. Level: Undergraduate-Graduate

**GEO 492 - Independent Study. 1-6 Credits.**

(R-6) Offered every term. Specific topics of particular interest to individual students. Level: Undergraduate-Graduate

**GEO 494 - Senior Geology Seminar. 1-10 Credits.**

(R-10) Offered intermittently. Prereq., upper-division standing in geosciences or consent of instr. Independent study of various topics under the direction of a faculty member. Level: Undergraduate-Graduate

**GEO 498 - Internship. 1-6 Credits.**

(R-6) Offered every term. Prereq., 12 credits in geosciences. Extended classroom experience which provides practical application of classroom learning during placements off campus. Prior approval must be obtained from the faculty supervisor and the Internship Services office. No more than 3 credits of GEO 398 may be applied to the geosciences minor. A maximum of 6 credits of Internship (198, 298, 398, 498) may count toward graduation. Level: Undergraduate-Graduate

**GEO 499 - Senior Thesis /Capstone. 3-10 Credits.**

(R-10) Offered every term. Prereq., 18 credits in geosciences, WRIT 101 or equivalent, and one intermediate writing course. Independent research project in any geosciences topic supervised by faculty member, and leading to completion of baccalaureate degree. Level: Undergraduate Gen Ed Attributes: Advanced Writing

**GEO 508 - Fundamentals of Academic Research. 3 Credits.**

Offered autumn. Prereq., graduate standing. An introduction to scientific research including strategies for designing projects, research methods, scientific tools, proposals and publishing, and the culture and trends within the field of geosciences. Intended for first semester graduate students in geosciences. Level: Graduate.

**GEO 518 - Research Workshop. 2 Credits.**

This course includes group discussion, analysis, and troubleshooting of research challenges. Analogous to writers' and artists' workshops where constructive critiques are used to refine and advance creative material, this workshop will assist students in addressing research challenges through group collaboration and guided discussion of relevant methods and approaches. Level: Graduate

**GEO 528 - Sedimentary Basin Analysis. 4 Credits.**

Offered intermittently. Influence of allocyclic processes (tectonism, climate, eustasy, etc.) in shaping the evolution of sedimentary basins. Emphasis on integration and synthesis of tools of sedimentary basins analysis, including the study of depositional systems, provenance, paleocurrents, subsidence, sequence stratigraphy, and well logs. Level: Graduate

**GEO 540 - The Food-Energy-Water Nexus. 3 Credits.**

Offered autumn. Same as NRSM 540. Interdisciplinary course examining interactions between food, energy, and water systems and core concepts and tools at the food-energy-water nexus. Perspectives and connections across scales, sectors, and disciplines (including social and biophysical sciences and engineering) are emphasized. Level: Graduate

**GEO 541 - Food-Energy-Water Nexus Field Lab. 2 Credits.**

(R-4) Offered spring. Same as NRSM 541. Field-based course connecting theory and practice by examining food-energy-water case studies, conducting interdisciplinary synthesis, and communicating with diverse stakeholders. Combines intermittent in-class meetings and a week-long field trip to regional sites to examine food-energy-water issues on-the-ground and to meet with and learn from producers, managers, policy-makers, and tribal members.

**GEO 542 - Food-Energy-Water Seminar. 1 Credit.**

(R-4) Offered autumn and spring. Same as NRSM 542. Autumn seminars will focus on building interdisciplinary knowledge of the food-energy-water nexus through presentations from guest speakers, readings, and domestic and international case studies. Spring seminars will focus on building skills for multiple career paths through presentations and guest lectures.

**GEO 546 - Seismology and Geodesy. 3 Credits.**

Offered Spring. Prereq., Graduate standing or consent of instructor. We will explore modern topics in geophysics, with a focus on seismology and geodesy. Advanced topics may vary with each offering, but will generally include selections from continuum mechanics, inverse theory, seismic wave propagation, earthquake location, tidal analysis and prediction, GNSS theory and analysis, spheroidal Earth deformation, and surface mass loading. Students will have the opportunity to engage directly with real seismic and geodetic datasets using computational tools, as well as to investigate problems of personal interest through individual research projects. Level: Graduate

**GEO 548 - Topics in Cryosphere. 3 Credits.**

(R-6) M.S., (R-12) Ph.D.) Prereq., graduate standing or consent of instructor. Readings, discussions, lectures, and field experiments on various topics related to snow, ice, and climate processes. Recent topics: meltwater infiltration in snow, glacier hydrology, climate cycles, ice, and sea level rise. Level: Graduate

**GEO 560 - Fluvial Geomorphology. 3 Credits.**

Offered spring. Prereq., graduate standing or consent of instructor. Application of fluid mechanics to sediment transport and development of river morphology. Form and process in river meanders, the pool-riffle sequence, aggradation, grade, and baselevel. Level: Graduate

**GEO 568 - Climate Sensitivity and Feedbacks. 3 Credits.**

Offered spring. Prereq., graduate standing in a science discipline. Earth's climate system response to global radiation imbalances caused by natural and anthropogenic forcings. Fundamentals of climate dynamics including earth's energy balance and the global circulation of heat; the numerous amplifying and dampening feedbacks governing fast and slow climate system response to forcing; and, the various estimates of earth's transient response and equilibrium sensitivity to increased atmospheric carbon dioxide concentration. Lectures, readings, discussions, small problem sets and projects. Level: Graduate

**GEO 572 - Advanced Hydrogeology. 3 Credits.**

Offered autumn. Prereq., GEO 420 or consent of instr. Advanced concepts used in groundwater investigations, including flow systems analysis, hydrogeologic monitoring and sampling, resource evaluation, exploration, development and monitoring, and contaminant transport. Special problem areas in groundwater exploration and management. Level: Graduate

**GEO 582 - Topics in Structure & Geophysics. 1-12 Credits.**

(R-6 for M.S., R-12 for Ph.D.) Prereq., consent of instr. Offerings on request of graduate students by arrangement with appropriate faculty. Recent topics: structural analysis, Precambrian crustal evolution, field trips on Rocky Mountain structure. Level: Graduate

**GEO 585 - Topics in Hydro Low-Temp Geochemistry. 1-12 Credits.**

(R-6 for M.S., R-12 for Ph.D.) Prereq., consent of instr. Offerings on request of graduate students by arrangement with appropriate faculty. Recent topics: field methods, well design, contaminant transport, geochemical modeling. Level: Graduate

**GEO 590 - Supervised Internship. 1-12 Credits.**

Offered intermittently. Directed individual research and study appropriate to the back ground and objectives of the student. Level: Graduate

**GEO 594 - Graduate Seminar. 1-10 Credits.**

(R-10) Offered intermittently. Seminar study of various topics under the direction of a faculty member. Level: Graduate

**GEO 595 - Special Topics. 1-8 Credits.**

(R-8) Offered intermittently. Prereq., consent of instr. Experimental offerings of visiting professors, experimental offerings of new courses, or one-time offerings of current topics. Level: Graduate

**GEO 597 - Research: Advanced Problems. 1-10 Credits.**

(R-10) Offered intermittently. Prereq., consent of instr. Investigations of geological problems exclusive of thesis or dissertation research. Level: Graduate

**GEO 599 - Thesis Research. 1-12 Credits.**

(R-6) Offered every term. Prereq., thesis proposal approval. Directed research to serve as thesis for the master degree. Credit assigned upon submittal of final copy of approved and bound thesis. Level: Graduate

**GEO 699 - Dissertation Research. 1-12 Credits.**

(R-12) Offered every term. Prereq., dissertation proposal approval. Directed research to serve as dissertation for the Ph.D. degree. Credit assigned upon submittal of final copy of approved and bound dissertation. Level: Graduate