Geology (GEO)

GEO 1010. Introduction to Geology (PS). 3 Hours.
Fulfills Physical Science General Education requirement. Focuses on the physical dynamics of the natural environment, delineating its geosphere, hydrosphere, atmosphere, and biosphere components, and their global patterns of interaction. Highlights the processes of science that underpin this systemic view of the world. Emphasizes issues of resource availability, along with their political and social ramifications. Particular emphasis is placed on the challenges natural hazards present to civilization, worldwide. The extraordinary geology of the region surrounding Utah Tech is featured in many textbook and lecture examples. One field trip required. GEO 1015 OR GEO 2000R lab course recommended. Inclusive Access Course Material (electronic book) fees may apply, see Fees tab under each course section for details. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Explain how the scientific method works and outline how it is employed. 2. Explain the formation of the Solar System Earth, and Earth systems, how earth systems have changed through time, and how they are predicted to change in the future as consequences of both natural and man-made processes. 3. Explain and model the fundamentals of how plate tectonics works, including the formation of geologic structures, the mechanics of earthquakes, and tectonics-related geologic hazards. 4. Identify various Earth Materials, explain how they form and are classified, assess their usefulness for humans as natural resources, and explain their involvement in geologic hazards. 5. Explain how surface processes work, generate and transport sediment, shape the Earth's surface, and affect the distribution of geologic hazards. 6. Explain how stratigraphic and radiometric dating work, are used to determine the age of a rock, and bracket events in Earth history. FA, SP, SU.

GEO 1015. Introduction to Geology Lab (LAB). 1 Hour.
A laboratory course to be taken concurrently with Geology 1010. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Explain and employ the scientific method. 2. Identify and classify minerals and for what they are used. 3. Identify the three types of rocks (igneous, sedimentary, and metamorphic), explaining how they form, and detailing their classifications. 4. Explain how stratigraphic and radiometric dating work and are used in determining the age of a rock. 5. Explain and modeling the fundamentals of how plate tectonics works, including the formation of geologic structures and the mechanics of earthquakes. 6. Identify pertinent features generated by surface processes from photographs and diagrams. Course fee required. Corequisite: GEO 1010. FA, SP.

GEO 1020. Life of the Past (PS). 3 Hours.
Fulfills General Education Physical Science requirement for non-Science majors. General survey of historical Geology focusing on the relationship between the tectonic history of the Earth, the evolution of life through time, and the histories of the Earth and life and the complex interactions between them. GEO 1025 lab course recommended but not required. One field trip required. Offered upon sufficient student need. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Understand what science is, how science works, and how science progresses. 2. Understand the basis of physical sciences (especially geology) and evolution, and communicate scientific ideas via written and/or oral assignments. 3. Demonstrate knowledge of and appreciation for the internal and external processes on Earth today. 4. Identify and describe Earth materials and landforms. 5. Apply basic geologic principles to understand the orders, rates, and superimposition of dynamic geologic processes. 6. Integrate and apply information learned in lecture and exercises in the field. Course fee required.

GEO 1040. Introduction to Dinosaurs (PS). 3 Hours.
Fulfills General Education Physical Science requirement. Utilizes the popular subject matter of dinosaurs to teach basic principles of geology, biology, physics, chemistry, and astronomy, with some basic math (algebra). Successful completion of this interdisciplinary course contributes to an understanding of science and scientific concepts as well as their applications in a multitude of disciplines. GEO 1045 lab course recommended but not required. One field trip required. Inclusive Access Course Material (electronic book) fees may apply, see Fees tab under each course section for details. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Explain and employ the scientific method. 2. Explain and model the fundamentals of how plate tectonics works, including the formation of geologic structures. 3. Identify the three types of rocks (igneous, sedimentary, and metamorphic), explaining how they form, and detailing their classifications. 4. Identify the types of fossils and detailing how they form, how they occur in sedimentary rocks, and how sedimentary rocks tell about ancient environments. 5. Explain how stratigraphic and radiometric dating work and are used in determining the age of a rock or fossil. 6. Identify various vertebrate skeletal anatomical structures. 7. Identify and explaining the principles of evolution and systematics as a classification system based on evolution. 8. Accurately reading cladograms and explaining how they are generated. 9. Identify the kinds of dinosaurs (in a systematic and anatomical framework). 10. Explain how we understand dinosaurs as living animals - their restoration, behavior, diet, reproduction, physiology, growth, and extinction. Course fee required. FA.

GEO 1045. Introduction to Dinosaurs Laboratory (LAB). 1 Hour.
A laboratory course to be taken concurrently with GEO 1040. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Explain and employ the scientific method. 2. Identify and classify sedimentary rocks, and explaining how their sediments are generated and how they affect fossilization. 3. Explain and model the fundamentals of how plate tectonics works, including the formation of geologic structures. 4. Identify the types of fossils. 5. Explain how sedimentary processes work and can be recognized, and the basics of taphonomy. 6. Explain how stratigraphic and radiometric dating work and are used in determining the age of a rock. 7. Identify various vertebrate anatomical structures and hypothesizing their functional morphologies. 8. Explain evolution by natural selection. 9. Employ the fundamentals of phylogenetic practices. 10. Identify basic characteristics of ornithischian and saurischian dinosaurs and hypothesize their functions. Course fee required. Corequisite: GEO 1040. FA.

GEO 1050. Geology of the National Parks (PS). 3 Hours.
Fulfills General Education Physical Science requirement. General survey of Physical Geology emphasizing the geology of Utah's scenic national parks and monuments, as well as state parks, to investigate the geologic history of and processes shaping the region, inherent geologic hazards, and natural resource use and availability. Inclusive Access Course Material fees may apply, see Fees tab under each course section for details. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Demonstrate knowledge of the skills required to make informed personal and social decisions about the issues that we will face locally as well as globally. 2. Demonstrate knowledge of basic fundamental laws, concepts, and theories in the physical sciences and be able to apply them to everyday life. 3. Be able to explain and apply the scientific method. 4. Demonstrate knowledge of the process of science by being able to utilize data in the form of tables, graphs, and charts through interpretation and then communicate those finding in oral and or written form. 5. Develop a basic understanding of the internal and external processes acting on the earth. 6. Identify and describe the origin and development of landforms found in the various National Parks of the southwest. 7. Identify and describe the earth materials. 8. Apply the principles of geologic time to analyze the rates of geologic processes related to the National Parks of the southwest. 9. Integrate information learned in class and laboratory studies to evaluate geologic processes in the field. Corequisite: GEO 1055. SP.

GEO 1055. Geology National Parks Lab (LAB). 1 Hour.
Field trip portion of GEO 1050. A seven day field trip featuring national parks and monuments, usually over Spring Break, to experience geologic processes shaping the landscape, interpret past environments/climates that created the resources utilized by society, and observe first-hand how our Earth has changed through geologic time and, in fact, is ever-changing. Requires hiking on park trails over uneven surfaces for average of three miles a day. Elevations up to 8300 feet. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Demonstrate knowledge of basic fundamental laws, concepts, and theories in the physical sciences and be able to apply them to everyday life. 2. Demonstrate knowledge of the process of science to interpret data in the form of tables, graphs, and charts and communicate those finding in oral and or written form. 3. Develop a basic understanding of the internal and external processes acting on the earth. 4. Identify and describe the origin and development of landforms found in the various National Parks of the southwest. 5. Apply the principles of geologic time to analyze the rates of geologic processes related to the National Parks of the southwest. 6. Integrate information learned in class and laboratory studies to evaluate geologic processes in the field. Course fee required. Corequisite: GEO 1050. SP.

GEO 1080. Introduction to Oceanography (PS). 3 Hours.
Fulfills General Education Physical Science requirement. Conveys the essential principles of ocean science, including an understanding of the earth's oceans focusing on sea floor topography and composition, plate tectonics, seawater dynamics and chemistry, atmospheric and ocean currents, waves, coastal land forms, and marine life as well as recognition of the close linkage of weather, climate, and humans to the oceans. GEO 1085 lab course recommended but not required. Offered upon sufficient student need. Inclusive Access Course Material (electronic book) fees may apply, see Fees tab under each course section for details. COURSE LEARNING OUTCOMES (CLOs) At the successful completion of this course, students will be able to: 1. Differentiate science from non-science by recognizing hypotheses, theories, and/or laws that meet the criteria of science and use the scientific process/method. 2. Describe geologic and geographic features of Oceanic features and their formation as part of plate tectonics, including a full description of the Theory of Plate Tectonics, the history of its development, its mechanisms and processes that shape Earth both internally and externally. 3. Explain the formation and potential geologic hazards of the geographic landforms in each section of the major Oceanic provinces. 4. Identify the Ocean's biological, physical, and chemical constituents including economically important natural resources, describe their importance and renewability, where they are located and how they might be recovered, managed, and protected. 5. Articulate an understanding of both relative (stratigraphic) and absolute (radiometric) geologic time using these concepts to interpret physical and biological events in Earth history, and how these events relate to biological evolution including natural and anthropogenic activities. FA.

GEO 1085. Intro to Oceanography Lab (LAB). 1 Hour.
A laboratory course in oceanography. Lab fee required for travel to marine laboratories and coastal regions in California. Offered upon sufficient student need. COURSE LEARNING OUTCOMES (CLOs) At the successful completion of this course, students will be able to: 1. Develop an integrated understanding of oceanographic processes and the following CLOs through an intensive 4-day field experience. 2. Differentiate science from non-science by recognizing hypotheses, theories, and/or laws that meet the criteria of science and use the scientific process/method. 3. Describe the theory of plate tectonics, including the history of its development, its mechanisms and processes that shape Earth both internally and externally, including distinguishing geologic and geographic features of Oceanic features and their formation as part of plate tectonics. 4. Explain the formation and potential geologic hazards of the geographic landforms in each section of the major Oceanic provinces. 5. Identify the Ocean's biological, physical, and chemical constituents including economically important natural resources, describe their importance and renewability, where they are located and how they might be recovered, managed, and protected. 6. Articulate an understanding of both relative (stratigraphic) and absolute (radiometric) geologic time using these concepts to interpret physical and biological events in Earth history, and how these events relate to biological evolution as well as natural and anthropogenic activities. Course fee required.

GEO 1110. Physical Geology (PS). 3 Hours.
Fulfills a General Education Physical Science requirement for students majoring in the Sciences or Engineering, including Civil Engineering, Geology, Range Management, Forestry, etc. Covers the study of the physical features of the earth and the processes that shape those features. Successful completion gives students the background necessary for further study in the sciences. Inclusive Access Course Material (electronic book) fees may apply, see Fees tab under each course section for details. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Demonstrate knowledge of basic fundamental laws, concepts, and theories in the physical sciences required to make informed personal and social decisions about local and global issues. 2. Explain and apply the scientific method. 3. Identify major rock forming minerals as well as the rocks in the three major groups and explain both their formation and use as natural resources. 4. Distinguish between the major internal and external processes acting upon the earth and identify various landforms created by those processes. 5. Apply the principles of geologic time to analyze the rates of geologic processes. Corequisites: GEO 1115. FA.

GEO 1115. Physical Geology Lab (LAB). 1 Hour.
Lab portion of GEO 1110. Three Saturday field trips required. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Integrate information learned in class studies to evaluate geologic processes in the field. 2. Identify some of the major rock forming minerals as well as the rocks in the three major groups and explain both their formation and use as natural resources. 3. Distinguish between the major internal and external processes acting upon the earth and identify various landforms created by those processes. 4. Create geologic cross sections from topographic and geologic maps. 5. Apply the principles of geologic time to analyze the rates of geologic processes. Course fee required. Corequisite: GEO 1110. FA.

GEO 1220. Historical Geology. 3 Hours.
Conceptual examinations of how the atmosphere, biosphere, hydrosphere, and lithospheres interact to create major structural and stratigraphic features (emphasizing North America) and how life has evolved through deep time. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Outline the history of how modern geology was developed. 2. Explain how stratigraphic and radiometric dating work and are used in determining the age of a rock. 3. Explain the natures of sedimentary rocks and their depositional environments and how they can be interpreted and inferred from the stratigraphic record. 4. Explain what fossils are and how they are useful in interpreting the stratigraphic record. 5. Explain how evolution works and has produced the lineages recorded in the fossil record. 6. Explain and modeling the fundamentals of how plate tectonics works. 7. Outline the major geological events during Earth history. 8. Outline the major evolutionary events during Earth history. Prerequisite: GEO 1110. Corequisite: GEO 1225. SP.

GEO 1225. Historical Geology Lab. 1 Hour.
Lab accompanying GEO 1220. Local field trip required. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Outline the history of how modern geology was developed. 2. Explain how stratigraphic and radiometric dating work and are used in determining the age of a rock. 3. Explain the natures of sedimentary rocks and their depositional environments and how they can be interpreted and inferred from the stratigraphic record. 4. Explain what fossils are and how they are useful in interpreting the stratigraphic record. 5. Explain how evolution works and has produced the lineages recorded in the fossil record. 6. Explain and modeling the fundamentals of how plate tectonics works. 7. Outline the major geological events during Earth history. 8. Outline the major evolutionary events during Earth history. Course fee required. Prerequisite: GEO 1115. Corequisite: GEO 1220. SP.

GEO 2000R. Applied Geologic Investigation of Grand Canyon, Zion, and Bryce National Parks (LAB). 1 Hour.
Fulfills General Education Laboratory Sciences requirement. Provides an opportunity for students to study topics such as depositional environments, plate tectonics , gradation, rock dating, geologic time, Earth history, and environmental issues in a field research setting through travel to Grand Canyon, Zion, and Bryce Canyon National Parks. The class will be held over a 4-5 day period. Overnight stays at the Tanner Field Station required. Repeatable up to 2 credits. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Examine evidence of climate change both in ancient and modern times. 2. Learn basic scientific processes used to develop hypotheses and theories. 3. Gain greater insight into the enormous length of geologic time and evidences that support this claim. 4. Learn the different ways that scientists can determine geologic ages. 5. Understand agents of gradation, particularly how the hydrologic cycle helps to shape the Earth. 6. Learn how the different subsystems of the Earth system interact as open systems as they exchange not just energy, but matter. 7. Know where and when the basic rock and mineral types form and how they are related to tectonic and hydrologic cycles. 8. Be able to identify common rocks and minerals. 9. Demonstrate the relationship between geological processes and resources and human activities. 10. Understand how plate tectonics works, including the role of the different types of plate boundaries and the forces that help drive the system. 11. Learn how tectonism has helped shape the Earth's surface. Course fee required. FA, SU.

GEO 2050. Earth Materials. 4 Hours.
Required for all geoscience degree programs. An introduction to the origin, classification, identification, and physical and chemical properties of minerals and rocks, including topics related to crystallography, mineral chemistry, petrology, and the importance of mineral and rock resources to society. Three lectures and one 3 hour laboratory per week. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Evaluate, identify, and classify minerals in hand samples and thin sections based on their physical properties. 2. Classify and categorize minerals based on chemistry and atomic structure. 3. Analyze variations in mineral chemistry and explain the chemical rules that dictate mineral structures. 4. Employ graphical methods to quantify and interpret mineral chemistry. 5. Describe how mineral chemistry and structure control physical and optical properties. 6. Evaluate various igneous, sedimentary, and metamorphic rocks and interpreting their environments of formation using their component mineral assemblages and textures. 7. Summarize how, where, and why minerals are important to manufacturing, economics, and politics. Course fee required. Prerequisites: GEO 1110 and GEO 1115 (Both Grade C or higher). FA.

GEO 2700R. Field Methods in Geoscience Research. 1 Hour.
A preparatory course for undergraduate participation in collaborative research projects in the geosciences. Repeatable for a max of 3 credits. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Develop skills in collecting and organizing scientific data from field investigations. 2. Consider how concepts and skills acquired in coursework can be developed through interdisciplinary research. 3. Develop a hypothesis for a research project in the geosciences or related sciences, and devise a protocol to test that hypothesis. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Develop skills in collecting and organizing scientific data from field investigations. 2. Consider how concepts and skills acquired in coursework can be developed through interdisciplinary research. 3. Develop a hypothesis for a research project in the geosciences or related sciences, and devise a protocol to test that hypothesis. Course fee required. Prerequisites: GEO 1110 and GEO 1115 (Both grade C- or higher).

GEO 2990R. Career Seminar in Geology. 1 Hour.
This seminar is aimed at helping students interested in Earth sciences identify and prepare for future careers in the field of Earth sciences. Students will interact with professionals to learn about Earth sciences career opportunities and will perform exercises to strengthen their resumes/CVs, cover letters, and professional communication skills. Can be repeated up to 4 times for credit. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Identify potential internship or employment opportunities as a geology degree graduate. 2. Evaluate professional materials that will be needed to apply for summer and post-graduate jobs and programs. 3. Collaborate with faculty, peer students, and guest speakers in a professional setting. 4. Develop professional skills for interviews and collaborative settings. FA.

GEO 3000. Advanced Geologic Investigation of Colorado Plateau Basin and Range provinces through national parks. 3 Hours.
Provides students an opportunity to engage in an advanced study of topics such as depositional environments, plate tectonics, gradation, rock dating, geologic time, Earth history, and environmental issues in a field research setting through travel to Grand Canyon, Zion, Bryce Canyon, Capitol Reef, Arches, Canyonlands, Great Basin, and Death Valley National Parks. The class requires two camping trips of 3-4 overnight stays, one of which is over Fall Break, plus two to three 1-day trips. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Collect and record geologic field observations/data including rock properties and structural/stratigraphic relationships. 2. Communicate geologic data and hypotheses to scientific peers. 3. Explain geological data products such as maps, cross sections, and stratigraphic columns to evaluate hypotheses about the depositional environments and tectonic history of the southwestern U.S. 4. Describe and evaluate hypotheses about the landscape evolution of notable landforms in the southwestern U.S. Course fee required. Prerequisites: GEO 1110 and 1115 (Both Grade C- or higher). FA (odd).

GEO 3060. Environmental Geology. 3 Hours.
Geological attributes of environmental settings with emphasis on the analysis of geologic conditions pertinent to resource availability, urban planning, recognition and assessment of geologic hazards, and environmental issues through geochemical investigation of Earth's atmosphere, hydrosphere and lithosphere. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Apply a Systems Science perspective to Geological topics. 2. Enhance critical thinking skills in the context of Earth sciences. 3. Utilize multiple sources of information to understand geology and make scientific analyses. 4. Develop and present research topics and findings. 5. Consider human interactions with the physical Earth, both human impacts on the environment and environmental hazards to human society. Prerequisites: GEO 1110 (Grade C or higher) AND GEO 1115 (Grade C or higher). FA (even).

GEO 3110. Scientific Writing. 3 Hours.
Augments research, writing, and communication skills of science majors. On successful completion, students will be able to effectively use scientific literature databases; find, read, understand, and critically assess primary scientific literature; write in a clear, concise, scientific style that will be required in upper-level science classes, including Senior Thesis, and in graduate study or future professions. In order to enter GEOL 3110 with the needed experience in scientific writing, students are required to have completed or be currently enrolled in a geology course that requires an original, student-designed research project and paper or must obtain instructor permission before enrolling. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Employ scientific literature databases. 2. Analyze and assess primary scientific literature effectively and efficiently. 3. Develop clear, concise, scientific context for all types of communication that you will be required to do in upper-level science classes (including senior thesis) and in your professional life (e.g., research reports for publication in primary literature and for corporate distribution). Prerequisites: ENGL 2010 and GEO 3000 or GEO 3180 or GEO 3200 or GEO 3500 or GEO 3550 or GEO 3600 or GEO 3700. FA, SP.

GEO 3180. Paleontology. 4 Hours.
Reviews theories, principles, and applications of paleontology, as well as the characteristics of important groups of fossil organisms and their geologic distributions and paleoecologies. The course includes a lab. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Review and debate the nature of the fossil record. 2. Appraise, criticize, debate, and defend the principles of and theories about evolution, speciation, systematics, and extinction. 3. Assess possible functional morphological and paleoecological features of a fossil organism. 4. Assess the paleobiogeographic and biostratigraphic utility of a fossil organism. 5. Evaluate and classify a fossil and assess what it contributes to understanding the evolutionary history and diversity of its clade. Course fee required. Prerequisites: GEO 1220 and GEO 1225, or instructor permission. FA (odd).

GEO 3200. Mineralogy. 4 Hours.
Exploration of the physical, chemical, and optical properties of common rock- and ore-forming minerals through the principles of crystallography, optical microscopy, and analytical chemistry. Three one-hour lectures, and one three-hour lab per week. Laboratories emphasize mineral studies at macro and micro scales, analytical methods, and data processing. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Determine the physical properties of minerals based on their chemical composition, and atomic structure. 2. Examine symmetry elements and functions of a mineral sample (or model), and correctly identify its corresponding crystal system. 3. Classify the most common rock and ore-forming minerals and recall their chemical formulas. 4. Summarize the nature and causes of various mineral features such as twinning, exsolution, defects, color, polymorphism, and pseudomorphism. 5. List various geochemical analytical techniques and elaborate on the theory they are based on. 6. Analyze mineral data, and effectively communicate the methods, results, and logical interpretations of those data in a scientifically written report. Course fee required. Prerequisites: GEO 1110 and 1115; and MATH 1050 (or higher); and CHEM 1210 and 1215 (All grade C or higher). FA (odd).

GEO 3400. Water Resources. 3 Hours.
A detailed examination of the water cycle, including: precipitation, surface water, ground water, glaciers, water conservation, water management, and water pollution with special emphasis on the water resources of Utah and neighboring areas. Offered upon sufficient student need. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Identify the water resources management issues (water quality and water quantity) in local and global regions. 2. Apply the basic principles of water resources, including hydrologic cycle, surface and groundwater hydrology to understand critical water needs. 3. Utilize quantitative models in water resources and hydrology. 4. Apply the scientific methods and critical thinking to analyze the hydrologic data in water resources management (e.g. surface water, groundwater, water quality). Prerequisites: GEO 1110/1115 AND CHEM 1210/1215. FA (even).

GEO 3500. Geomorphology. 4 Hours.
The course focuses on understanding the physical and chemical processes that affect landscapes including erosion, sediment transport, and soil development. Students will become familiar with interpreting landscape evolution in the field and from data products such as geologic/geomorphic maps, digital topography datasets, and aerial photography. Societally important applications will be considered, such as hazards associated with active faults, landslides, soil properties, and rockfall. Field trips required during class/lab time, plus one weekend trip, although alternative arrangements are available for students with differing abilities. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Identify major landforms and describe the conditions that contributed to their formation. 2. Analyze landforms within a given area using topographic maps, aerial imagery, and field observations, interpret the ages of these landforms, and hypothesize about why they formed. 3. Demonstrate a basic understanding of the mass balance of physical and chemical transport at the Earth's surface. 4. Evaluate hazards associated with Earth surface processes, such as floods and landslides. 5. Employ software including Google Earth and GIS to conduct geomorphic analyses. Prerequisites: GEO 1110 or GEO 1010 or GEOG 1000 (Grade C or higher), AND MATH 1060 or higher (Grade C or Higher) OR ACT Math score of 25 or higher or equivalent placement score. Corequisites: GEOG 3600 and GEOG 3605. Course fee required. SP (even).

GEO 3550. Sedimentology & Stratigraphy. 4 Hours.
Sedimentology is the study of the transport, deposition, arrangement, and diagenesis of sediment. Stratigraphy is the interpretation of preserved sedimentary rock layers, which record much of Earth's geologic history. Both grant insight into depositional environments, tectonic settings, changes in sea level, and climate. In this course, students will learn strategies and techniques to read, interpret, and communicate the sedimentary rock record. Required field trips include one weekend-long regional trip and approximately six local field trips during scheduled lab time. Alternative arrangements will be made for students not able to attend field trips. **COURSE LEARNING OUTCOMES (CLOs): At the successful conclusion of this course, students will be able to: 1. Describe and identify sedimentary rock types and the sedimentary processes and conditions that led to their formation. 2. Collect, analyze, and communicate data characterizing stratigraphic sequences. 3. Use sedimentologic and stratigraphic data to make and test hypotheses about depositional and tectonic environments and geologic history. 4. Make predictions about the types of sedimentary rocks likely to be found in different tectonic environments around the world and in the geologic past. Course fee required. Prerequisites: GEO 1220 AND GEO 1225. FA (even).

GEO 3600. Igneous and Metamorphic Petrology. 4 Hours.
An examination of igneous and metamorphic rocks including their classification, petrogenesis, evolution, and field settings. Tectonic associations, thermodynamic processes, mineralogy, and chemistry of these types of rocks will also be explored. Three lecture hours, and one three-hour lab per week. Laboratories emphasize mineral and rock studies at macro and micro scales, and interpretation of petrographic data. One required field trip. **COURSE LEARNING OUTCOMES (CLOs)** At the conclusion of this course, students will be able to: At the conclusion of this course, a successful student will be able to: 1) Classify igneous and metamorphic rocks based on mineralogical and geochemical data (PLO 1, 4). 2) Explain the petrogenetic history of these rocks within the context of various tectonic settings (PLO 4, 5). 3) Interpret geochemical data, including isotopes, to identify sources and protoliths, and calculate ages of these rocks, and understand the theory of dating techniques (PLO 1, 2). 4) Apply principles learned in the classroom and lab to field and real-life based problems and investigations (PLO 1,3). Course fee required. Prerequisites: GEO 1110 and 1115; Math 1050 (or higher); Chem 1210 and 1215; GEO 3200 - all a grade of C or higher. SP (even).

GEO 3700. Structural Geology and Tectonics. 4 Hours.
Examination of the geometries, mechanisms, and mechanics of rock deformation. Includes stress and strain relationships, fault and fold classification, and relationships to major tectonic features of Earth, with application to geological engineering, petroleum geology, mining, water recovery and waste disposal. Labs present techniques to interpret and evaluate deformed rock in map, cross section, and three-dimensional views. Three lecture hours and one 3-hour lab per week. Field trips are required, although alternative arrangements will be made where necessary. Course fee required. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Identify in the field and interpret both brittle and ductile structural deformation. 2. Produce a viable geological cross section from structural data. 3. Conduct a kinematic structural analysis of an area and relate deformation kinematics to tectonic processes. 4. Conduct a dynamic structural analysis, formulate constitutive equations for deformation, and quantify the contribution of each deformational mechanism in a region. 5. Assess and justify the best location to drill for water, oil, or gas, predict the location of mineral resources, and/or judge the environmental impact of toxic waste disposal from a set of structural data. Prerequisites: GEO 1110 and 1115; and MATH 1060 or MATH 1080 or higher level MATH (All grade C or higher). SP (odd).

GEO 3710. Hydrology. 3 Hours.
This course includes the study of some important aspects in the field of hydrology including hydrological cycle and its components such as precipitation, infiltration and evapotranspiration. In this course, students will learn how to collect hydrological data, understand and employ the common numerical methods, and analyze the data to estimate the hydrologic cycle components. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Identify and differentiate the essential components of the hydrologic cycle. 2. Complete engineering hydrology computations and water balance. 3. Analyze experimental hydrological data. 4. Collaborate with other students and serve as effective members of multidisciplinary project teams. SP (even).

GEO 3910. Applied Geologic Investigation of Iceland. 3 Hours.
Iceland, the land of fire and ice, offers students an experiential learning opportunity to study nearly every basic topic in Geology. Both tectonic processes powered by Earth's internal energy such as plate boundaries, volcanoes, earthquakes, and geysers, and gradation processes powered by the sun such as glaciers, rivers, shorelines, weathering and erosion are observed first hand. Environmental issues like resource use and its relationship to climate change and utilizing geothermal as a green energy resource to generate electricity are also examined. Course participants will meet for an hour a week during the semester then travel to Iceland for a six day travel abroad experience. Pre-trip classes include the above topics to prepare students to understand their experiences in Iceland. For international travel, see studyabroad.utahtech.edu for additional travel costs that may apply. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Identify evidence that meets the criteria of science in recognizing and differentiating hypotheses, theories and/or laws using the resources of Iceland. 2. Apply the concepts of both stratigraphic and radiometric dating to interpret physical and biologic events in Earth history as evidenced in Iceland. 3. Identify Iceland's geologic and geographic landforms and explain both their formation (origin) and potential geologic hazards. 4. Identify Iceland's economically important Earth materials and natural resources and their impacts on global climate change, politics, and economics. 5. Describe how the geology of Iceland is explained by the theory of plate tectonics. SP.

GEO 3920. Applied Geological Investigation of the Andes. 3 Hours.
A course that introduces students to the incredible geology of the Andes. The course will meet for one hour per week during the semester, then the participants will travel to the Andes for a 2-week study abroad experience. Students will travel to multiple locations across the Andes mountain belt to develop a synoptic perspective of crustal deformation, magmatism, Earth resources, and how they relate to plate tectonics in Earth's second largest mountain belt. Pre-trip preparation will include readings and assignments to prepare students to understand their observations in South America. Offered upon sufficient student need. ***COURSE LEARNING OUTCOMES (CLOs)*** At the successful conclusion of this course students will: 1. Make observations and interpretations about the geologic processes and evolution of the Andean mountain belt. 2. Evaluate geologic hypotheses using evidence from field observations and scientific literature. 3. Present scientific information about geologic processes and topics to peers. 4. Engage in scientific discussions across cultural boundaries. Prerequisites: GEO 1110 (Grade C- or higher).

GEO 4000R. Selected Geology Field Excursions. 1 Hour.
The course consists of a 1-week geological field trip to a rotating location, typically during Spring Break and within the western US. Students will build on their classroom learning to investigate the broad range of geologic processes that have affected and are affecting the Earth's lithosphere, climate, and landscapes. Field observational skills and application of geological knowledge are emphasized. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course, students will be able to: 1. Describe geologic processes that affect or have affected the investigated area. 2. Assess the importance of the studied processes to the evolution of the Earth. 3. Evaluate scientific literature on the selected areas and topics. 4. Prepare and present scientific information about the areas and topics to peers. 5. Describe how these geologic processes affect human society and economics. Course fee required. Prerequisites: GEO 1110 or instructor permission.

GEO 4600. Field Geology. 5 Hours.
An intensive, field-based course that gives students hands-on experience with geoscience field research, including geologic mapping, data collection, and interpretation and communication of field results. The course occupies 8-10 hours/day for 5 weeks. The course additionally touches on several societally relevant applications of geologic data, including analysis of geologic hazards and resource distribution. The techniques and scientific reasoning students gain in the course provide a foundation for pursuing a variety of different geoscience career paths. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Develop a map and interpret the geology of a given area to understand its regional geologic history. 2. Apply a hypothesis-based framework to field observation and interpretation. 3. Use geologic mapping and related techniques to characterize geologic hazards and natural resource potential. 4. Communicate their findings both in writing and verbally, and produce standard geologic data products, including geologic maps, cross sections, and reports. Prerequisites: GEO 2700R, and GEO 3550, and GEO 3700 (All grade C or higher). Course fee required. FA (even).

GEO 4800R. Independent Research. 1-3 Hours.
An independent research course that allows the students to explore science through the scientific method, and allows close interaction between the student and faculty member to address scientific problems through experiment design and execution. Projects are at the discretion of the faculty member, in line with the student's interests in the various scientific areas. Repeatable up to 6 credits subject to graduation and program restrictions. Variable credit: 1-3. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Use the scientific method to develop hypothesis for a research project in the environmental sciences, design experiments or identify resources from which to collect data, and draw conclusions from results. 2. Design and modify experiments throughout the progress of a research project. 3. Complete research projects independently while also interacting with other students and faculty that are engaged in the project. 4. Utilize outside resources (scientific databases, literature, etc) to interpret results and compare to existing and previous work in the field of your research project. Prerequisite: GEO 2700R (Grade C- or higher). FA, SP, SU.

GEO 4910. Senior Seminar. 1 Hour.
A seminar course where students will share their research results or literature searches with fellow students and faculty in written and oral formats. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Use the scientific method to develop hypotheses, search literature or utilize results from experimentation, and defend in an oral presentation to faculty and students. 2. Discuss relevant scientific topics in oral presentations in a scientific group setting. 3. Collaborate with other geoscience students and faculty that are engaged in scientific research to analyze data, results, and varying perspectives, and participate in scientific discussions. 4. Utilize outside resources (scientific databases, literature, etc.) to help interpret results and compare to existing and previous work in the field. 5. Prepare written reports that effectively summarize a chosen scientific topic related to the environmental sciences using the vast literature and compiled data. SP.