## Geology and Geophysics (GEOS)

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>GEOS 101X</td>
<td>The Dynamic Earth</td>
<td>(n)</td>
<td>4 Credits</td>
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<tr>
<td>GEOS 103</td>
<td>Landslides/Resources Of Ak</td>
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<tr>
<td>GEOS 104</td>
<td>Principles of Geology</td>
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<tr>
<td>GEOS 106X</td>
<td>Life in the Age of Dinosaurs</td>
<td>(n)</td>
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<tr>
<td>GEOS 112X</td>
<td>The History of Earth and Life</td>
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<tr>
<td>GEOS 120X</td>
<td>Glaciers, Earthquakes and Volcanoes: Past, Present and Future</td>
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<tr>
<td>GEOS 190</td>
<td>The Geology of Wine</td>
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<td>GEOS 192</td>
<td>Seminar</td>
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<tr>
<td>GEOS 212</td>
<td>Geology of Alaska</td>
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<tr>
<td>GEOS 213</td>
<td>Mineralogy</td>
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<td>GEOS 214</td>
<td>Petrology and Petrography</td>
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GEOS F222  Fundamentals of Geospatial Science
3 Credits
Offered As Demand Warrants
This course is an introduction to the principles and applications of geospatial science (remote sensing, GIS and GPS). Fundamental concepts include electromagnetic radiations, map projections, basic computer science, data formats, map-reading and map-making, etc. Practical exercises include field data collections using GPS, photo-interpretation using image processing and GIS software packages.
Prerequisites: GEOF F111X or GEOF F101X or permission of instructor.
Cross-listed with GEOF F222.
Lecture + Lab + Other: 2.5 + 1.5 + 0

GEOS F225  Field and Computer Methods in Geology (n)
2 Credits
Basic field methods, including field notes, topographic maps, measurement of structural elements, field safety, illustration, field mapping, and the use of GPS for field work are discussed and practiced. Use of computers for processing geologic field data and analytical data, and integration of field data into a simple Geographic Information System. Computers are used for the production of reports and technical illustration. This course will fulfill the department requirement for computer literacy. Co-requisites: GEOS F214; or GEOS F262.
Lecture + Lab + Other: 1 + 3 + 0

GEOS F262  Rocks and Minerals
3 Credits
Offered Fall Even-numbered Years
Physical properties of minerals and rocks, classification, mode of occurrence and economic applications. Labs on recognition and measurement of physical properties. Course may not be used to satisfy degree requirements in geology or geological engineering.
Prerequisites: GE F261, GEOF F101X or equivalent.
Lecture + Lab + Other: 2 + 3 + 0

GEOS F292  Seminar
1-6 Credits
Lecture + Lab + Other: 1-6 + 0 + 0

GEOS F292P  Seminar
1-6 Credits
Lecture + Lab + Other: 1-6 + 0 + 0

GEOS F304  Geomorphology (n)
3 Credits
Offered Fall
Surface features of the Earth and the processes which create or modify them. Application to Quaternary history, environmental science and related fields. Laboratory examination of topographic maps and aerial photographs, introduction to geomorphic measurements.
Prerequisites: GEOF F101X.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F309  Tectonics (W)
3 Credits
Offered Fall
In-depth exploration of the theory of Plate Tectonics including plate boundary interactions—which trigger volcanoes and earthquakes, form mountain belts and oceans—via geochemistry, sedimentology, geophysics and structure. Understanding the creation and evolution of the lithosphere and mantle, how we detect tectonic processes and how present tectonic environments help reconstruct ancient crustal events.
Prerequisites: WRTG F211X or WRTG F213X; GEOF F112X; GEOS F214 or GEOS F262 (either may be taken concurrently).
Lecture + Lab + Other: 3 + 0 + 0

GEOS F314  Structural Geology (n)
4 Credits
Offered Spring
Introductory overview of how rocks are deformed, types of geological structures including folds, faults and penetrative fabrics, and the associations of structures characteristic of different tectonic settings. Provides background in structural geology. Emphasis in the laboratory on examples and techniques that are broadly applicable in geology, especially the interpretation of geologic maps.
Prerequisites: GEOS F322 or concurrent enrollment in GEOS F214; MATH F152X; PHYS F103X or PHYS F211X.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F315  Paleobiology and Paleontology (W, n)
4 Credits
Offered Fall
Survey of the history of life on Earth as represented in the fossil record. Contribution of paleontology to the study of evolution, paleoenvironments and paleogeography; biostatigraphically important invertebrate fossil groups and their temporal ranges; evolution of terrestrial flora and fauna; current issues in paleontology. Emphasis on recognition of major fossil groups and paleontological problem solving in labs and assignments.
Prerequisites: BIOL F103X or BIOL F115X or GEOF F112X; WRTG F111X; WRTG F211X or WRTG F213X; or permission of instructor.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F317  Paleontological Research and Laboratory Methods (O)
2 Credits
Offered Spring Even-numbered Years
Introduction to the research methods in paleontology. This course covers the fundamentals of fossil preparation, digital techniques for imaging and analyzing paleontological data, and discusses the current theory and practice of curation of fossil material in a museum setting. Common techniques for preparing research results to a scientific and public audience are also covered, with an emphasis on oral presentations. Labs emphasize practical experiences in the methods and presentation of research.
Prerequisites: GEOF F101X and GEOF F112X or permission of the instructor.
Lecture + Lab + Other: 1 + 3 + 0

GEOS F320  Sedimentology for Geological Engineers
3 Credits
Lecture + Lab + Other: 2 + 3 + 0
GEOS F322  Stratigraphy and Sedimentation  (n)
4 Credits
Offered Fall
Analysis and interpretation of sedimentary rocks in stratigraphic successions based on comparison with features found in modern depositional environments. Application of the principles of facies analysis and litho-, bio-, sequence, and chronostratigraphy in surface and subsurface examples. Emphasis in the laboratory on interpretation of depositional environments based on lithofacies, biofacies and sedimentary structures and correlation of stratigraphic sequences using surface and subsurface data.
Prerequisites: GEOS F101X or GEOS F112X.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F332  Ore Deposits and Structure
3 Credits
Offered Spring
Distribution and characteristics (especially mineralogy, morphology, and structure) of major mineral deposit types with background on structural techniques. Emphasis on application to mineral exploration and development. Laboratory exercises stress recognition of major mineral deposit types, zoning and grade patterns; and use of structural techniques in mineral deposit exploration/development.
Prerequisites: GEOS F262 or permission of instructor.
Lecture + Lab + Other: 1 + 6 + 0

GEOS F339  Maps and Landscape Analysis  (n, n)
4 Credits
Offered Spring Odd-numbered Years
This course will build student knowledge and practical experience regarding the visualization and mapping of landform evolution in response to Earth surface processes. A semester long research project will allow students to gain experience in the collection and use of a variety of datasets and equipment used in landscape analysis including ground penetrating radar, real-time-kinematic GPS, Drones and GIS. Overnight field trip required. Special fees apply.
Prerequisites: GEOG F111X; GEOS F304; or permission of instructor.
Cross-listed with GEOG F339.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F351  Field Geology  (W, n)
8 Credits
Offered Summer Odd-numbered Years; As Demand Warrants
Practical experience in a variety of field settings collecting and presenting basic geologic field data. Includes field mapping of stratigraphic and structural problems using topographic maps, airborne and satellite images. Students will prepare geologic maps in a variety of tectonic and lithologic settings and develop written reports detailing the geologic history for several study areas. Exercises in collection and use of geophysical data as an aid to geologic mapping. Hiking off trails in a variety of terrains with up to 2,000 vertical feet of elevation gain per day. Course fees cover transportation and subsistence outside of Fairbanks. Entrance by preregistration only; apply through the department. Early registration recommended.
Prerequisites: GEOS F214; GEOS F225; GEOS F309; GEOS F314; GEOS F315; GEOS F322; permission of instructor.
Lecture + Lab + Other: 8 + 0 + 0

GEOS F370  Sedimentary and Structural Geology for Petroleum Engineers  (n)
4 Credits
Offered Fall Odd-numbered Years
Origin and distribution of sedimentary rocks including depositional environments, stratigraphic relationships and structures. Emphasis on the relationship to petroleum occurrences and petroleum exploration. Laboratory exercises on mapping, structural problems and facies relationships in petroleum exploration.
Prerequisites: GEOS F101X or GEOS F261.
Cross-listed with PETE F370.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F375  Oral Communication Skills for Geoscientists
1 Credit
Offered As Demand Warrants
This course will give you skills and practice in oral communication, especially as applied to professional geology. The course will provide a comfortable environment for students to develop and improve their skills both in creating and delivering oral presentations. The specific focus will vary with the instructor.
Prerequisites: COJO F131X or COJO F141X; GEOS F225; junior standing.
Lecture + Lab + Other: 0.5 + 0 + 1.5

GEOS F380  Geological Hazards
3 Credits
Offered Spring
Survey of natural hazards and the disasters they cause, with emphasis on geological hazards in Alaska. Investigation of hazardous phenomena, prediction and mitigation. Topics to include: earthquakes, volcanoes, tsunamis, weather/climate, and asteroid impacts. Provides a foundation in basic geological hazards related to science, suitable for use in teaching, communications, policy and emergency management careers.
Prerequisites: GEOS F101X or GEOS F120X or GEOS F106X or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F392  Seminar
1-6 Credits
Lecture + Lab + Other: 0 + 0 + 0

GEOS F392P  Seminar
1-6 Credits
Lecture + Lab + Other: 1-6 + 6 + 0

GEOS F398  Research
1-6 Credits
Lecture + Lab + Other: 0 + 0 + 0

GEOS F401  Invertebrate Paleontology  (n)
3 Credits
Offered Fall Even-numbered Years
Study of invertebrate phyla with extensive geologic records. Emphasis on principles of biostratigraphy and paleoecology, application to geologic problems and case studies from Alaska. Laboratory study of fossil assemblages with emphasis on stratigraphically significant groups. Designed to complement GEOS F322.
Prerequisites: GEOS F315 or permission of instructor.
Recommended: GEOS F322.
Lecture + Lab + Other: 2 + 3 + 0
GEOS F406  Volcanology  
3 Credits  
Offered Spring Odd-numbered Years  
Physical processes of volcanism. Topics include physical properties of magmas, eruption mechanisms, deposition mechanism and volcanic hazards. Emphasis on explosive volcanism and its products, pyroclastic rocks. Geochemistry and petrology will not be emphasized in this course.  
Prerequisites:  GEOS F101X or GEOS F120X; MATH F251X; PHYS F103X or PHYS F211X; or permission of instructor.  
Lecture + Lab + Other:  3 + 0 + 0  
GEOS F408  Photogeology  
2 Credits  
Offered Spring Even-numbered Years  
Use of topographic maps, geologic maps, aerial photographs and satellite imagery in interpretation of geological structures, landscapes, landforms and geomorphic processes. Techniques included are map compilation, photo mapping, statistical treatment of map data and composite mapping for planning.  
Prerequisites:  GEOS F304 or permission of instructor.  
Lecture + Lab + Other:  1 + 3 + 0  
GEOS F417  Introduction to Geochemistry  
3 Credits  
Offered Fall  
Application of chemical principles and elemental/isotopic behavior to the study of the Earth. Topics include: aqueous geochemistry, high-temperature mineral-elemental chemistry, isotopic chemistry, kinetics and thermochemistry.  
Prerequisites:  CHEM F106X; GEOS F322 or CHEM F202.  
Lecture + Lab + Other:  3 + 0 + 0  
GEOS F419  Solid Earth Geophysics  
3 Credits  
Offered Alternate Fall  
Concepts and techniques of geophysics including origin of the Earth, its structure and large scale dynamic processes responsible for its surface features. Geophysical techniques including seismology, gravity and magnetic methods are discussed along with measurements of the Earth's thermal structure, rotation rates, and tidal effects.  
Prerequisites:  MATH F251X; PHYS F104X; or permission of instructor.  
Lecture + Lab + Other:  3 + 0 + 0  
GEOS F422  Geoscience Applications of Remote Sensing  
3 Credits  
Offered Fall  
Remote sensing and its applications to geologic, environmental and physical sciences. Includes physical principles, digital image processing and hands-on project experience using satellite images for mapping and change detection. Course is not available for audit.  
Prerequisites:  PHYS F104X or PHYS F212X; junior standing; or permission of instructor.  
Lecture + Lab + Other:  2 + 3 + 0  
GEOS F428  Elementary Scanning Electron Microscopy  
1 Credit  
Offered Spring  
Basic theory and operating procedures for scanning electron microscopy. Includes sample preparation, imaging and qualitative elemental analysis. Biological and nonbiological applications are covered.  
Prerequisites:  Junior standing or permission of instructor.  
Lecture + Lab + Other:  0.5 + 1.5 + 0  

GEOS F430  Statistics and Data Analysis in Geology  
3 Credits  
Offered Spring  
Computer-supported geologic applications of elementary statistics, Markov chains, time-series analysis, trend-surface analysis, factor analysis, cluster analysis, discriminant analysis, and multiple regression.  
Prerequisites:  GEOS F225; STAT F200X.  
Lecture + Lab + Other:  3 + 0 + 0  

GEOS F431  Foundations of Geophysics  
4 Credits  
Offered Fall  
Applications of continuum mechanics, heat flow theory, and potential theory to geophysical, geologic and glaciological problems. Topics such as postglacial rebound, non-Newtonian fluid flow, thermal convection, stress-relaxation, rheology of earth materials, gravity, and magnetics will be discussed. Emphasis will be placed on methods and tools for solving a variety of problems in global and regional geophysics and the geophysical interpretation of solutions.  
Prerequisites:  GEOS F318, MATH F302, and MATH F314 or permission of instructor.  
Stacked with  GEOS F631.  
Lecture + Lab + Other:  3 + 3 + 0  

GEOS F436  Beyond the Mouse: Computer Programming and Automation for Geoscientists  
2 Credits  
Offered Fall  
Basic concepts of computer programming and effective automation of tasks using a computer, with an emphasis on tools and problems common to the geosciences and other physical sciences. Use of MATLAB, shell scripting and various command line tools for data analysis, making scientific figures, maps and visualizations.  
Prerequisites:  Senior standing or permission of the instructor.  
Stacked with  GEOS F636.  
Lecture + Lab + Other:  1 + 3 + 0  

GEOS F438  Basin Analysis  
3 Credits  
Offered Spring Odd-numbered Years  
Examines sedimentary basins as a record of subsidence. Review and discuss techniques used to image basin stratigraphy as well as the quantitative techniques which can be used to recover basin history.  
Prerequisites:  GEOS F322 or GEOS F370.  
Recommended:  GEOS F314; GEOS F416; GEOS F418.  
Stacked with  GEOS F638.  
Lecture + Lab + Other:  3 + 0 + 0  

GEOS F452  Quaternary Seminar  
3 Credits  
Offered As Demand Warrants  
Learning about the Quaternary Period (relatively recent past--spanning the past two million years) in order to gain a better understanding of the landscape, biota and climate of the present day. Quaternary studies are concerned with the historical dimension of the natural sciences. This seminar will range widely over diverse interdisciplinary subjects of Quaternary interest, such as paleoclimatology, paleobiogeography, vertebrate paleontology and sedimentology.  
Prerequisites:  GEOS F304; GEOS F315; GEOS F322.  
Cross-listed with ANTH F451.  
Stacked with  GEOS F651; ANTH F651.  
Lecture + Lab + Other:  3 + 0 + 0
GEOS F453  Palynology and Paleopalynology  (n)
4 Credits
Offered Fall Even-numbered Years
Survey of the evolutionary record of palynomorphs and their uses in biostratigraphy and paleoclimatology. Focus on evolution of palynomorphs from Precambrian to the present and concurrent evolutionary developments of producing plants. Use of Quaternary palynofloras in reconstructing global climates. Labs involve collection of herbarium specimens, processing of fossil palynomorphs, study of type slides and a survey of palynofloras from each geologic period.
Prerequisites: BIOL F115X or GEOS F315; senior standing.
Stacked with GEOS F653.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F456  Paleopedology
3 Credits
Offered Fall Even-numbered Years
A survey course focusing on the recognition and use of paleosols (fossil soils) as paleoenvironmental indicators, stratigraphic markers and in paleogeographic reconstructions from Precambrian to Holocene. Examination of theories of soil formation, major soil processes and approaches to soil classification. Review of geochemical, mineralogical, morphological and micromorphological techniques. Use of paleosols for paleolandscap evolution and basin analysis. Geological, tectonic, archaeological and environmental applications of paleosols are discussed.
Prerequisites: GEOS F322 or GEOG F111 or NRM F380 or permission of instructor.
Stacked with GEOS F656.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F458  Applications of GPS and GIS in Geophysics  (n)
3 Credits
Offered Spring
Prerequisites: GEOG/NRM F338 or equivalent; or permission of instructorStacked with GEOS F658.
Lecture + Lab + Other: 2 + 3 + 0

GEOS F460  The Dynamic Alaska Coastline
3 Credits
Offered Spring Even-numbered Years
Alaska’s diverse coastal system provides abundant ecosystem services and globally important resources. This course provides an interdisciplinary perspective on the dynamic coastal landscape of Alaska from Southcentral to the Arctic, and delves into the driving geological, oceanographic and climate processes shaping Alaska’s past and present coastline. Through a semester long research projects students will learn how to measure and map coastal changes associated with natural and human perturbations. An overnight field trip will serve as an active learning opportunity to integrate course knowledge with hands-on field work.
Prerequisites: Junior standing; GEOG F111X or GEOS F101; CHEM F105X or PHYS F103X; NRM F338 or equivalent GIS coursework.
Cross-listed with GEOG F460.
Stacked with GEOS F660; GEOG F660.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F462  Glacial & Periglacial Geology  (O, n)
4 Credits
Prerequisites: GEOS F322 or GEOG F111 or NRM F380 or permission of instructor.
Lecture + Lab + Other: 0 + 0 + 0

GEOS F463  Glacial and Periglacial Geology  (O, n)
4 Credits
Offered Fall Odd-numbered Years
Prerequisites: COJO F131X or COJO F141X; GEOG F304.
Stacked with GEOG F460.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F475  Presentation Techniques in the Geosciences  (O, W)
2 Credits
Offered Fall
Instruction and practice in oral and written communication skills specifically related to the geosciences. Oral and written presentation of abstracts, resumes, proposals and reports required. Works critically analyzed by instructor(s) and peers for both geoscience content and communication effectiveness.
Prerequisites: COJO F131X or COJO F141X; WRTG F111X; WRTG F211X or WRTG F213X; senior standing; or permission of instructor.
Stacked with GEOS F675.
Lecture + Lab + Other: 1 + 3 + 0

GEOS F477  Ice in the Climate System  (O, n)
3 Credits
Offered Spring Even-numbered Years
Earth’s cryosphere includes seasonal snow, permafrost, sea ice, mountain glaciers and ice sheets. This course will cover the formation of each of these forms of snow and ice and their response to changing environmental conditions. Interdisciplinary perspectives allow study of the role snow and ice plays within the Arctic system (including atmosphere, ocean and ecosystems), with an emphasis on Alaska. The cryosphere will also be placed in context of the global climate system. Course will include instructor and peer feedback.
Prerequisites: PHYS F103X or PHYS F211X; MATH F251X; or permission of instructor.
Lecture + Lab + Other: 2 + 3 + 0
GEOS F478  Ice Age Alaska  (a)  
3 Credits  
An overview of the paleoenvironments of Alaska including climate, glacier and biotic history including humans. Emphasis on events of the past that have left important legacies on present landscapes. The course begins with two weekend field trips and then surveys key literature describing Alaska’s ice-age history. The focus is on Alaska and the Yukon, but topics will range more widely into other parts of the Arctic and its adjacent seas.  
Prerequisites: Senior standing in anthropology, biological sciences, earth science, geography, geoscience, or northern studies; or permission of instructor.  
Cross-listed with GEOG F478.  
Stacked with GEOG F678; GEOS F678.  
Lecture + Lab + Other: 3 + 0 + 0  

GEOS F482  Geoscience Seminar  
1 Credit  
A weekly seminar, given by guest speakers, on a topic in geosciences. Students are expected to complete written summaries of the seminars.  
Stacked with GEOS F682.  
Lecture + Lab + Other: 1 + 0 + 0  

GEOS F483  Research Design, Writing and Presentation Methods  
(0, W, n)  
3 Credits  
Offered Fall  
This course is designed as a capstone research and professional development course for geography, natural resources management and geoscience majors. Students will focus on designing an individual research project and proposal. This course will provide real world active learning assignments that seek to integrate the knowledge and skills gained through undergraduate work, and prepares students for graduate and professional level projects. The course is writing intensive and will focus on scientific writing, and the oral, written and graphical presentation of data and research results.  
Prerequisites: COJO F131X or COJO F141X; WRTG F211X or WRTG F213X; at least one writing intensive course designated (W); junior standing.  
Cross-listed with GEOG F483.  
Lecture + Lab + Other: 3 + 0 + 0  

GEOS F485  Mass Extinctions, Neocatastrophism and the History of Life  
3 Credits  
Offered Spring Odd-Numbered Years  
In-depth analysis of the literature regarding mass extinction, focusing on evidence for catastrophes and impact on the uniformitarian paradigm. Effects of mass extinctions on the evolutionary history of extant and fossil animals and plants will be explored through readings from classic and current literature in paleontology. The course will emphasize critical reading and application of scientific methods to reconstruction of geologically rapid events in deep time.  
Prerequisites: GEOS F322 and GEOS F315W, or permission of instructor.  
Lecture + Lab + Other: 3 + 0 + 0  

GEOS F486  Vertebrate Paleontology  
(n)  
3 Credits  
Offered Spring Odd-numbered Years  
The study of vertebrate evolution through geologic time. Covers the temporal range, diversity and systematics of major vertebrate groups as documented in the fossil record, with an emphasis on current problems in vertebrate evolutionary pattern and process. Labs emphasize comparative morphology and identification of major vertebrate groups.  
Prerequisites: BIOL F310 or GEOS F315 or permission of instructor.  
Cross-listed with BIOL F486.  
Stacked with GEOS F686; BIOL F686.  
Lecture + Lab + Other: 2 + 3 + 0  

GEOS F488  Undergraduate Research  
1-3 Credits  
Advanced research topics from outside the usual undergraduate requirements.  
Prerequisites: Permission of instructor.  
Recommended: A substantial level of technical/scientific background.  
Lecture + Lab + Other: 1-3 + 0 + 0  

GEOS F492  Seminar  
1-6 Credits  
Lecture + Lab + Other: 0 + 0 + 0  

GEOS F492P  Seminar  
1-6 Credits  
Lecture + Lab + Other: 0 + 0 + 0  

GEOS F499  Geology and Geophysics Senior Thesis  
3 Credits  
This course is intended for talented students to explore geology or geophysics more deeply through research under the mentorship of a faculty member in the department.  
Prerequisites: Geology and Geophysics major with senior standing and a GPA of 3.2 or higher, completion of a minimum of 2 credits of GEOS F488 on a project approved by faculty mentor and department chair, and submission of a proposal approved by faculty mentor and department chair.  
Lecture + Lab + Other: 3 + 0 + 0  

GEOS F600  Introduction to X-ray Spectrometry  
3 Credits  
Offered Fall  
Theory of X-ray spectrometry, qualitative and quantitative elemental analysis. Mechanics of electron, microprobe and X-ray fluorescence analysis. Applicable to geologic, materials science and biologic samples. Required for use of the microprobe at UAF.  
Prerequisites: PHYS F212X; STAT F300; GEOS F417; graduate standing in the sciences or engineering; or permission of instructor.  
Lecture + Lab + Other: 2 + 3 + 0  

GEOS F602  Geophysical Fields  
3 Credits  
Offered Spring Odd-numbered Years  
Introduction to the application of potential theory and its associated mathematical tools to fields of geophysical interest, namely gravity, magnetics, and heat flow. Emphasis will be placed on methods and tools for solving a variety of problems in global and regional geophysics, and the geophysical interpretation of solutions.  
Prerequisites: MATH F421 and MATH F422 and permission of instructor; or graduate standing.  
Lecture + Lab + Other: 3 + 0 + 0
GEOS F604 Seismology
3 Credits
Offered Spring Odd-numbered Years
Sources of ground motion including focal mechanisms, magnitude and propagation of waves within the earth. Measurement of seismic data by analog and digital techniques and subsequent treatment of seismic data by various techniques including inversion.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F605 Geochronology
3 Credits
Offered Fall Even-numbered Years
Application of the most commonly used radiometric dating methods to geologic problems. Fundamentals of the K-Ar, Rb-Sr, fission-track, U-Th-Pb and C methods. Laboratory training in K-Ar and fission-track dating techniques.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F606 Volcanology
3 Credits
Offered Fall Odd-numbered Years
Physical processes of volcanism. Topics include physical properties of magmas, eruption mechanisms, deposition mechanism and volcanic hazards. Emphasis on explosive volcanism and its products, pyroclastic rocks. Geochemistry and petrology will not be emphasized in this course.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F607 Advanced Paleomagnetism
2 Credits

GEOS F611 Advanced Structural Geology and Tectonics
3 Credits
Offered Fall Even-numbered Years
An advanced course providing an in-depth treatment of specific aspects of structural geology and tectonics. Topics to be considered in different semesters include tectonics and sedimentation, mountain belts of the world, structural analysis, structural geology of a specific tectonic setting (such as fold-and-thrust belts or rifts), (E) active tectonics and topography, (F) structural interpretation of seismic reflection data, and (G) other special topics in structural geology or tectonics. Note: Course may be repeated for different topics up to three times for credit.
Prerequisites: GEOS F314; graduate standing; or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F612 Geologic Evolution of Alaska (a)
3 Credits
Offered Fall Even-numbered Years
An overview of the geological provinces of Alaska and neighboring continental and oceanic regions. Emphasis will be on the geologic history and tectonic evolution of Alaska.
Prerequisites: GEOS F314 and GEOS F322; OR graduate standing.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F613 Global Tectonics
3 Credits
Offered Fall Odd-numbered Years
An advanced course dealing with tectonic theory. Emphasis on plate tectonics with discussions of the evidence supporting the plate hypothesis and the interaction of plates both past and present.
Prerequisites: GEOS F314 and GEOS F322; OR graduate standing.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F614 Ice Physics (a)
3 Credits
Offered Spring Even-numbered Years
A survey of the physics of ice. Topics will include the crystal structure and properties of ice, high pressure phases, hydrogen bonding, mechanical, thermal, electrical and acoustic properties, nucleation and growth, and optical and surface properties (adhesion, friction).
Prerequisites: MATH F421 and MATH F422 and permission of instructor; OR graduate standing.
Cross-listed with PHYS F614.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F615 Sea Ice (a)
3 Credits
Offered Fall Even-numbered Years
A study of sea ice in the natural environment including sea ice properties and processes on the micro-scale and the macro-scale, freezing processes and sea ice growth, ice decay and ice dynamics.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F616 Permafrost (a)
3 Credits
Offered Spring Odd-numbered Years
Study of the occurrence, thickness, environmental problems, and mass and energy transport of permafrost, including soil and ice interaction, freezing and thawing processes, and mechanical and petrological properties and processes.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F617 Glaciers (a)
3 Credits
Offered Fall Odd-numbered Years
The mechanisms responsible for the existence, motion and variations of present-day glaciers and ice sheets, the paleoclimate information they contain and their role in engineering hydrology.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F618 Introduction to Geochemistry
3 Credits
Offered Fall
Application of chemical principles and elemental/isotopic behavior to study of the Earth. Topics include: aqueous geochemistry, high-temperature mineral-elemental chemistry, isotopic chemistry, kinetics and thermochemistry.
Prerequisites: CHEM F106X; GEOS F322 OR CHEM F331 and CHEM F332; graduate standing.
Stacked with GEOS F417.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F619 Advanced X-ray Spectroscopy
2 Credits
Offered As Demand Warrants
Advanced X-ray techniques. Topics include preparation of unusual samples, quantification methods, x-ray mapping and classification, and error analysis. Each student will develop a project to explore the limits of x-ray analysis. Note: Course may be repeated three times for credit.
Prerequisites: GEOS F600 or permission of instructor.
Lecture + Lab + Other: 1 + 3 + 0
GEOS F620  Geodynamics
3 Credits
Offered Fall Even-numbered Years
Applications of continuum mechanics and heat flow theory to geophysical, geologic and glaciological problems. Topics such as postglacial rebound, non-Newtonian fluid flow, thermal convection, stress-relaxation and the rheology of earth materials will be discussed.
**Prerequisites:** MATH F421 and MATH F422 and permission of instructor; OR graduate standing.
**Lecture + Lab + Other:** 3 + 0 + 0

GEOS F621  Advanced Petrology
4 Credits
Offered As Demand Warrants
A detailed treatment of various aspects of petrology. Specific topics to be considered in different semesters include metamorphic petrology, igneous petrology, and igneous and metamorphic petrography. Each time the course is offered, only one topic will be presented.
**Prerequisites:** Graduate standing; permission of instructor.
**Lecture + Lab + Other:** 3 + 3 + 0

GEOS F621B  Adv Petrology: Igneous Petrology
3-4 Credits
**Lecture + Lab + Other:** 2-3 + 3-6 + 0

GEOS F621C  Advanced Petrology
3-4 Credits
An advanced course providing a detailed treatment of various aspects of petrology. Specific topics to be considered in different semesters include: (A) metamorphic petrology, (B) igneous petrology, and (C) igneous and metamorphic petrography. Each time the course is offered, only one topic will be presented.
**Prerequisites:** Graduate standing and permission of instructor.
**Lecture + Lab + Other:** 2-3 + 3-6 + 0

GEOS F622  Digital Image Processing in the Geosciences
3 Credits
Offered Fall Odd-numbered Years
Image processing and analysis techniques as they relate to remote sensing and other applications in the geosciences. Apart from lectures and demonstrations, the advantages and drawbacks of different methods and approaches and their applicability to geoscience problems will be evaluated through exercises and a course project.
**Lecture + Lab + Other:** 3 + 0 + 0

GEOS F626  Applied Seismology
4 Credits
Offered Spring Even-numbered Years
Presentation of modeling techniques for earthquakes and Earth structure using wave propagation algorithms and real seismic data. Covers several essential theories and algorithms for applications in seismology, as well as the basic tools needed for processing and using recorded seismograms. Topics include the seismic wavefield (body waves and surface waves), earthquake moment tensors, earthquake location and seismic tomography. Assignments require familiarity with vector calculus, linear algebra and computational tools such as Matlab.
**Prerequisites:** MATH F253X; MATH F314; or permission of instructor.
**Lecture + Lab + Other:** 3 + 3 + 0

GEOS F627  Inverse Problems and Parameter Estimation
3 Credits
Offered Spring Odd-numbered Years
An inverse problem uses observations to infer properties of an unknown physical model. One example is how seismometer recordings can be used to infer the location of an earthquake. This course covers inverse theory and methods for solving inverse problems, including numerous examples arising in the natural sciences. Topics include linear regression, method of least squares, discrete ill-posed inverse problems, estimation of uncertainties, iterative optimization, and probabilistic (Bayesian) sampling approaches. Assignments and computational laboratory exercises require familiarity with linear algebra and computational tools such as Matlab.
**Prerequisites:** MATH F253X; MATH F314; or permission of instructor.
**Cross-listed with PHYS F625.**
**Lecture + Lab + Other:** 2 + 3 + 0

GEOS F628  Elementary Scanning Electron Microscopy
1 Credit
Offered Spring
Basic theory and operating procedures for scanning electron microscopy. Includes sample preparation, imaging and qualitative elemental analysis. Biological and non-biological applications are covered.
**Prerequisites:** Graduate standing or permission of instructor.
**Stacked with GEOS F428.**
**Lecture + Lab + Other:** 0.5 + 1.5 + 0

GEOS F629  Geologic Hazards and Natural Disasters
3 Credits
Offered Spring Odd-numbered Years
Examination of hazardous geologic processes which produce natural disasters, including volcanism, tectonism, flooding, etc. Includes scientific approaches to evaluating the magnitude and probability of risk from future hazardous events.
**Prerequisites:** Graduate standing or permission of instructor.
**Lecture + Lab + Other:** 3 + 0 + 0

GEOS F631  Foundations of Geophysics
4 Credits
Offered Fall
Applications of continuum mechanics, heat flow theory, and potential theory to geophysical, geologic and glaciological problems. Topics such as postglacial rebound, non-Newtonian fluid flow, thermal convection, stress-relaxation, rheology of earth materials, gravity, and magnetics will be discussed. Emphasis will be placed on methods and tools for solving a variety of problems in global and regional geophysics and the geophysical interpretation of solutions.
**Prerequisites:** Graduate standing.
**Recommended:** GEOS F318; MATH F302; MATH F314.
**Stacked with GEOS F431.**
**Lecture + Lab + Other:** 3 + 3 + 0
GEOS F633  Environmental Geochemistry
3 Credits
Offered Spring Even-numbered Years
Advanced topics and methods in chemistry of aquatic and soil environments. Detailed treatment of the thermodynamic, kinetic and structural principles involved in the description and modeling of low-temperature aqueous geochemical systems. Particular emphasis will be placed on heterogeneous interactions, including dissolution/precipitation, sorption and microbial processes, involved in the partitioning, transformation and transport of chemical species in the environment.
Prerequisites: ENVE F641 or GEOS F618 or permission of instructor.
Cross-listed with CHEM F609.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F635  Advanced Economic Geology
1-4 Credits
Offered As Demand Warrants
An advanced course providing an in-depth treatment of various aspects of economic geology. Specific topics will be covered in different semesters. They include ore microscopy, industrial minerals, economics of minerals, geochemistry of ore deposits, modern fossil fuel exploration and detailed study of particular ore deposit type. Each time the course is offered, only one topic will be presented. May be repeated for credit.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 1-4 + 3 + 0

GEOS F635D  Geochemistry of Ore Deposits
1-4 Credits
Lecture + Lab + Other: 1-4 + 3 + 0

GEOS F635F  Adv Econ Geology: Ore Deposits
1-4 Credits
Lecture + Lab + Other: 1-4 + 3 + 0

GEOS F636  Beyond the Mouse: Computer Programming and Automation for Geoscientists
2 Credits
Offered Fall
Basic concepts of computer programming and effective automation of tasks using a computer, with an emphasis on tools and problems common to the geosciences and other physical sciences. Use of MATLAB, shell scripting and various command line tools for data analysis, making scientific figures, maps and visualizations.
Prerequisites: Graduate standing.
Stacked with GEOS F436.
Lecture + Lab + Other: 1 + 3 + 0

GEOS F637  Rock-Forming Minerals
4 Credits
Offered Spring Odd-numbered Years
Examination of the rock-forming minerals; their structure and composition. Application of mineral data to problems in geochemistry, petrology and ore deposits. Laboratory involves analysis of minerals by various analytical techniques.
Prerequisites: GEOS F417 and permission of instructor; or graduate standing.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F638  Basin Analysis
3 Credits
Offered Spring Odd-numbered Years
Examines sedimentary basins as a record of subsidence. Review and discuss techniques used to image basin stratigraphy as well as the quantitative techniques which can be used to recover basin history.
Prerequisites: Graduate standing or permission of instructor.
Stacked with GEOS F438.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F639  InSar and Its Applications
3 Credits
Offered As Demand Warrants
Introduction to the concepts of repeat-pass spaceborne SAR interferometry. Practical use of the technique to derive displacements of the solid earth, glaciers and ice sheets to a precision of a few centimeters and accurate digital elevation models of the earth's surface.
Prerequisites: Basic remote sensing course or permission of instructor.
Cross-listed with PHYS F639.
Lecture + Lab + Other: 2 + 2 + 0

GEOS F640  Petrology of Carbonate Rocks
4 Credits
Offered Spring As Demand Warrants
Origin, depositional environments, diageneis and classification of limestones, dolostones and related rocks.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 3 + 0

GEOS F643  Sandstone Depositional Environments
3 Credits
Offered Fall Even-numbered Years
Sedimentary depositional environments treating the hydrodynamics, sediment dispersal patterns and preservation potential of modern terrigenous clastic depositional environments and criteria for recognizing their ancient counterparts in the geologic record.
Prerequisites: GEOS F322 and GEOS F421; or graduate standing.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F647  Advanced Sedimentology and Stratigraphy
3 Credits
Offered Spring As Demand Warrants
Various topics in sedimentology and stratigraphy. Specific offerings to be presented at various times include sequence stratigraphy and sea-level analysis, paleoclimatic and paleoceanographic analyses, sandstone petrology, thermal maturation and geohistory analysis of sediments.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F651  Quaternary Seminar
3 Credits
Offered As Demand Warrants
Seminar about the Quaternary Period (relatively recent past -- spanning the past two million years) in order to gain a better understanding of the landscape, biota and climate of the present day. Quaternary studies are concerned with the historical dimension of the natural sciences. This seminar will range widely over diverse interdisciplinary subjects of Quaternary interest, such as paleoclimatology, paleobiogeography, vertebrate palaeontology and sedimentology.
Prerequisites: Graduate standing or permission of instructor.
Cross-listed with ANTH F651.
Stacked with ANTH F451; GEOS F452.
Lecture + Lab + Other: 3 + 0 + 0
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
<th>Prerequisites</th>
<th>Stacked with</th>
<th>Lecture + Lab + Other:</th>
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</thead>
<tbody>
<tr>
<td>GEOS F653</td>
<td>Palynology and Paleopalynology</td>
<td>4</td>
<td>Survey of the evolutionary record of palynomorphs and their uses in biostratigraphy and paleoclimatology. Focus on evolution of palynomorphs from Precambrian to the present and concurrent evolutionary developments of producing plants. Use of Quaternary palynofloras in reconstructing global climates. Labs involve collection of herbarium specimens, processing of fossil palynomorphs, study of type slides and a survey of palynofloras from each geologic period.</td>
<td>Graduate standing or permission of instructor.</td>
<td>GEOS F453.</td>
<td>3 + 3 + 0</td>
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<tr>
<td>GEOS F654</td>
<td>Visible and Infrared Remote Sensing</td>
<td>3</td>
<td>In-depth coverage of the principles, physics, sensor technology, processing and applications of remote sensing in the visible and infrared region, including but not limited to electromagnetic spectrum, radiation laws, spectral signatures, atmospheric interactions, temperature emissivity estimation, analysis and feature extraction from data sets. The laboratory part of the course will provide hands-on experience on special processing techniques, and the possibility of using these techniques for a student-defined term project in areas of geology, volcanology, glaciology, hydrology, environmental sciences, etc.</td>
<td>GEOS F422 or permission of instructor.</td>
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<td>3 + 0 + 0</td>
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<tr>
<td>GEOS F655</td>
<td>Tectonic Geodesy</td>
<td>3</td>
<td>Introduction to modern space geodetic methods and details their application to the study of active earth processes such as plate tectonics, fault mechanics and volcanology. Includes space geodesy methods such as global positioning system, as standard geophysical tools for the study of earthquakes, active tectonics and volcanology.</td>
<td>MATH F314; MATH F421; MATH F422; graduate standing; or permission of instructor.</td>
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<td>3 + 0 + 0</td>
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<tr>
<td>GEOS F656</td>
<td>Paleopedology</td>
<td>3</td>
<td>A survey course focusing on the recognition and use of paleosols (fossil fuels) as paleoenvironmental indicators, stratigraphic markers and in paleogeographic reconstructions from Precambrian to Holocene. Examination of theories of soil formation, major soil processes and approaches to soil classification. Review of geochemical, mineralogical, morphological and micromorphological techniques. Use of paleosols for paleolandscape evolution and basin analysis. Geological, tectonic, archaeological and environmental applications of paleosols are discussed.</td>
<td>Graduate standing or permission of instructor.</td>
<td>GEOS F456.</td>
<td>3 + 0 + 0</td>
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<tr>
<td>GEOS F657</td>
<td>Microwave Remote Sensing</td>
<td>3</td>
<td>The principles and applications of active and passive microwave remote sensing with emphasis on spaceborne remote sensing of the Earth's atmosphere, land and oceans. The laboratory section will provide hands-on experience on special processing techniques, and the possibility of using these techniques for a student-defined term project in areas of geology, volcanology, glaciology, hydrology, environmental sciences, etc.</td>
<td>GEOS F422 or equivalent.</td>
<td></td>
<td>2 + 2 + 0</td>
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<tr>
<td>GEOS F658</td>
<td>Applications of GPS and GIS in Geophysics</td>
<td>3</td>
<td>Application of Geographic Information Systems (GIS) to geospatial problems in volcanology, glaciology, environmental mapping and other geophysical disciplines. Landscape classification, linear regression modeling, and manipulation of geodatabases using ESRI's ArcGIS software. Use of model builder and Python scripting to automate geospatial processing. Hands-on experience with recreational, mapping and survey-grade GPS receivers. Differential correction of GPS solutions using real-time and post-processing methods. Course is not available for audit.</td>
<td>Graduate standing or permission of instructor.</td>
<td>GEOS F458.</td>
<td>2 + 3 + 0</td>
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<tr>
<td>GEOS F660</td>
<td>The Dynamic Alaska Coastline</td>
<td>3</td>
<td>Alaska's diverse coastal system provides abundant ecosystem services and globally important resources. This course provides an interdisciplinary perspective on the dynamic coastal landscape of Alaska from Southcentral to the Arctic, and delves into the driving geological, oceanographic and climate processes shaping Alaska's past and present coastline. Through a semester long research projects students will learn how to measure and map coastal changes associated with natural and human perturbations. An overnight field trip will serve as an active learning opportunity to integrate course knowledge with hands-on field work.</td>
<td>Graduate standing or permission of instructor.</td>
<td>GEOG F660.</td>
<td>3 + 0 + 0</td>
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<tr>
<td>GEOS F663</td>
<td>Glacial and Periglacial Geology</td>
<td>4</td>
<td>Glaciers and their geological processes. Emphasizes recognition and understanding of glacial landforms, sediments and stratigraphic relations, and implications for paleoclimatology and paleogeography. Includes non-glacial techniques and methods for interpreting Quaternary sediments.</td>
<td>GEOS F304 or graduate standing. Cross-listed with GEOG F660.</td>
<td>GEOG F460; GEOS F460.</td>
<td>3 + 0 + 0</td>
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GEOS F666 Scientific Teaching
2 Credits
Offered Spring Even-numbered Years
This course explores methods for teaching science at the university level. Emphasis is placed on methods of course design, instructional techniques, assessment and course management that have been shown by research to improve student learning. This course is intended for graduate students in the sciences who have an interest in improving their teaching skills. The course format will be a mixture of discussion, workshops and seminars. If the course is over-enrolled, priority will be given to teaching assistants who are assigned to teach large, introductory level (100 or 200 level) courses during the semester they are taking this course.
Prerequisites: Graduate standing or permission of the instructor.
Lecture + Lab + Other: 2 + 0 + 0

GEOS F670 Selected Topics in Volcanology
1-3 Credits
Offered Fall
Survey course in subjects relating to volcanology. Possible subjects include, but are not limited to, eruption dynamics, geophysics of eruptions, volatiles in volcanic systems, modeling volcanic systems. May be repeated for credit.
Prerequisites: GEOS F621 and GEOS F417; or graduate standing.
Lecture + Lab + Other: 1-3 + 0 + 0

GEOS F671 Volcano Seismology
3 Credits
Offered Spring Odd-numbered Years
Survey of seismic behavior of volcanoes. Topics include instrumentation, terminology, swarms and their attributes, high-frequency events, volcanic explosions, volcanic tremor, attenuation and velocity structure, cycles of activity, eruption forecasting, detection of magma chambers, case studies and selected topics. Oral and written student presentations will be required.
Prerequisites: Graduate standing or permission of instructor.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F675 Presentation Techniques in the Geosciences
2 Credits
Offered Fall
Development of oral and written presentation skills in the geological sciences with emphasis on the critical analysis of both peers and the instructor(s). Oral and written presentations of abstracts, resumes, proposals and reports.
Prerequisites: Graduate standing.
Stacked with GEOS F475.
Lecture + Lab + Other: 1 + 3 + 0

GEOS F676 Remote Sensing of Volcanic Eruptions
3 Credits
Offered As Demand Warrants
Focuses on the use of satellite images to detect, monitor and mitigate volcanic hazards, and to understand eruption processes. Thermal anomalies, volcanic clouds and surface morphological features will be discussed in the lecture and test cases analyzed in the laboratory. Satellite data include GOES, AVHRR, MODIS, ASTER, Landsat and SAR. Course may be repeated twice for credit.
Recommended: GEOS F422 or equivalent Remote Sensing Class or permission of instructor.
Lecture + Lab + Other: 2 + 3 + 0

GEOS F678 Ice Age Alaska (a)
3 Credits
An overview of the paleoenvironments of Alaska including climate, glacier and biotic history including humans. Emphasis on events of the past that have left important legacies on present landscapes. The course begins with two weekend field trips and then surveys key literature describing Alaska's ice-age history. The focus is on Alaska and the Yukon, but topics will range more widely into other parts of the Arctic and its adjacent seas.
Stacked with GEOG F478; GEOS F478
Prerequisites: Graduate standing in anthropology, biological Sciences, Earth science, geography, geoscience, or northern studies; or permission of instructor.
Cross-listed with GEOG F678.
Lecture + Lab + Other: 3 + 0 + 0

GEOS F682 Geoscience Seminar
1 Credit
A weekly seminar, given by guest speakers, on a topic in geosciences. Students are expected to prepare for the seminars and to participate in discussion following the seminars.
Prerequisites: Graduate standing or permission of instructor.
Stacked with GEOS F482.
Lecture + Lab + Other: 1 + 0 + 0

GEOS F686 Vertebate Paleontology
3 Credits
Offered Spring Odd-numbered Years
The study of vertebrate evolution through geological time. Covers the temporal range, diversity and systematics of major vertebrate groups as documented in the fossil record, with an emphasis on current problems in vertebrate evolutionary pattern and process. Labs emphasize comparative morphology and identification of major vertebrate groups.
Prerequisites: Graduate standing; or permission of instructor.
Cross-listed with BIOL F686.
Stacked with BIOL F486; GEOS F486.
Lecture + Lab + Other: 2 + 3 + 0

GEOS F692 Geol/Geophys Seminar
1-6 Credits
Lecture + Lab + Other: 0 + 0 + 0

GEOS F692A Geology/Geophysics Seminar
1-6 Credits
Lecture + Lab + Other: 1-6 + 0 + 0

GEOS F692B Geology/Geophysics Seminar
1-6 Credits
Lecture + Lab + Other: 1-6 + 0 + 0

GEOS F692P Seminar
1-6 Credits
Lecture + Lab + Other: 1-6 + 0 + 0

GEOS F692P Thesis
1-12 Credits
Lecture + Lab + Other: 0 + 0 + 0

GEOS F694 Trial Course
1-6 Credits
Lecture + Lab + Other: 1-6 + 0 + 0

GEOS F698 Non-Thesis Research/Project
1-9 Credits
Lecture + Lab + Other: 0 + 0 + 0

GEOS F699 Thesis
1-12 Credits
Lecture + Lab + Other: 0 + 0 + 0