815. Application of Research Methods to Planning and Analysis
Spring, 3(3-0) U P 814. Interdepartmental with and administered by Urban Planning.
Applied techniques used in planning research. Analysis and forecasting of urban population, economic activity, and land use. Analysis of transportation and other community facilities.

818. Readings in Geography
Fall, Winter, Spring, Summer. Variable credit. May reenroll for a maximum of 15 credits. Approval of department.

819. Theories of Urban Forms and Structure
Spring, 3(3-0) Approval of department. Interdepartmental with and administered by Urban Planning.
Idealized urban forms, theories and models in urban form as it relates to function and location of urban activities.

825. History and Philosophy of Geography
Fall, 3(3-0) Approval of department. Analysis of the monographic and serial literature dealing with the theory and evolution of geographic science.

826. Research Design in Geography
Winter, Spring, 3(3-0) Approval of department. Formalized approach to research and writing in geography: Identification of geographic problems and their relative importance, structuring and stating hypotheses, data acquisitions, and tests for validity.

828. Seminar in Recreation Geography
Spring, 3(3-0) GEO 309 or approval of instructor. Selected current problems in recreation geography in the U.S. and abroad.

834. Seminar in Physical Geography
Winter, Spring, 3(3-0) May reenroll for a maximum of 9 credits. Approval of department. Analysis of classical and contemporary problems in physical geography treated as follows: climatology (winter), biogeography (spring), geomorphology (spring).

835. Seminar in Location Theory
Fall, 3(3-0) Approval of department. GEO 435. Recent developments and research in location analysis and regional science.

839. African Research
(JDC 855) Fall, Winter, Spring. 2 to 4 credits. May reenroll for a maximum of 8 credits. Graduate standing or approval of instructor. Interdepartmental with African Languages and the departments of Anthropology, Educational Administration, History, Political Science, and Sociology, Administered by the Department of Anthropology.
African-related archival and field research topics and methodologies viewed from perspective of relevant social science and humanistic disciplines associated with the African Studies Center.

845. Proseminar in Cartography
Winter, 3(3-0) Approval of department. Contemporary cartographic research. Research questions and methods in cartography.

846. Seminar in Cartography
Spring, 3(3-0) May reenroll for a maximum of 12 credits. Approval of department. Research projects in cartography.

850. Advanced Field Techniques
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 8 credits. Instruction and practical training in the selection, data-gathering, on-site analysis, and presentation of geographic field problems.

859. Master's Thesis Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

901. Problems in Cultural Geography
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 6 credits. Approval of department. Special research problems.

902. Problems in Physical Geography
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 6 credits. Supervised research in specific topics of physical geography.

906. Problems in Economic Geography
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 6 credits. Approval of department. Special research problems.

910. Problems in Historical Geography
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 6 credits. Approval of department. Special research problems in historical geography.

912. Independent Study in Regional Geography
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 15 credits. Approval of department. Individual studies in regional geography.

918. Problems in Geography
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 9 credits. Approval of department. Research on specific geographical problems.

934. Problems in Population
Fall, Winter, Spring. 1 to 3 credits. May reenroll for a maximum of 9 credits. Approval of department. Special research problems.

999. Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

GEOLOGICAL SCIENCES
(GEO 815, 819, 825, 826, 828, 834, 835, 839, 845, 846, 850, 859, 901, 902, 906, 910, 912, 918, 934, 999)

GEological Sciences — Descriptions of Courses

GEOLOGY

200. Geology of Human Environment
(N)
Fall, Winter, Spring, Summer, 3(3-0) Not open to Geology majors. Credit will be given in only one of the following: GLG 200, GLG 201, GLG 306.
An exploration of social philosophical and political events which require a geological viewpoint for resolution. The application of geologic and social/historical information will also reinforce the concept of the scientific method.

201. Laboratory — Geology of Our Environment
Fall, Winter, Spring. 1(3-3) GLG 200 or concurrently.
Laboratory study of geologic processes associated with environmental hazards. Emphasis placed on land-use planning, applying geologic criteria to evaluate land potentials.

202. Evolution of the Earth
Fall, Winter, Spring. 4(4-2) Credit will be given for only one of the following: GLG 200, GLG 201, GLG 306.
Integration of physical, chemical and biological processes from which our present environment has evolved: problems and controversies in the development of ideas of geologic and organic evolution.

205. Oceanology — The Marine Environment
Fall, 3(3-0)
Physical oceanography, including origin, hydrologic, chemical, geological properties; and environmental quality of the oceans. Human-sea interactions are emphasized including resource utilization and pollution.

252. Energy Resources of the Earth
Winter, 3(3-0)
World energy resources of petroleum, coal, and atomic fuel. Social, political, economic and environmental problems of fuels.

300. Solar System Geology
Winter, 4(4-0)AST 119 or AST 217 or AST 229; GLG 300 or GLG 201.
The origin, relationships, make-up and features of the bodies in the solar system emphasizing recent space exploration results and developing theories.

302. Vertebrate Life of the Past
Fall, 3(3-0) One course in a physical or biological science or junior-level interdisciplinary with the Department of Zoology.
Fossil vertebrates from fish to humans.

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### Descriptions — Geological Sciences of Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester(s)</th>
<th>Credits</th>
<th>Additional Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>304.</td>
<td>Geology of Michigan</td>
<td>Fall, 3(3-0) GLG 200 or GLG 201 and/or GLG 202, or approval of department.</td>
<td>3</td>
<td>A historical accounting of the physical, historical and economic geology of Michigan and its environs; a course designed for students seeking an overall picture of the rather unique Michigan geological environment.</td>
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<tr>
<td>306.</td>
<td>Engineering Geology</td>
<td>Fall, Spring, 3(3-2) Credit will be given for only one of the following: GLG 200, GLG 201, GLG 306. Sophomore Engineering students. Fundamentals of geology as applied to civil engineering practice. Minerals and rocks, aerial photographs, topographic and areal geologic maps and geologic cross sections studied in laboratory. Source of geologic literature and maps.</td>
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<tr>
<td>307.</td>
<td>Geology Central Appalachians</td>
<td>Winter, 1(0-2) GLG 200, or GLG 201, or GLG 202, or concurrently.</td>
<td>1</td>
<td>General geology of the Central Appalachians. A preparatory course for GLG 308. Field excursions—Central Appalachians during spring vacation.</td>
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<tr>
<td>308.</td>
<td>Field Excursion—Central Appalachians</td>
<td>Spring, 2 or 3 credits. GLG 307. Training in stratigraphic, sedimentological, palaeontologic, and structural principles as applied to field methods.</td>
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<td>322.</td>
<td>Introduction to Optical Mineralogy</td>
<td>Winter, 1(0-3) GLG 321. Basic principles underlying the use of the polarizing microscope. Recognition and understanding fundamental optical properties. Identification of minerals and texture in thin sections of rocks.</td>
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<td>327.</td>
<td>Introduction to Geochemistry</td>
<td>Winter, 3(3-0) CEM 152, GLG 321.</td>
<td>3</td>
<td>Geochronological evolution of the universe, solar system, earth. Application of crystal field theory and thermodynamics to the solution of geological problems. Factors affecting the distribution of elements on earth. Principles of isotope geology.</td>
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<td>335.</td>
<td>Fossil Plants, Their History and Paleocology</td>
<td>Spring, 3(3-0) One course in geology or botany or biology, or approval of department. Interdepartmental with the Department of Botany and Plant Pathology. History of plants through geologic time; their form and evolution; how and where found, identified and reconstructed; their use in determining ancient geographic patterns, paleoenvironments, paleoclimates and community structure. Field trip.</td>
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<td>337.</td>
<td>The Fossil Record of Organic Evolution</td>
<td>Spring, 3(3-0) One course in a natural science; Junior standing. Interdepartmental with the Department of Zoology.</td>
<td>3</td>
<td>The direct evidence for organic evolution in the fossil record. Evolution of life from prebiological systems to humans; impact of fossil discoveries on human thought.</td>
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<tr>
<td>344.</td>
<td>Field Geology—Summer Camp</td>
<td>Summer, 8 credits. GLG 351, GLG 363, GLG 392. GLG 437, GLG 446 recommended. Methods and techniques of geological surveying and mapping. Field interpretation of geological phenomena in igneous, metamorphic and sedimentary rocks in northern Michigan and Wisconsin.</td>
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<td>351.</td>
<td>Structural Geology</td>
<td>Winter, 4(4-3) GLG 263, MTH 111. Description, classification, and origin of secondary structures such as folds, faults, joints, cleavages, foliations and lineations. Three-dimensional visualization stressed in economic laboratory problems involving descriptive geometry, stereographic projections, areal, and structural geologic maps.</td>
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<td>363.</td>
<td>Introduction to Igneous and Metamorphic Petrology</td>
<td>Spring, 4(3-4) GLG 321, GLG 323, GLG 327. Processes that form igneous and metamorphic rocks. Origin, distribution, variation and occurrence of rock. Study of rock properties in the field, in laboratory, and with the microscope.</td>
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<td>375.</td>
<td>Introduction to Geophysics</td>
<td>Fall, 3(4-0) GLG 201; MTH 111; one year of physics. Noncalculus introduction to the theory, terminology, and applications of geophysics to exploration, solid earth, and tectonic studies. Topics include reflection and refraction seismology, internal structure of the earth, gravity, paleomagnetism, lithospheric tectonics, global seismology, and planetary geology.</td>
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<td>392.</td>
<td>Sedimentology</td>
<td>Spring, 3(2-3) GLG 323, GLG 337. Grain and aggregate properties of sediments; relationships of these properties to processes in the environment of deposition and to the pre depositional and post-depositional history.</td>
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<td>400H</td>
<td>Honors Work</td>
<td>Fall, Winter, Spring, 1 to 3 credits. May reenroll for a maximum of 9 credits. Honors College student or 3.00 grade-point average, or approval of chairperson, written proposal approved by faculty sponsor and chairperson.</td>
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<td>403.</td>
<td>Fluvial Geomorphology</td>
<td>Fall, 4(3-4) Major juniors in GLG, C E, and CSS; one course in physical geology and junior standing in geology, civil engineering or soil science. Quantitative analyses of the fluvial processes associated with the development of drainage basin morphology, with emphasis on stream bed erosion and sediment transport. Field trips are required.</td>
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<td>411.</td>
<td>Hydrogeology</td>
<td>Winter, 3(3-2) One term of geology and trigonometry. Principles of the sources, occurrence, and movement of ground water and elementary ground water hydrology.</td>
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<td>413.</td>
<td>Glacial Geology</td>
<td>Spring, 4(3-4) GLG 201. Geologic aspects of glaciers and glaciation. Theories of ice ages through geologic time. Origin and development of glacial geomorphic features. Character and chronology of the Pleistocene. Laboratory techniques, with field trips to observe glacial materials and features of Michigan.</td>
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<td>426.</td>
<td>Optical and X-Ray Mineralogy</td>
<td>Fall, 4(3-4) GLG 321, PHY 239 or PHY 280. Theory, principle and application of the polarizing microscope and X-ray diffraction meter in mineral analysis.</td>
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<td>430.</td>
<td>Vertebrate Paleontology</td>
<td>Winter, 4(3-3) ZOL 326 or approval of department. Interdepartmental with the Department of Zoology. Vertebrates with emphasis on the evolution of major groups. Laboratories on modern techniques and on the identification and interpretation of fossils.</td>
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<td>437.</td>
<td>Invertebrate Paleontology</td>
<td>Fall, 4(3-4) GLG 202 or ZOL 306 or approval of department. Interdepartmental with the Department of Zoology. Systematics and evolution of marine invertebrates; use of fossils in correlation and delineation of geologic time; structure and morphology of fossils as related to evolutionary development.</td>
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<td>438.</td>
<td>Paleocology</td>
<td>Spring, 4(3-4) GLG 202 or ZOL 389 or approval of department. Interdepartmental with the Department of Zoology. Distribution and abundance of marine fossils; response of skeletal morphology to environmental conditions; uses of fossils in reconstructing ancient climates and depositional environments.</td>
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<td>445.</td>
<td>Field Studies</td>
<td>Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 9 credits. Approval of department. Advanced geologic or geophysical field studies.</td>
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<td>446.</td>
<td>Principles of Stratigraphy</td>
<td>Fall, 3(3-0) GLG 437, GLG 392 or approval of department. Covers principles of stratigraphy and application and exemplification of these principles to known geologic occurrences.</td>
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<td>452.</td>
<td>Petrology</td>
<td>Winter, 4(3-4) GLG 363, GLG 426. Introduction to the chemical and physical processes that are responsible for the origin and evolution of igneous and metamorphic rocks. Laboratory studies of rock suites that illustrate basic processes in petrology.</td>
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<td>474.</td>
<td>Exploration Geophysics</td>
<td>Fall, 4(3-2) GLG 375; MTH 214; PHY 239 or PHY 280. Techniques used in geophysical exploration, with application in petroleum prospecting, mineral exploration and engineering. Includes gravity, magnetic, seismic, electrical and other methods, and well logging. Interpretation of geophysical data.</td>
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</table>
475. Solid Earth Geophysics
Winter. 3(3-0) GLG 474, MTH 310, PHY 289 or approval of department.
Theoretical geophysics as applied to the solid earth, Geochronology, potential fields, gravity and shape of the earth, heat flow equation and solutions, rock and paleomagnetism, wave equation and body and surface waves, differential equations of mathematical physics used in geophysical analysis.

478. Exploration Seismology
(872) Spring, 4(2-4) GLG 474. Theory and technique of field seismic exploration methods. An associated geophysical survey will be conducted and a report prepared.

479. Tectonophysics
Spring. 3(3-0) GLG 351, GLG 375, MTH 113.
Seismotectonics and geophysics of the lithosphere emphasizing recent developments in plate tectonics. Principles of seismograms, focal mechanisms, plate kinematics, tectonics of plate margins, seismicity, inter- and intra-plate stresses, paleocontinental reconstructions, and planetary evolution.

482. Mineral Resources
Spring of odd-numbered years. 4(4-0) GLG 321, GLG 351.

482B. Mineral Resources Evaluation
Spring of even-numbered years. 3(3-0) GLG 321, GLG 351, approval of department.
Emphasis on practical applications of geoscience to mineral resources and the extractive industries. Aspects of exploration and development of reserves including evaluation, grade estimation, drilling, recovery, and beneficiation.

483. Petroleum Geology
Fall. 4(3-2) Approval of department.
Fundamental principles of the origin, migration and accumulation of petroleum. Exploration techniques to include well drilling, electric and radioactivity well logging, surface and subsurface exploration methods, seismic surveys, land leasing and oil field development. Laboratory study of well log plotting and subsurface mapping technique.

484. Applied Petroleum Geology
Winter. 4(1-6) GLG 483.
Microscopic examination of well cuttings, practice in the use of electric and radioactivity log exploration for petroleum in selected areas by subsurface mapping techniques, economics of petroleum exploration. Field trips.

492. Carbonate Environments I
Summer. 1 credit. GLG 392.
A field examination of carbonate sediments and their depositional environments. A ten-day field trip, two weeks prior to the beginning of Fall term.

493. Carbonate Environments II
Fall. 2(1-2) GLG 492 or approval of department.
An examination of carbonate sediments and their depositional environments.

497. Geochemistry
Spring. 3(3-0) GLG 261; CEM 152 or approval of department.
Oxidation-reduction systems, chemical weathering, stable and unstable isotopes, the geochemistry of co-forming diagenetic reactions, and the behavior of trace components in silicate melts.

800. Special Problems
Fall, Winter, Spring, Summer. 1 to 3 credits. May enroll for a maximum of 9 credits. Approval of department.
Special problems in hydrogeology, geomorphology and glacial geology, mineralogy and crystallography, petrology, paleontology, structural geology, and petroleum reservoir engineering. Seminar in paleontology emphasizing recent developments in vertebrate paleontology including origin, classification, phylogeny, and stratigraphic relationships of fossil vertebrates.

810. Seminar
Fall, Winter, Spring. 1 to 3 credits. May enroll, for a maximum of 12 credits. Seminar relating to current research in geology.

825. Clay Mineralogy
Winter. 4(3-4) CSS 940, CSS 850 or approval of department. Interdepartmental with the Department of Crop and Soil Sciences.
Structures and properties of clays; their origins, occurrence, and utilization. Methods of studying clays including x-ray diffraction, differential thermal analysis, infrared absorption and other chemical and physical techniques.

830. Paleobotany
Fall. 4(3-4) Approval of department. Interdepartmental with and administered by the Department of Botany and Plant Pathology.
Survey of fossil plants: their preservation, occurrence, geology, paleoecography, paleoecological evolutionary history, classification and representative types. One weekend field trip to fossil plant locality.

831. Palynology
Spring. 4(3-4) Approval of department. Interdepartmental with the Department of Botany and Plant Pathology.
Stratigraphy and paleontology with emphasis on fossil plants. Microscopic analysis of plant remains, pollen and spore analysis, both fossil and recent. Laboratory work involves construction of correlation charts, structure and restored sections, paleoecography, paleoecography and lithofacies maps, and study of certain key fossils.

844. Mesozoic and Cenozoic Stratigraphy
Winter of odd-numbered years. 4(5-0) GLG 446.
Classification, distribution, paleogeography, stratigraphy, interrelation, and structural setting of stratigraphic units within the Paleozoic systems. Laboratory work involves construction of correlation charts, structure and restored sections, paleoecography, paleoecography, and lithofacies maps, and study of certain key fossils.

851. Evolution of the Earth's Crust and Mantle
Fall. 3(3-0) GLG 462.
The composition, mineralogy and petrology of the Earth's crust and mantle. Plate tectonics and its relationship to earlier models of geodynamics, orogenic cycles, continental drift, etc.

862. Petrology—Igneous
Spring of even-numbered years. 2 to 4 credits. May enroll for a maximum of 8 credits. GLG 482, M. Must enroll for laboratory with initial registration.
Physical and chemical principles involved in the origin of igneous rocks. Application of experimental techniques in petrology.

863. Petrology—Metamorphic
Spring of odd-numbered years. 2 to 4 credits. May enroll for a maximum of 8 credits. GLG 482, M. Must enroll for laboratory with initial registration.
Origin and classification of metamorphic rocks. Study includes thin section investigation of the metamorphic textures and mineral associations and the physical-chemical principles involved in their development.
870. Topics in Geophysics
Spring, 1 to 3 credits. May reenroll for a maximum of 12 credits. Approval of department.
Topics and problems in geophysics, such as tectonophysics, terrestrial heat flow, processing and analysis of geophysical data, geomagnetism, paleomagnetism, high-pressure geophysics.

873. Seismology I
Fall of even-numbered years. 3(3-0) MTH 215 or concurrently; PHY 280 or concurrently.
Theory and application of seismic wave propagation in earth materials.

874. Seismology II
Winter of odd-numbered years. 3(3-0) GLG 873 or approval of department.
Continuation of GLG 873.

875. Advanced Geophysical Exploration I
Fall of odd-numbered years. 4(3-2) GLG 474 or concurrently.
Theory and technique of gravity and magnetic methods, and their use in geophysical exploration. Associated practical exercises.

877. Geophysics of the Lithosphere
Spring, 3(3-0) GLG 475, GLG 479 or approval of department.
Theory and applications of the deformation of the lithosphere and the state of stress in the crust. Stress and strain analysis, rheology of materials, buckling and folding of strata, lithospheric stresses, stresses due to loading, intra-plate stresses, evolution of basins, and geofluid dynamics.

884. Regional Petroleum Geology
Spring, 3(3-0) Approval of department.
Regional study of tectonics, stratigraphy and sedimentation in the U.S. and their relationship to petroleum occurrences in sedimentary basins. Analysis of petroleum distribution with emphasis on creative thinking in petroleum exploration. Practice in the analysis of petroleum possibilities in selected foreign areas.

891. Advanced Sedimentology
Fall, 3(2-4) GLG 392, GLG 462.
Origin, deposition and diagenesis of sandstones. Study includes thin section, X-ray, and SEM analysis of sediments.

892. Carbonate Petrology
Spring, 4(3-2) GLG 362, GLG 497.
Petrology, petrography, and geochemistry of carbonate sediments and rocks. Emphasis on diagenesis. Chemical and mineralogic trends through time. The role of diagenesis in petroleum reservoir potential.

893. Petrology of Weathering and Soil
Winter, 4(3-2) GLG 382 or GLG 497 or CSS 470 or CSS 480.
Application of petrological and geochemical principles to rock and mineral weathering, soil formation, and landscape evolution. Weathering and soils through geologic time.

894. Aqueous Geochemistry
Spring, 3(3-0) GLG 461 or a course in physical chemistry or approval of department.
Nature and regulation of electrolytes in solution (fresh water, seawater, brine); activity, complexion, and redox effects. Trace metals in solution. Carbonate, silica, alumina systems. Chemical weathering and mobility of elements.

899. Master's Thesis Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

900. Special Problems
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 9 credits. Approval of department.
Special problems in hydrogeology, geomorphology and glacial geology, mineralogy and crystallography, petrology, paleontology, structural geology and petrofabrics, stratigraphy, aerogeochemistry, geophysics, economic geology, petroleum geology, sedimentation, and geochemistry.

999. Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

Earth Science

445. Field Studies
Fall, Winter, Spring, Summer. 1 to 9 credits. May reenroll for a maximum of 15 credits. Approval of department.
Experience and techniques in field investigation of the near surface layers of the earth.

446. Laboratory Investigations
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 15 credits. E S 445 or concurrently.
Independent laboratory investigation of materials and phenomena obtained from field studies.

800. Problems in Earth Science
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 12 credits. Approval of department.
Independent study in topics related to earth science education.

GERMAN
See Linguistics and Germanic, Slavic, Asian and African Languages.

GERMAN AND RUSSIAN
See Linguistics and Germanic, Slavic, Asian and African Languages.

Greek
See Romance and Classical Languages.

HEALTH AND PHYSICAL EDUCATION

(HEP 100, 101, 102, 103)
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 12 credits if different activities or the same activities at higher levels are involved. Students are limited to a combined total of 12 credits in HEP 104 through HEP 114.
Development of sports skills and physical fitness through participation in individual sports activities.

106. Dual Sports I
Fall, Winter, Spring, Summer. 1(0-3) May reenroll for a maximum of 12 credits if different activities or the same activities at higher levels are involved. Students are limited to a combined total of 12 credits in HEP 104 through HEP 114.
Development of sports skills and physical fitness through participation in dual sports activities.

107. Dual Sports II
(HEP 107, 108, 109)
Fall, Winter, Spring, Summer. 1(0-3) May reenroll for a maximum of 12 credits if different activities or the same activities at higher levels are involved. Students are limited to a combined total of 12 credits in HEP 104 through HEP 114.
Development of sports skills and physical fitness through participation in dual sports activities.

108. Team Sports
(HEP 108, 109, 110)
Fall, Winter, Spring. 1(0-3) May reenroll for a maximum of 12 credits if different activities or the same activities at higher levels are involved. Students are limited to a combined total of 12 credits in HEP 104 through HEP 114.
Team sports skills and physical fitness through participation in group activities.