Senior and Graduate Level GSC Course Descriptions and Learning Outcomes: July 2019

Course Number and Name
GSC 4010: GIS Applications for Earth and Environmental Scientists (1 unit)

Catalog Description
Theory underlying GIS methods for digital mapping and quantitative analysis of geospatial data. Coordinate systems, raster vs. vector data sets, procedures for georeferencing raster images, creation of geodatabases linked to topology, geocoding procedures. Spatial analysis of geologic, hydrologic, and environmental processes or phenomena. Team project(s) to integrate data acquisition with GIS map production. One hour lecture

Learning Outcomes
On successful completion of this course, students will be able to:
1. Demonstrate functional working knowledge of ArcGIS software and other GIS programs as applicable.
2. Recognize and reconcile differences between coordinate systems used by disparate raster and vector data sets.
3. Acquire geospatial data from the many available public-domain web sources
4. Custom-design and organize geodatabases to accommodate geocoded sets of topological elements
5. Utilize various spatial analysis tools to contour, color-code, or otherwise create visual renditions of geospatial data sets
6. Complete a capstone project with class team-mates, entailing: a. Analysis of raw data (e.g., X, Y, Z coordinates and various geologic or hydrologic attributes), b. Creation of digital map and corresponding geo-database, c. Written description and analysis of spatial relationships and d. oral presentation of results to student peers and faculty.

Course Number and Name
GSC 4010L: GIS Applications for Earth and Environmental Scientists Laboratory (2 units)

Catalog Description
Practical GIS methods for map representation and quantitative spatial analysis of coordinate-based geoscience data. Laboratory and field techniques for converting raw geoscience data into digital map layers. Acquisition of X-Y-Z-attribute data from raster scans or natural field settings. Creation of geo-databases linked to topology. Manipulation of digital data layers; enhancement with graphics programs. Two 3-hr laboratory sessions

Learning Outcomes
On successful completion of this course, students will be able to:
1. Demonstrate functional working knowledge of ArcGIS software and its various analysis tools.

2. Know standard procedures for geo-registering raster images (topographic maps, satellite images, aerial photos, geologic maps, etc.) into ArcGIS, OziExplorer, and other GIS platforms.
3. Acquire raw field data (e.g., X,Y, Z coordinates and various geologic or hydrologic attributes) at remote field sites using contemporary surveying and mapping equipment.
4. Convert raw field notes or field data to geodatabase spreadsheets that link X,Y, Z coordinates and various geologic, hydrologic or meteorology attributes.
5. Create contour and shade relief maps of various topographic, geologic, hydrologic and meteorology data sets, then generate derivative maps showing spatial variation in slope aspect, gradient, precision, etc.
6. Create a clean topology from digitized line, polygon and point files that links topology elements to a geo-database.
7. Utilize Adobe Illustrator or other graphics programs to enhance map products originally created in ArcGIS

Course Number and Name
GSC 4100: Presentation, Writing, and Research Skills in the Geosciences (2 units)

Catalog Description
Discussion and practice of the design, mechanics and style of geoscience oral presentations and posters. Writing effective conference abstracts, professional reports and theses. Literature search and critically evaluating sources. Data analysis and visualization. May be enrolled by undergraduate or graduate students. 2 hours seminar.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Effectively present geoscience information to a wide range of audiences.
2. Write informative conference abstracts and topic/article summaries.
3. Create effective scientific posters.
4. Perform the literature searches necessary for the background reading on research and professional projects.

Course Number and Name
GSC 4150: Engineering Geology II (2 units)

Catalog Description
Geologic and geophysical principles applied to engineering problems in the geotechnical industry. Slope stability assessment, faults and seismology of southern California, Alquist-Priolo/fault trench studies, strong ground motion and site effects, shake maps, probabilistic hazard analysis. Case studies of landslides, earthquakes, and engineering infrastructure. May be enrolled by undergraduate or graduate students.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Map and describe geologic site conditions leading to problems related to stability or safety of man-made structures (buildings, roads, dams, or cut slopes)
2. Understand the Alquist-Priolo Act and its foundations in fault trenching studies
3. Use a Brunton compass to measure orientation of fractures and other planar discontinuities, and orientation of sedimentary bedding planes in natural and cut slopes.
4. Statistically analyze planar orientation data with a Stereonet.
5. Write a geotechnical report based on observations and data acquired in the field

Course Number and Name
GSC 4150L: Engineering Geology II Laboratory (1 unit)

Catalog Description
Laboratory study of engineering problems pertinent to the geotechnical industry; e.g., slope stability assessment, dam site analysis, fault trench studies, grading of housing developments. Site investigations involving field measurements and 3-dimensional analysis of structural data. May be enrolled by undergraduate or graduate students.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Recognize geologic site conditions leading to problems related to stability or safety of man-made structures; e.g., buildings, roads, dams, or cut slopes.
2. Know the major earthquake faults and related seismic hazards in southern California.
3. Understand seismic wave propagation, strong ground motion, and site effects associated with earthquakes.
4. Access and interpret various forms of geologic hazards maps produced by government agencies; e.g., shake maps, landslide hazards maps, probabilistic seismic hazards maps.
5. Present a case study synthesis focusing on a historical earthquake or seismic hazard; landslide or slope failure; dam or bridge failure.

Course Number and Name:
GSC 4230: Sedimentary Geology (2 units)

Catalog Description
Study of sedimentary rocks based on textures, mineralogy, classification, and structures and their significance in relation to transport/depositional processes, regional setting, and post depositional history; focus on depositional facies models and controls of tectonics and sediment supply on sedimentation

Learning Outcomes
On successful completion of this course, students will be able to:
1. Understand the fundamentals properties of sedimentary rocks and stratigraphic principles
2. Make process interpretations of sedimentary textures and structures, linking products to processes

3. Interpret depositional environments and tectonic settings based on observed sedimentological data

Course Number and Name:
GSC 4230L: Sedimentary Geology Laboratory (1 unit)

Catalog Description
Laboratory investigations of sedimentary rocks based on textures, mineralogy, classification, and structures and their significance in relation to transport/depositional processes, regional setting, and post depositional history; focus on depositional facies models and controls of tectonics and sediment supply on sedimentation

Learning Outcomes
On successful completion of this course, students will be able to:

1. Understand the fundamentals properties of sedimentary rocks and stratigraphic principles
2. Make process interpretations of sedimentary textures and structures, linking products to processes
3. Interpret depositional environments based on observed sedimentological data
4. Identify different types of sedimentary rocks in field outcrops, hand samples, and thin sections
5. Measure and describe a stratigraphic section

Course Number and Name
GSC 4240: Igneous and Metamorphic Petrology (2 units)

Catalog Description
Theory of the origin, classification, chemistry, and mineralogy of igneous and metamorphic rocks. Properties of igneous and metamorphic minerals in thin section. Interpretation of rock textures and structures. Geothermobarometry.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Classify common igneous and metamorphic rocks.
2. Use a petrographic microscope to identify minerals, textures, and structures in igneous and metamorphic rocks.
3. Apply phase diagrams to the understanding of igneous and metamorphic rocks.
4. Interpret metamorphic and igneous rocks in the field and/or using geologic maps.
5. Use modern thermobarometric software to estimate metamorphic temperatures and pressures from mineral data.

Course Number and Name
GSC 4240L: Igneous and Metamorphic Petrology Laboratory (2 units)

Catalog Description
Practical laboratory and field exercises regarding the origin, classification, chemistry, and mineralogy of igneous and metamorphic rocks. Use of petrographic microscopes to describe igneous and metamorphic minerals in thin section. Analysis of pressures and temperatures of geologic events via calculations and software.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Know the common classifications of igneous and metamorphic rocks.
2. Be able to relate differences in mineralogy and chemistry of rocks to their genesis.
3. Understand the basics of magma differentiation and diversification.
4. Understand and apply the concept of metamorphic facies.
5. Use the chemical, mineral, textural, and structural information recorded in igneous and metamorphic rocks to decipher earth history.

Course Number and Name
GSC 4320: Soil Physics (2 units)

Catalog Description
Methods to characterize physical attributes of soil. Soil particle size distribution and structure, nature and behavior of clay, state and movement of water and solutes in saturated and unsaturated soil conditions, gas and energy exchange between soil and atmosphere, principles of rheology.

Learning Outcomes
On successful completion of this course, students will be able to:
1) A good understanding of the physical properties of soils including particle size distribution, the behavior of clays and soil structures
2) A good understanding of soil moisture relationships with respect to mass balance calculations, effects of plants on soil moisture, infiltration/redistribution, and percolation of water to groundwater.
3) A good understanding of the movement of water and gasses under saturated and unsaturated soil conditions.
4) Knowledge of field and laboratory techniques for describing and quantifying soil physical properties

Course Number and Name
GSC 4320L: Soil Physics Laboratory (1 unit)

Catalog Description
Laboratory and field investigations of Soil Physics. Laboratories emphasize physical attributes of soil. Soil particle size distribution and structure, nature and behavior of clay, state and movement of water and solutes in saturated and unsaturated soil conditions, gas and energy exchange between soil and atmosphere, principles of rheology.

Learning Outcomes
On successful completion of this course, students will be able to:

1) Analyze soil physical properties including particle size distribution, and soil structures;
2) Measure soil moisture retention with tensiometers, infiltrometers, and soil columns;
3) Calculate saturated and unsaturated fluid flow using Buckingham-Darcy, and mass balance equations;
4) Quantify soil moisture-plant-atmospheric relationships
5) Depict and analyze water infiltration percolation, and redistribution in soils.
6) Quantify soil thermal properties including effects on plant growth and organic decay.
7) Utilize field and laboratory techniques for describing and quantifying soil physical properties

Course Number and Name
GSC 4340: Shallow Subsurface Geophysics (2 units)

Catalog Description
Geophysical methods used to investigate the Earth's shallow subsurface structure. Fundamentals of seismic methods. Exploration using gravity. Principles of electrical resistivity, magnetic methods and ground-penetrating radar. Equipment, field procedures and experiment design. Data processing and analysis using modeling. Examples of applications.

Learning Outcomes
On successful completion of this course, students will be able to:

1) Describe the types of seismic waves used in exploration seismology and their main characteristics
2) Apply travel time equations for subsurface structures ranging in degree of complexity from a homogeneous subsurface to multiple dipping interfaces using the seismic refraction method
3) Describe the different steps used in the analysis and processing of seismic reflection data
4) Describe the basic properties of the Earth's gravitational field
5) Predict the effects of subsurface density anomalies with simple geometric shapes on profiles of gravitational acceleration
6) Describe the fundamentals of the magnetic method, ground penetrating radar and electrical resistivity

7) Explain the principles of applying subsurface geophysical methods to societally relevant problems including natural hazards, resource exploration and management, and environmental issues
8) Effectively communicate their scientific knowledge of shallow subsurface geophysics through written and oral presentations
9) Interpret and evaluate published literature and conference presentations on shallow subsurface geophysics

Course Number and Name
GSC 4340L: Shallow Subsurface Geophysics Laboratory (1 unit)

Catalog Description
Laboratory and field-based investigations of the geophysical methods used to investigate the Earth's shallow subsurface: seismic methods, gravity, electrical resistivity, electromagnetic and magnetic methods, and ground-penetrating radar. Equipment use, field procedures and experiment design. Data processing and analysis using modeling. Examples of applications.

Learning Outcomes
On successful completion of this course, students will be able to:
1) Make their own observations with a variety of geophysical instruments
2) Describe the equipment used in a variety of different types of geophysical exploration
3) Describe and apply proper geophysical field procedures
4) Process, reduce and correct geophysical data
5) Determine basic subsurface model parameters from a variety of geophysical observations acquired in the field
6) Write summary reports describing geophysical laboratory and field investigations

Course Number and Name:
GSC 4400: Exploration and Mining Geology (2 units)

Catalog Description
Planning and implementation of mineral exploration programs, resource extraction and ore-processing. Exploration techniques, ore deposit evaluation, mining methods, and processing systems. Ore deposit models used to target sampling and drilling of mineral resources. Mineral economic theory and practical aspects of developing mineral properties.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Describe the current techniques for planning and implementation of mineral exploration programs, resource extraction and ore-processing.
2. Describe preferred methods for sampling and drilling mineral resources given geometric constraints of tested ore-deposit models.

3. Analyze global economic factors that drive ebbs and flows in the multi-billion dollar mining industry
4. Recognize practical aspects (engineering and environmental) of developing mineral properties

Course Number and Name:
GSC 4400L: Exploration and Mining Geology Laboaratory (1 unit)

Catalog Description
Field and laboratory exercises related to mineral exploration: claim staking, geochemical/geophysical prospecting, assay contouring, underground mine mapping, computer-generated ore reserve models, and automated data base literature searches. Field trips to active or decommissioned mines of California, Arizona or Nevada.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Apply surveying and sampling methods and available geochemical/geophysical technologies to acquire reconnaissance exploration data pertaining to a mineral prospect.
2. Integrate multi-component mineral exploration data (geologic mapping, mineral assays, core logs) to evaluate mineral resources of hypothetical or real-world sites.
3. Create geologic field maps and cross sections of underground and/or surface mines.
4. Participate in field trips to active or decommissioned mines.
5. Write summary reports describing laboratory and field investigations.

Course Number and Name:
GSC 4440: Tectonics (2 units)

Catalog Description
Study of the major tectonic elements of the Earth, including their geometry, kinematics and dynamics, with special emphasis on the Cordillera of western North America. Geologic features will be analyzed in the context of plate tectonic theory.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Describe the historical development of ideas and scientific breakthroughs associated with formulation of plate tectonic theory.
2. Understand the basic geophysical and geochemical observations that constrain our modern models for Earth's internal structure and dynamics.
3. Relate distinctive rock assemblages and geologic structures with specific tectonic processes occurring at divergent, convergent, and strike-slip plate boundaries.
4. Interpret the major tectonic cycles (Wilson cycles) associated with formation, breakup, and dispersal of various continents throughout Earth's history.
5. Analyze the Paleoproterozoic to Recent tectonic history of southwestern North America, with an emphasis on distinctive rock packages and structures preserved in southern California.

Course Number and Name:
GSC 4440L: Tectonics Laboratory (1 unit)

Catalog Description
Field examples of plate tectonics, both in the geologic record and also ongoing activity, in southern California and the southwest U.S. Oral presentation of tectonic topics during field trips.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Recognize distinctive rock assemblages and geologic structures associated with modern extensional, compressional, and strike-slip tectonic environments.
2. Analyze the Paleoproterozoic to Recent tectonic history of southwestern North America, with an emphasis on distinctive rock packages and structures preserved in southern California.
3. Conduct literature research on a topic related to tectonic development of a noteworthy rock assemblage, fault zone, tectonic feature, or historical earthquake in southern California.
4. Present an oral report of research topic to peers in an appropriate field setting.

Course Number and Name:
GSC 4500: Introduction to Seismology, Earthquakes and Earth Structure (2 units)

Catalog Description
Study of generation, propagation and recording of seismic waves and their sources. Stress and strain. Body waves and surface waves. Interpretation of seismograms. Determination of Earth structure. Focal mechanisms; earthquake statistics; seismotectonics.

Learning Outcomes
On successful completion of this course, students will be able to:
1) Describe the different types of seismic body and surface waves and their main characteristics
2) Explain surface wave dispersion
3) Correctly use terminology that describes the different types of faults and their main features
4) Interpret focal mechanisms in terms of fault geometry and type of faulting
5) Describe how earthquake magnitude and intensity are determined
6) Describe the characteristics of different types of earthquake sequences, such as foreshock and aftershock sequences
7) Describe current state of knowledge on earthquake prediction and forecasting, as well as early warning
8) Use specific Internet sites to obtain global as well as local seismic data, and near real-time and post-earthquake information on earthquakes
9) Effectively communicate their scientific knowledge of seismology through written and oral presentations

Course Number and Name:
GSC4500L: Introduction to Seismology, Earthquakes and Earth Structure Laboratory (1 unit)

Catalog Description

Laboratory study of generation, propagation and recording of seismic waves and their sources. Interpretation of seismograms. Determination of Earth structure. Interpretation of focal mechanisms; seismotectonics. Analysis of earthquake statistics.

Learning Outcomes

On successful completion of this course, students will be able to:
1) Apply Snell's law to calculate ray paths of seismic waves
2) Calculate and interpret surface wave dispersion curves
3) Use first motion data to determine earthquake focal mechanisms
4) Use arrival time picks and polarization analysis to determine earthquake locations
5) Analyze GPS data to determine velocities and identify different parts of the seismic cycle
6) Calculate statistical parameters for different types of earthquake sequences
7) Use specific Internet sites to obtain global as well as local seismic data, and near real-time and post-earthquake information on recent earthquakes
8) Effectively communicate their scientific knowledge of seismology through written and oral presentations
9) Interpret and evaluate published literature and conference presentations on seismology

Course Number and Name
GSC 4610: Senior Project and Presentation (2 Units)

Catalog Description

Independent research study of a geologic problem following standard scientific methodology. Topic selection, research techniques, data acquisition and analysis/interpretation guided by a GSC faculty research advisor. Formal presentation of results via a poster or an oral presentation to peers and faculty.

Learning Outcomes

On successful completion of this course, students will be able to:
1. Utilize standard scientific research methods to acquire a data set appropriate for the chosen problem or topic;
2. Organize, analyze, and interpret the data;
3. Present results of the research project in oral or poster format to student peers and GSC faculty;

Course Number and Name
GSC 4620: Senior Thesis (2 Units)

Catalog Description
Completion of a formal written thesis document, formatted to GSC Department specifications with appropriate scientific citation style. The thesis will be evaluated for clarity, organization, and scientific merit. Carried out under supervision of a GSC faculty research advisor.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Write full first draft of senior thesis document that integrates purpose, objectives, methods, analysis, interpretation, and results of scientific research project;
2. Follow GSC Department formatting guidelines regarding organization, figures, captions, bibliography, and reference citation;
3. Complete and print out final thesis document that incorporates suggestions and corrections of thesis supervisor

Course Number and Name
GSC 4700: Volcanology (2 Units)

Catalog Description
Geophysics and geochemistry of volcanoes. Plate tectonic setting. Properties of magma. Shape and structure of volcanic edifices. Products of eruptions. Hazards and risk. Effects of volcanic eruptions on climate and human history. Field measurements and remote sensing. Forecasting and prediction. Graduate students may enroll for graduate credit.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Explain the plate tectonic setting of different types of volcanoes.
2. Describe the shape and subsurface structure of the major types of volcanic edifices.
3. Describe methodologies used to forecast volcanic eruptions and assess the hazard and risk level of volcanoes.
4. Describe different types of remote sensing used to study volcanic landforms.

Course Number and Name
GSC 4700L: Volcanology Laboratory (1 unit)

Catalog Description
Laboratory study of the geophysics and geochemistry of volcanoes. Plate tectonic setting. Properties of magma. Shape and structure of volcanic edifices. Products of eruptions. Hazards and risk. Effects of volcanic eruptions on climate and human history. Field measurements and remote sensing. Forecasting and prediction. Graduate students may enroll for graduate credit.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Explain the plate tectonic setting of different types of volcanoes.
2. Describe the shape and subsurface structure of the major types of volcanic edifices.
3. Describe methodologies used to forecast volcanic eruptions and assess the hazard and risk level of volcanoes.
4. Describe different types of remote sensing used to study volcanic landforms.
5. Perform basic geochemical and geophysical field measurements on volcanoes and volcanic landforms.
6. Write a report based on observations and data carried out in the field.

Course Number and Name
GSC 4800: Quantitative and Computer Skills in Geosciences (3 units)

Catalog Description
Data analysis, quantitative and computer skills necessary to succeed in geoscience careers. Solving realistic quantitative problems in the geosciences using standard mathematical procedures as well as more specialized techniques and software. Graduate students may enroll for graduate credit.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Apply fundamental mathematical approaches to model geoscience data, including both forward modeling as well as inversions.
2. Display geoscience data using a variety of different types of graphs and visualization techniques.
3. Use specialized software to process, interpret, model and/or visualize geoscience datasets.
4. Apply basic statistical methods in the analysis of errors, probabilities and uncertainty in measurements and models.

Course Number and Name
GSC 4910L: Field Module Laboratory (1 or 2 units)

Catalog Description
Advanced geologic mapping and/or data collection in a variety of settings. Exact topics to vary based on expertise of instructor. Use of modern geospatial tools and instrumentation. Reports, maps, and field data analysis required. Minimum four field days per unit, plus additional time to complete assignments. May be taken unlimited times.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Use a variety of modern tools and instrumentation to collect geoscience data in the field.
2. Record field data in legible notebooks that can be used by others.

3. Analyze and interpret field data using modern techniques, such as digitization of geologic maps via GIS software.
4. Understand how their mapping/field work fits into the bigger scientific picture.
5. Prepare a final field report similar to those used in geotechnical fields.

Course Number and Name
GSC 4950: Planetary Science (3 units)

Catalog Description
Characteristics of planets, satellites and small bodies in our solar system; space exploration and remote sensing of these bodies; formation and evolution of their surfaces, atmospheres and interiors. Discussions of simulations of planetary processes and field studies of landforms on Earth analogous to extraterrestrial features. Extrasolar planets.

Learning Outcomes
This class emphasizes the part of the universe that is within reach of direct human experience and exploration. Planetary science is an area of increasing interest, as we learn more about our solar system with each new mission. The goal of this class is to teach students about other worlds in our Solar System and beyond, and thus also enhance their understanding of the place our own planet has in the universe. This class will furthermore provide students with practical knowledge of cutting edge technology and methodology used in remote sensing, which is increasingly being applied to our own planet.
On successful completion of this course, students will be able to:

1. Describe how planets and other large bodies evolve, the processes that govern their surface features, crustal structures and interior compositions and how active these processes are/were in shaping each individual planet.
2. Relate data obtained from other planets to environmental processes and evolutionary processes on our own planet.
3. Explain how astronomical concepts and methods are applied to the solution of problems relating to the evolution of planets, moons, and other planetary bodies.
4. Describe the principles of remote sensing and the types of data these techniques produce, for Earth as well as other planets.
5. Explain the basic concepts that underlie the methods that are currently used to detect extra-solar planets and the physical characteristics of the extra-solar planets that have been detected using those methods.
6. Use specific Internet sites to obtain data from recent space missions and interpret/implement/process these data.

Course Number and Name
GSC 5010: Advanced Topics in Geosciences (2 units)

Catalog Description
Literature review and analysis of geoscience concepts, principles and processes. Topics may draw upon sub-disciplines of Hydrogeology, Geophysics, Engineering Geology, Structural Geology, Tectonics, Petrology, Geochronology, Mineral and Energy Resources, and Natural

Hazards. Participants present oral and written summaries of assigned readings, and participate in discussion sessions that examine the underlying hypotheses and recent research advances.

Learning Outcomes

On successful completion of this course, students will be able to:

4. Critically read, analyze and interpret technical articles or other reading materials;
5. Participate in group discussions in a seminar setting;
6. Present oral summaries of articles or other readings to student peers and faculty moderator;
7. Create written abstracts or analyses underscoring salient methods, data, interpretations and conclusions contained in assigned readings

Course Number and Name

GSC 5030L: Field Investigations Laboratory (1 unit)

Catalog Description

Field excursions to sites of geological, geophysical, hydrologic or geotechnical importance within California and the southwestern U.S. Advanced field mapping projects, geophysical surveys, and/or hydrogeologic/geotechnical investigations with “”on-site”” reviews of field relationships or data collected by instruments. Written reports presenting and analyzing data collected during student field experiences in the context of various current research topics. Multi-day field trips and/or one-day excursions. May be taken unlimited times.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Demonstrate proficiency with a variety of modern tools and instrumentation used to collect geoscience data in the field
2. Acquire and utilize remotely sensed data and other sources of geospatial information
3. Prepare multi-parameter digital maps by integrating field and other data using GIS software
4. Compile and analyze data from a variety of sources and present it in a coherent format within the appropriate scientific context.
5. Prepare a final field report in a similar format to types of reports that would be required by employees in geotechnical fields

Course Number and Name

GSC 5330: Advanced Topics in Structural Geology and Tectonics (2 units)

Catalog Description

Advanced topics related to outstanding tectonic problems. Discussion and presentation of scientific literature. Use of structural, petrological, and geochronological data to evaluate geologic hypotheses. Emphasis on field data sources. Application to exploration for groundwater, minerals, and energy resources

Learning Outcomes

On successful completion of this course, students will be able to:
1. Demonstrate detailed knowledge of advanced topics in structural geology and tectonics.
2. Present an overview of the newest research and crucial literature within these topics.
3. Use the acquired knowledge to evaluate geologic hypotheses.
4. Apply structural principles to exploration for groundwater, mineral, and energy resources.

Course Number and Name

GSC 5330L: Advanced Topics in Structural Geology and Tectonics Laboratory (1 unit)

Catalog Description

Advanced laboratory and field investigations in Structural Geology and Tectonics. Geological mapping related to outstanding tectonic problems. Use of structural and petrologic field data to evaluate tectonic hypotheses.

Learning Outcomes

On successful completion of this course, students will be able to:
1. Apply laboratory techniques to three-dimensional resolution of structural problems
2. Conduct field investigations related to topical issues in structural geology / tectonics.
3. Create geologic field maps and cross sections from data acquired in the field.
4. Write summary reports of structure/tectonics field investigations

Course Number and Name

GSC5340: Quaternary Geology (2 units)

Catalog Description

History of the Earth during the Quaternary Period (last 2.6 Million Years), including the Pleistocene ice ages and Holocene warm epoch. Study of geologic and geomorphic records of Quaternary climate cycles, glaciation, sedimentation, sea level fluctuation, and active tectonics. Quaternary stratigraphic methods, geochronology, ice core studies, glacial geology, and paleoseismology. Causes and global environmental effects of cyclical Quaternary climate change.

Learning Outcomes

On successful completion of this course, students will be able to:
1. Explain basic concepts of Quaternary stratigraphy and subdivisions of the Quaternary time period.
2. Describe fundamental causes and mechanisms for cyclic Quaternary climate change, including Milankovitch orbital cycles, ocean thermohaline circulation, and variations in atmospheric greenhouse gases.
3. Identify and interpret common geologic and geomorphic records of Quaternary climate change, including ice core stratigraphy, marine oxygen isotope records, paleo-sea level curves,

marine terraces, glacial landforms, paleo-sols, and terrestrial sediment records (e.g., alluvium, loess, varves, pollen, middens, fossils, etc.)
4. Describe common Quaternary geochronologic methods, including radiocarbon, cosmogenic radionuclides, argon and uranium isotopes, optically-stimulated and thermo-luminescence, paleo-magnetics, tree ring dating, lichenometry, aminostratigraphy, paleo-sols, and varve stratigraphy.
5. Explain common methods of active faulting and paleoseismic investigations utilizing Quaternary stratigraphic and geochronologic records, including fault trenching, faulted landform studies, marine and fluvial terrace analysis, wetland coring, etc.

Course Number and Name
GSC5340L: Quaternary Geology Laboratory (1 unit)

Catalog Description
Laboratory and field investigations of Earth history during the Quaternary Period. Geologic and geomorphic records of Quaternary climate cycles, glaciation, sedimentation, sea level fluctuation, and active tectonics. Quaternary stratigraphic methods, geochronology, ice core studies, glacial geology, and paleoseismology. Causes and global environmental effects of cyclical Quaternary climate change.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Conduct basic Quaternary geologic field investigations, collect and synthesize meaningful field data, interpret landscape processes, and evaluate Quaternary climatic and tectonic forcing.
2. Utilize topographic maps, aerial photographs, and digital terrain models to delineate Quaternary geologic and geomorphic units, analyze topographic properties, and interpret active geologic and geomorphic processes.
3. Describe field stratigraphic sections and soil profiles, and map Quaternary deposits at field study sites.
4. Conduct basic topographic surveying using laser range finders, hand levels, stadia rods, and GPS instruments.
5. Construct Quaternary geologic maps, topographic profiles, geologic cross-sections, soil profiles, stratigraphic core logs, sea level curve correlation diagrams, and fault slip structural diagrams.
6. Work cooperatively and effectively as a member of a science research team. Prepare professional geoscience reports, including properly formatted and grammatically sound written text, and properly drafted illustrations, maps, and tables.

Course Number and Name
GSC 5450: Advanced Hydrogeology (2 units)

Catalog Description
Discussions of fluid mechanics, fluid flow equations, surface water/groundwater interactions, contaminant fate and transport, and conceptual/computer models used to characterize the occurrence and transport of fluids in a variety of geologic and subsurface environments

Learning Outcomes
On successful completion of this course, students will be able to:

1) Understand techniques for measuring and quantifying fluid flow in different geologic environments.
2) Understand surface water/groundwater interactions.
3) Understand Darcy's law, its derivation and its applicability for solving groundwater flow problems.
4) Understand the concept of hydraulic head and how it is utilized to solve groundwater flow problems.
5) Be able to quantify the migration of contaminants in a variety of geologic and environmental conditions
6) Understand source and sink relationships with respect to common contaminants
7) Understand common remediation techniques and mitigation strategies
8) Synthesize technical information and disseminate related information

Course Number and Name
GSC 5450L: Advanced Hydrogeology Laboaratory (1 unit)

Catalog Description
Advanced laboratory and field investigations of Hydrogeology. Laboratories and field trips will focus on aspects of fluid mechanics, quantifying fluid flow, surface water/groundwater interactions, contaminant fate and transport, and conceptual/computer models to characterize fluid/contaminant transport.

Learning Outcomes
On successful completion of this course, students will be able to:

1) Measure and quantify fluid flow in different geologic environments and at regional scales.
2) Apply fluid mechanics principals for the transport of fluids at pore and molecular scales
3) Derive Darcy's law.
4) Solve fluid flow problems in 2- and 3- dimensions.
5) Apply principles of mathematical models for solving fluid flow and pump test problems
6) Estimate resident time and velocities of contaminants in groundwater
7) Analyze fluid flow through fractured media
8) Measure soil water and matric potential relationships

Course Number and Name
GSC 5510: Petroleum Geology (2 units)

Catalog Description
Origin and occurrence of petroleum and related products. Study of the geologic structure and stratigraphy of major oil and gas fields. Contemporary techniques for exploration, extraction, and management of petroleum resources.

Learning Outcomes

The course will be based largely on traditional methods and techniques of exploration for conventional petroleum (includes gas) resources. Significant time will be spent, however, on increasingly important alternative hydrocarbon resources (tar sands, oil shales, and in situ coal gasification). Secondary and tertiary extraction of fuels (including hydrofracturing) also will be discussed.

After completion of this course, students should have developed, and demonstrated mastery of, the following knowledge and skill sets:

1. Describe the origin of oil and gas (liquid and gaseous phase hydrocarbons); biological versus abiotic models; the chemistry of petroleum; review of basic organic chemical structures
2. Know the processes governing the maturation of oil and gas; in source sediments: Diagenetic, Catagenetic, and Metagenetic Phases
3. Understand the early (primary) migration of hydrocarbons from sources to reservoir rocks, competing hypotheses: the effects of over-pressured source sediments
4. Describe the process of segregation of oil and gas at lithologic boundaries: accumulation of fluids within a trapping mechanism; separation and migration of fluids within a reservoir; porosity and permeability and their measurement; DARCY'S LAW and its application to petroleum migration
5. Demonstrate knowledge of trapping mechanism: structural versus stratigraphic traps; hydrodynamic traps, and combination traps; other miscellaneous trapping mechanisms (clastic versus carbonate reservoirs and their attributes)
6. Know the technology relevant to the discovery, evaluation, and management of oil and/or gas resources. Well log types and their applications, seismic profiling and seismic section interpretation; the significance of "bright spots" on seismic sections; seismic stratigraphy and sequences; correlation using geophysical logs and biostratigraphic data points; dip meter
7. Develop working understanding of basin analysis, reserve estimation and possible development of (at present) non-economic, alternative fuels including tar sands, oil shale, bituminous diatomites, and methane clathrates
8. Describe the future of petroleum geology particularly in relation to Hubbert's Curve and HUBBERT'S PEAK; non hydrocarbon alternative energy sources: wind, solar, hydroelectric and nuclear

Course Number and Name

GSC 5510L: Petroleum Geology Laboratory (1 unit)

Catalog Description

Laboratory and field investigation related to origin and occurrence of petroleum and associated products. Study of the geologic structure and stratigraphy of major oil and gas fields. Contemporary techniques for exploration and extraction of petroleum resources. Field trips to accessible oil and gas research facilities.

Learning Outcomes

The course will be based largely on traditional methods and techniques of exploration for conventional petroleum (includes gas) resources. Significant time will be spent, however, on increasingly important alternative hydrocarbon resources (tar sands, oil shales, and in situ coal gasification). Secondary and tertiary extraction of fuels (including hydrofracturing) also will be discussed. An updated version of the computer generated "Oil Game" (or similar) will be used as part of the course laboratory component, and at least one field trip to a petroleum production operation (likely Chevron in Bakersfield) will be required. Laboratory exercises will include graphical solutions to hydrocarbon trapping mechanisms. Volumetric calculations of hydrocarbon reserves will be undertaken.

On successful completion of this course, students will be able to:

1. Describe the origin of oil and gas (liquid and gaseous phase hydrocarbons); biological versus abiotic models; the chemistry of petroleum; review of basic organic chemical structures
2. Describe the process of segregation of oil and gas at lithologic boundaries: accumulation of fluids within a trapping mechanism; separation and migration of fluids within a reservoir; porosity and permeability and their measurement; DARCY'S LAW and its application to petroleum migration
3. Demonstrate knowledge of trapping mechanism: structural versus stratigraphic traps; hydrodynamic traps, and combination traps; other miscellaneous trapping mechanisms (clastic versus carbonate reservoirs and their attributes)
4. Know the technology relevant to the discovery, evaluation, and management of oil and/or gas resources. Well log types and their applications, seismic profiling and seismic section interpretation; the significance of "bright spots" on seismic sections; seismic stratigraphy and sequences; correlation using geophysical logs and biostratigraphic data points; dip meter
5. Develop a working understanding of basin analysis, reserve estimation and possible development of (at present) non-economic, alternative fuels including tar sands, oil shale, bituminous diatomites, and methane clathrates

Course Number and Name

GSC 5640: Advanced Shallow Subsurface Geophysics (2 units)

Catalog Description

Advanced geophysical methods used to investigate the Earth's shallow subsurface. Focus on application of these methods and interpretation of geophysical data through forward and inverse modeling. Methods include: seismic refraction, resistivity, magnetics, gravity, ground penetrating radar. Discussion of case studies and scientific literature.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Recognize numerous characteristics of the subsurface model in unprocessed refraction data, such as the presence of a dipping layer, varying topography, abrupt

lateral changes or a non-planar interface
2. Predict the gravitational signal due to the presence of simplified subsurface density bodies
3. Describe the principles of the resistivity method
4. Interpret resistivity measurements produced by simplified models of subsurface resistivity anomalies
5. Describe the fundamentals of the magnetic method and the analysis of magnetic anomalies
6. Describe how Ground Penetrating Radar (GPR) may be used to determine subsurface structure
7. Evaluate the advantages and disadvantages of the use of different geophysical techniques for specific types of societally relevant problems including natural hazards, resource exploration and management, and environmental issues
8. Effectively communicate their scientific knowledge of shallow subsurface geophysics in writing and through oral presentations
9. Interpret and evaluate published literature and conference presentations on shallow subsurface geophysics

Course Number and Name
GSC5640L: Advanced Shallow Subsurface Geophysics Laboratory (1 unit)

Catalog Description
Laboratory and field study of advanced geophysical methods used to investigate the Earth's shallow subsurface. Design of experiments and use of geophysical equipment to generate data; processing and interpretation of this data through forward and inverse modeling. Methods include: seismic refraction, resistivity, magnetics, gravity, ground penetrating radar. Discussion of scientific literature and case studies.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Recognize numerous characteristics of the subsurface model in unprocessed refraction data, such as the presence of a dipping layer, varying topography, abrupt lateral changes or a non-planar interface
2. Apply proper field procedures in the use of various types of geophysical equipment, such as a gravimeter, magnetometer, seismic refraction equipment, Ground Penetrating Radar (GPR) and resistivity equipment
3. Create proper and complete field logs for geophysical experiments
4. Design appropriate geophysical experiments for a variety of societally relevant problems including natural hazards, resource exploration and management, and environmental issues
5. Plot and perform basic interpretation of data generated in various types of geophysical experiments, such as gravity, magnetic, resistivity and GPR surveys
6. Effectively communicate the results of geophysical experiments through industry-style reports and oral presentations

7. Interpret and evaluate published literature and conference presentations on shallow subsurface geophysics

Course Number and Name
GSC 5680: Topics in Advanced Seismology (2 units)

Catalog Description
Advanced topics in structural, engineering and earthquake seismology, with a focus on concepts and applications of observational seismology. Earthquake rupture and strong ground motion. Use of seismic waves for the study of Earth's interior. Site response and hazard. Tectonophysics and seismotectonics. Discussion of scientific literature and research on recent earthquakes.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Describe the principles of the rupture process of large earthquakes: concepts such as rupture velocity, rise time and particle velocity, and present order-of-magnitude estimates of these parameters for different size earthquakes
2. Explain the factors that control earthquake ground motion parameters and damage, as well as the geophysical methods that may be used to measure these site response parameters
3. Explain the types of earthquakes and geophysical processes that are expected to occur in different types of tectonic environments, such as within different parts of the subduction zone
4. Explain the use of moment tensors to describe seismic sources
5. Describe the different types of earthquake triggering
6. Explain the fundamental mathematical and computational approaches used in seismic tomography and earthquake location
7. Describe examples of structural parameters that may be resolved using seismology, and which types of seismic waves and phases are commonly analyzed to obtain these structural parameters
8. Discuss the types of data and methodologies used to determine seismic hazard and interpret hazard maps
9. Effectively communicate their scientific knowledge of seismology in writing and through oral presentations
10. Interpret and evaluate published literature and conference presentations on seismology

Course Number and Name
GSC5680L: Topics in Advanced Seismology Laboratory (1 unit)

Catalog Description
Laboratory and field study of advanced topics in structural, engineering and earthquake seismology, focused on applications of observational seismology. Use of seismic equipment to record seismic waveforms; processing and interpretation of this data. Site response and hazard. Tectonophysics and seismotectonics. Discussion of scientific literature and research on recent earthquakes.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Discuss important factors to consider in the installation of seismometers and other seismic equipment
2. Carry out measurements of site response using seismological methods such as Refraction Microtremor or Spectral Ratio
3. Apply basic mathematical and computational approaches to calculate seismic tomography models and to locate earthquakes
4. Interpret moment tensors of a variety of seismic sources, such as earthquakes, explosions and volcanic sources
5. Collate data on recent earthquakes from Internet sources and scientific literature, and present a summary of the seismotectonics of these events
6. Effectively communicate their scientific knowledge of seismology in writing and through oral presentations
7. Interpret and evaluate published literature and conference presentations on seismology

Course Number and Name

GSC 5850: Isotope Geochemistry (2 units)

Catalog Description

Geochemistry of stable and radiogenic isotopes. Use as tracers in hydrology and petrology. Fractionation and mixing. Paleoclimate proxies. Geochronology and thermochronology. Measurement techniques and data analysis.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Understand stable and radiogenic isotope systematics commonly used in the geosciences
2. Synthesize current research utilizing isotope geochemistry
3. Analyze isotopic data for interpreting geologic processes
4. Utilize radiogenic isotope data for determining geologic rates and geochronology
5. Communicate isotopic results

Course Number and Name

GSC 5850L: Isotope Geochemistry Laboratory (1 unit)

Catalog Description

Laboratory exercises in the geochemistry of stable and radiogenic isotopes. Use of isotopes as tracers in hydrology and petrology, fractionation and mixing, paleoclimate proxies, geochronology and thermochronology. Measurement techniques and data analysis.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Understand isotopic measurement techniques

2. Evaluate quality of isotope data used in research.
3. Analyze isotopic data for interpreting geologic processes
4. Utilize radiogenic isotope data for determining geologic rates and geochronology
5. Communicate isotopic results

Course Number and Name
GSC 5950: Advanced Topics in Sedimentology / Stratigraphy (2 units)

Catalog Description
Advanced topics and applications related to sediment transport, depositional environments, stratigraphy, or basin analysis. Application to groundwater and energy resource evaluation or tectonics research. Discussion and presentation of scientific literature.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Demonstrate detailed knowledge of current topics in sedimentology and stratigraphy.
2. Present an overview of the newest research and crucial literature within these topics.
3. Use the acquired detailed knowledge in research projects.
4. Apply principles of sedimentology and stratigraphy to groundwater and energy resource evaluation or tectonics problems.

Course Number and Name
GSC 5950L: Advanced Topics in Sedimentology / Stratigraphy Laboratory (1 unit)

Catalog Description
Laboratory and field investigations in sedimentology and stratigraphy. Topics may include sediment transport, depositional environments, stratigraphic interpretation methods, sedimentary petrography, provenance studies, basin analysis, interpretation of well logs and drill core.

Learning Outcomes
On successful completion of this course, students will be able to:
1. Understand the fluid mechanical processes that control of sedimentation
2. Interpret sediment provenance from petrographic examination of thin sections and outcrops.
3. Conduct field investigations in sedimentary terrain.
4. Apply industry standard techniques to three-dimensional interpretation of sedimentary rock packages.

Course Number and Name
GSC 6930: Thesis Proposal (1 unit)

Catalog Description
Oral presentation and discussion of a proposed research plan for the Master's thesis, accompanied by a written proposal. Required for Advancement to Candidacy.

Learning Outcomes
This course constitutes the important preliminary step of initiating a successful Master's thesis. Masters candidates will work closely with a Geology faculty adviser to develop a thesis plan fit to student interests and work or family constraints. A wide variety of thesis projects may be appropriate, ranging from classical research to scientific extensions of industry-related work efforts.

Students are expected to achieve the following learning outcomes:

1. Conduct preliminary background investigation to select a unique project;
2. Define a research topic and attainable research objectives appropriate for a Master's Thesis in Geology,
3. Write a thesis proposal, formatted to Geology Department specifications, that includes research questions, methods, work plan and timeline necessary to complete the thesis, and annotated bibliography;
4. Present a formal Powerpoint talk of thesis proposal to the Graduate Committee and graduate student peers.

Course Number and Name
GSC 6940: Thesis Research (1 to 3 units)

Catalog Description
Independent research study of a Geoscience problem following standard scientific methodology. Research techniques, data acquisition and analysis/interpretation guided by a GSC faculty research supervisor. Total number of units allowed to count toward degree is 3.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Utilize standard scientific research methods to acquire a data set appropriate for the chosen problem;
2. Organize and analyze the data;
3. Interpret the results and their significance in context of the purpose and objectives of original thesis proposal

Course Number and Name
GSC 696: Master's Thesis (2 units)

Catalog Description
Compilation, evaluation, interpretation, and report of research for Master's thesis directed by a committee of Geology faculty members. Completion of university-approved, bound thesis. Oral defense of thesis. May be taken up to two times for a total credit of 2 units.

Learning Outcomes
On successful completion of this course, students will be able to:

1. Write full first draft of Master's thesis document that integrates purpose, objectives, methods, analysis, interpretation, and results of scientific research project;
2. Follow GSC Department formatting guidelines regarding organization, figures, captions, bibliography, and reference citations;
3. Complete oral defense of thesis to peers and thesis committee
4. Submit library-ready final thesis document that incorporates suggestions and corrections of thesis committee and thesis supervisor