Graduate Courses 2021-2022

Fall 2021

Course	Course Title	Units	Instructor	Breadth area
GEL 206	Stratigraphic Analysis	3	Sumner	2 or 4
GEL 240	Foundations of Geophysics	3	Rudolph	6
GEL 290	Seminar	1	TBD	N/A
GEL 294	Structure & Tectonics forum	1	Roeske	N/A
GEL 298	Planet Formation *CRN: 35500*	3	Stewart	7
GEL 390	Methods of Teaching Geology	2	Billen	N/A

Winter 2022

Course	Course Title	Units	Instructor	Breadth area
GEL 216	Tectonics	3	Cowgill	3
GEL 260	Paleontology	3	Vermeij	1
GEL 298	Microbial Photosynthesis *CRN: 26810*	3	Grettenberger	1
GEL 298	Geodynamic Modeling *CRN: 26818*	3	Rudolph	6
GEL 290	Seminar	1	TBD	N/A

Spring 2022

Course	Course Title	Units	Instructor	Breadth area
GEL 219	Fracture & Flow of Rocks	3	Billen	3 or 6
GEL 230	Geomorphology & River Management	3	Pinter	5
GEL 251	Thermodynamics for Earth and Planetary Scientists	3	Yin	4
GEL 253	Petrology seminar	3	Ratschbacher	4
GEL 290	Seminar	1	TBD	N/A
GEL 294	Structure & Tectonics forum	1	Roeske	N/A

Course Descriptions

Fall, 2021

GEL 206: Stratigraphic Analysis (Sumner)

Graduate course breadth area: #2 or 4

This course will provide students the opportunity to learn and apply sedimentary geology, regional stratigraphy, and sedimentary basin analysis to tectonically active basins. It will be divided into three components: 1) specific techniques (tailored to student prior experience level); 2) a 3-day field trip (likely to the Ridge Basin, Southern California) and application of analysis techniques to those data; and 3) small group projects on topics of interest. Small group projects can focus on Martian stratigraphy for students interested in planetary science.

GEL 240: Foundations of Geophysics (Rudolph)

Graduate course breadth area: #6

This course presents foundational concepts in geophysics at a level accessible to all graduate students in the EPS department. Topics to be covered include the geophysical constraints on the large-scale structure and dynamics of Earth and planetary interiors such as seismology, gravity, heat flow, magnetic field, and geodesy. We will explore the physics of the processes that shape planetary surfaces and interiors including impact events, differentiation, mantle convection, and tectonics. The course will include a computer laboratory with hands-on programming activities in Python that reinforce the concepts covered in lecture.

Format: Lectures, weekly problem sets/labs, midterm, final

Note: This course is one of several regular 'core classes' being developed to strengthen our graduate curriculum.

GEL 298: Planet Formation (Stewart)

Graduate course breadth area: #7

Course Registration Number (CRN): 35500

This course presents foundational concepts in the physics and chemistry of planet formation, focusing on the early stages of growing planets and incorporating recent observations from exoplanets. Course provides foundational material related to protoplanetary disk physics, the solar nebula chemical condensation sequence, meteorite components and chemistry, chondrules and planetesimal formation, accretion of terrestrial planets, accretion of giant planets, current grand challenges in planet formation. The material is targeted at beginning graduate students and accessible to upper-level undergraduates.

Pre-requisites: Physics (e.g., PHY 7 or 9 or equivalent). Recommended: introductory physical chemistry/thermodynamics; introductory astronomy or planetary science course.

Meeting Times: Two 1.5 hour lectures/week. Time TBD.

Required text:

Astrophysics of Planet Formation Second Edition (2020) by Philip Armitage.

Supplemental readings on associated chemical observations and concepts will be posted on Canvas.

Grading: Weekly problem sets: 80% (primarily analytic calculations and concept reinforcement)

Final exam/integrative calculations (take-home): 20%

Lecture Outline:

Week 1: Armitage Chapter 1: Observations of Planetary Systems
Week 2: Armitage Chapter 2. Protoplanetary Disk Structure
Week 3: Armitage Chapter 3. Protoplanetary Disk Evolution
Week 4: Armitage Chapter 4. Planetesimal Formation
Week 5: Armitage Chapter 5. Terrestrial Planet Formation
Week 6: Terrestrial planet formation continued.
Week 7: Armitage Chapter 6. Giant Planet Formation.
Week 8: Armitage Chapter 7. Evolution of Planetary Systems.
Week 9: Thermodynamics and chemistry of the solar nebula / Thanksgiving

Week 10/11: Thermodynamics and chemistry of the solar nebula cont.

GEL 294: Structure-Tectonics-Geophysics seminar (Roeske)

1-unit

This on-going discussion group meets once/week to discuss a paper selected by participants in the group. The theme of the articles varies each quarter; the seminar's goal is to emphasize breadth and we read and discuss a range of articles that cover the diverse interests of members of the group. As an example, we have recently read articles on subduction zone processes, ranging from UHP metamorphism and exhumation, to response of the upper plate to degree of coupling in the subduction zone. If schedules allow, we plan a multi-day field trip to examine rocks that may show some of the processes of interest to the group and focus the reading around the field trip.

Winter, 2022

GEL 216: Tectonics (Cowgill)

Graduate course breadth area: #3

Tectonic processes provide the fundamental mechanisms by which the exosphere (atmosphere, hydrosphere, and biosphere) and the deep interior of Earth interact. This course seeks to understand tectonic systems by examining processes of mass and energy flux at modern and ancient plate boundaries. Our approach will be fundamentally geological in nature, in the sense that we will strive to link the rock record of processes with observations from modern settings. The course will involve readings/lectures based on *Global Tectonics* (Keary, Klepeis, Vine) and the primary literature, problem sets, and a research project and presentation.

Planned topics: 1. Basics of Plate Motion on Sphere; 2. Basics of Isostacy & Flexure; 3. Divergent Boundaries & Passive Margins (e.g., Red Sea, Atlantic); 4. Transform Boundaries (e.g., San Andreas, Alpine, North Anatolian faults); 5. Convergent Boundaries (e.g., Andes); 6. Collision & Orogeny (e.g., Alpine-Himalayan Belt & Demise of NeoTethys); 7. Tectonics, Climate & Ocean Chemistry; 8. Tectonics and Life. Simultaneous enrollment in GEL253 is strongly encouraged.

GEL 260: Paleontology (Vermeij)

Graduate course breadth area: #1

This course will explore a broad topic of interest (still to be decided). We will read and discuss relevant papers and there will be a short final presentation and paper.

GEL 298: Microbial Photosynthesis (Grettenberger)

Graduate course breadth area: #1

Course Registration Number (CRN): 26810

Photosynthesis is one of the most important evolutionary innovations in Earth's history. It permanently changed Earth's surface geochemistry, fundamentally reshaping the cycling of key elements and altered the evolutionary path of life by allowing widespread aerobic respiration. This course will explore the importance of oxygenic photosynthesis in biogeochemical cycling, its evolutionary history, and the history of it in the fossil record. The course will include classroom, field, and laboratory components. Students will participate in a quarter long hands-on project during which they will 1) collect samples from a nearby field site, 2) extract DNA and sequence it using a MinION sequencer, 3) analyze the data using common bioinformatic pipelines, and 4) present their findings in a 10 minute talk format.

GEL 298: Geodynamic Modeling (Rudolph)
Graduate course breadth area: #6
Course Registration Number (CRN): 26818
We will cover the design and implementation of numerical geodynamic models. We will address problems involving advection of material properties, advection and diffusion of heat, viscous flow, and visco-elasto-plastic deformation. Students will produce a 2D geodynamic modeling code that can be used to model the deformation of the lithosphere and mantle. The coursework will involve programming in a language of the student's choice.

Spring, 2022

GEL 219: Fracture and Flow of Rocks (Billen)
Graduate course breadth area: #3 or 6
This revised course is designed to provide students with diverse undergraduate backgrounds with a strong foundation in brittle, ductile and viscous behavior of rocks. Compared to how the class was taught previously there is a shift to more time spent on brittle/ductile behavior of the lithosphere, including the rheologies used to model earthquake rupture, and less time spent on the viscous behavior of the mantle (but this is still covered). For each topic, I will present the experimental data, the equations used to describe the behavior and a discussion of the microscopic origin of the observed behavior. Targeted paper discussions will occur at key junctures in the course to help synthesize the topics and learn how to critically read papers establishing or applying rheological concepts. Each student will also complete a literature review-based term project on a specific type of rheology of relevance to their own research. Please also see detailed syllabus.

GEL 230: Geomorphology and River Management (Pinter)
Graduate course breadth area: #5
The course is a multidisciplinary study of the ecology, geomorphology and management of rivers of the US West, and one river (TBD) in particular. The field of watershed science, including the study of rivers and streams, is inherently multidisciplinary, involving a broad array of physical, biological, and social sciences. Traditional education programs emphasize in-depth study within a specific discipline, whereas most careers in water-related science and management rarely are limited to a single discipline. The ability to work collaboratively with professionals from different backgrounds is fundamental to success in watershed science and management, and indeed in most applied-science fields. Comprised of upper division undergraduate students and first-year graduate students, this course will bring together students from a range of biological and physical sciences to address the geology, ecology, and management of a targeted river and watershed. The course will be followed by an optional, private rafting and research expedition on the study river. Trip participants will

be expected to help organize logistics for the field trip, including food, gear, transportation and field itineraries.

GEL 251: Thermodynamics for Earth and Planetary Scientists (Yin)

Graduate course breadth area: #4

If you are a geologist, or a planetary scientist, or aspired to become one in the near future, and were ever pondering on the questions such as why magma ocean crystallization proceeds from bottom up; if you ever wondered about what the heck does it mean by oxygen fugacity, and why it is a useful measure for a planetary object interior (Earth included); if you ever questioned why geochemists are so crazy about trace and ultra-trace elements in rocks and minerals, instead of (well, in addition to) major rock forming elements; or if you wanted to brush up your knowledge about how pressure and temperature of rocks, minerals and their assemblages were determined; if you were wondering what is solidus, liquidus, and what is adiabat, what is the “potential” temperature of the mantle; what is bridging oxygen and non-bridging oxygen and their roles in elemental partitioning from magma; what are the thermodynamic reasoning behind mass dependent isotope fractionation and its associated temperature dependance (another way of reading temperature record of minerals in nature)……the list could go on and on…… I know you have wondered about these questions in your mind, because I did too. If the answers to the list above were yes to most of them, I recommend you plan on taking GEL 251 in the Spring Quarter 2022 and we will learn together and build up our knowledge bases.

It is a 3-credit graduate level course. We will have a first organizational meeting in the first week of Spring Quarter, 2022. I encourage graduate students interested in the general subject to register for GEL 251: Thermodynamics for Earth Scientists.

If you have taken thermodynamics from general physics or general chemistry at college level, physical chemistry, petrology and mineralogy at undergraduate level, it would be helpful. If you are interested in the subject matter but are concerned with prior technical knowledges of the subject required, please feel free to contact me for consultation (qyin@ucdavis.edu). As Richard Feynman put it: “When the knowledge is weak and the situation is complicated, thermodynamic relations are really the most powerful”. A situation, which I am sure you would encounter in your research career. I believe “Digestion of thermodynamic concepts often requires more than one attempt”. This is to say to those of you who have already taken physical chemistry / thermodynamics in the past and know a lot already, it might still be beneficial to take it again. After all, “For example, the P-T conditions for the processes at the Earth’s surface are 1 bar, 25 °C, whereas those for the processes in the deep interior of the Earth are at pressures of the order of 106 bars and temperatures of the order of 103 °C. The pressures for processes in the solar nebula are 10−3–10−4 bars. The extreme range of conditions encompassed by natural processes requires variety of manipulations and approximations that are not readily available in the standard textbooks on thermodynamics” (Ganguly 2020).

The students' performance will be evaluated and graded based on your active participation, contribution to the class discussion, problem sets, and term papers.

GEL 253: Petrology seminar (Ratschbacher)

Graduate course breadth area: #4

This course will focus on the formation of continental crust in subduction zone settings. Topics about magma generation, ascent, and mechanisms of differentiation will be discussed using scientific journal articles. Further topics can be decided depending on the interest of participating students. The course will comprise weekly student-lead discussion of scientific journal articles as well as short lectures by the instructor.

GEL 294: Structure-Tectonics-Geophysics seminar (Roeske)

1-unit

This on-going discussion group meets once/week to discuss a paper selected by participants in the group. The theme of the articles varies each quarter; the seminar's goal is to emphasize breadth and we read and discuss a range of articles that cover the diverse interests of members of the group. As an example, we have recently read articles on subduction zone processes, ranging from UHP metamorphism and exhumation, to response of the upper plate to degree of coupling in the subduction zone. If schedules allow, we plan a multi-day field trip to examine rocks that may show some of the processes of interest to the group and focus the reading around the field trip.