FOUNDATIONS OF GEOPHYSICS
FALL 2012 GEOS F431/631 Syllabus
4 Credits

INSTRUCTORS:

Erin Pettit
Tel: 474-5389 (don't leave message please, send an email)
email: pettit@gi.alaska.edu
Offices: 338 Reichardt and 410 B Elvey (GI)
Office hours: long questions are by appointment
short questions any day after noon when I am in my office

Jeff Freymueller
Tel: 474-7286
email: jeff.freymueller@gi.alaska.edu
Office: 413B Elvey (GI)
Office hours: long questions are by appointment
short questions any day after noon when I am in my office

COURSE LOGISTICS:

We will meet Tuesdays 1-4pm in Seminar Room (TBD) and Thursdays 1-4pm in Geology Computer Lab.

COURSE CATALOG TEXT:

GEOS F431 Foundations of Geophysics

4 Credits
Offered Fall

Applications of conservation of mass momentum and energy to geophysical, geologic and glaciological problems. Introduction to mathematical approaches such as continuum mechanics, potential theory. Topics such as postglacial rebound, non-Newtonian fluid flow, stress-relaxation, the rheology of earth materials, gravity, magnetics, and heat flow. Emphasis will be placed on methods and tools for solving a variety of problems in global and regional geophysics, and the geophysical interpretation of solutions. Stacked with F631. Prerequisites: GEOS F418, MATH 302 and 314 or permission of instructor.

GEOS F631 Foundations of Geophysics

4 Credits
Offered Fall

Applications of conservation of mass momentum and energy to geophysical, geologic and glaciological problems. Introduction to mathematical approaches such as continuum mechanics, potential theory. Topics such as postglacial rebound, non-Newtonian fluid flow, stress-relaxation, the rheology of earth materials, gravity, magnetics, and heat flow. Emphasis will be placed on methods and tools for solving a variety of problems in global and regional geophysics, and the geophysical interpretation of solutions. Stacked with F431. Prerequisites: GEOS F418, MATH 302 and 314 or permission of instructor.

COURSE GOALS:

1. The primary goal of **GEOS 631** is to train new graduate students in the fundamental problem solving methods (including computational skills) used in a variety of geophysics problems. The foci are on the applications of the Conservation Laws for Mass, Momentum, and Energy to geophysical problems and to introduce modern views of plate tectonics and potential theory.
2. The primary goal of **GEOS 431** is to offer a solid foundation in the problem solving methods for undergraduate students concentrating in Geophysics. As the final (or "capstone") course undergraduate students will take, it is intended to set them up for success in graduate school or in the geophysics workforce.

COURSE DESCRIPTION:

This course is designed for incoming graduate student in geophysics and upper level undergraduate students. The overarching goal of the course is for you to be able to recognize and apply various approaches to solving geophysical problems. After taking this course, you should be able to

1. Describe the large-scale structure of the Earth, including the gravity and magnetic fields.
2. Discuss the current theories and research methods in plate tectonics.
3. Determine which conservation laws are the most important one for a particular problem.
4. Recognize the properties of the materials and state equations that will be important to the solution.
5. Decide on the set of simplifying assumptions to use and be able to justify those assumptions.
6. Apply the specific mathematical techniques related to continuum mechanics.
7. Apply the specific mathematical techniques related to potential theory.

The first half of the semester will focus on fundamental principles of the three conservation laws and introduce concepts in continuum mechanics. The second half will look deeper into applications of the conservation laws and emphasize potential theory and its methods. The computational lab will allow you to deepen your understanding of the concepts and improve your skills at numerical methods and modeling. The computational lab will use the Matlab scientific programing language, which is very common among geophysics researchers; these are skills you will need to succeed in graduate school and as a future geophysicist.

Because this course is teaching you problem solving skills in addition to geodynamic and geophysical fields content, you will spend a substantial amount of time solving problems (individually and in groups) and designing problems for each other to solve. As instructors, we will minimize time lecturing in order to give you time to practice solving problems. This course is provided for you to learn these skills and to challenge yourself.

In order to succeed in this course, you will need to have an understanding and be able to apply

1. basic linear algebra, such as a basis transformation (for vector or matrix), orthogonality
2. vector calculus: grad, div, and all that (Cartesian global coordinates, x-y-z)
3. vector calculus: grad, div, and all that (spherical local coordinates, r-theta-phi)

If you do not have these skills, please discuss this with the instructors and with your graduate advisor.

We will meet once per week for a 3 hour discussion and problem solving session and once a week for a 3 hr computing lab session. Most homework is to be done *before* attending class, not after. This will include coming to class prepared by reading course material, outlining the key concepts, and answering short practice questions and problems. During class, we will discuss the material you have read (guided by your questions from the reading) and we will use team problem solving, small group discussions, and other in class activities to probe the material more deeply.

After class each week you will complete the problem-based assignment you began as a group during the class – either through matlab computational methods as part of the computing lab or through a paper/pencil solution.

Assessment in this class will take the form of ungraded formative assessments such as preparing your notes and questions for class or graded formative assessments such as problem sets or the equation dictionary. Summative assessment will include two exams.

STUDENT LEARNING OUTCOMES:

The specific learning outcomes on which the assessments will be based include:

Problem Solving Methods

1. Define a Continuum and provide examples for geodynamic problems
2. Define a vector, define a tensor
3. Read and interpret equations written in index notation (in comparison with vector/matrix notation)
4. Describe and visualize the 6 components of stress and strain
5. Identify several special states of stress and provide multiple examples of each
6. Explain the Conservations of Momentum, Mass, and Energy and describe the physical process underlying each of the terms within the equations
7. Explain what an equation of state (constitutive eqn) is and provide examples related to geodynamic problems
8. List the steps toward solving a general geodynamics problem (define geometry, list assumptions and boundary conditions, write conservation equations using appropriate terms, choose and write eqns of state and constitutive laws to build a solvable system of X eqns and X unknowns, solve the system of eqns)
9. Apply the general process for solving geodynamics problems to specific problems (defining assumptions, boundary conditions, conservation laws, etc)

10. Recognize and evaluate other scientists' approaches to geodynamics problems (using the general process)
11. Classify geodynamics example problems according to which conservation laws are most important and which solution techniques might be useful.
12. Apply concepts of Fourier Series
13. Explain the concept behind spherical harmonics and how it is useful for describing gravity and magnetic fields of the earth
14. Understand relationship between vector and potential fields
15. Set up and solve differential equations for potential field problems

Geodynamics Content

1. Draw the 1D Earth and label the core, mantle, crust, important distances, and basic properties of each layer
2. Draw the 1D Earth and label the core, mantle, crust, important distances, and basic properties of each layer
3. Explain the fundamental concept behind plate tectonics
4. Understand the mathematical description of (plate) motion on a sphere (key: euler vectors)
5. Explain the factors that affect the gravity field on Earth and how it varies in time
6. Describe the variability in the Earth's magnetic field through time and space
7. Discuss the sources of heat with the earth and the effect of these sources on processes in the mantle and crust such as radioactive heating, solidification of the outer core, etc.
8. Show familiarity with different processes involved with local and global sea-level changes (e.g., isostatic rebound, changes in dynamic topography due to internal mass redistributions, orbital fluctuations, etc, etc)

COURSE MATERIALS:

Book:

1. Required: Geodynamics by Turcotte and Schubert (2002)
2. Recommended: Geophysical Continua by Kennett and Bunge (2008)
3. Additional books will be on reserve at the library.

Notes: We will supply instructor-written notes and outlines of key concepts to supplement the reading and guide your preparations for class. These will be handed out early in the semester, so that you can plan and read ahead as necessary (i.e. being in the field is not an excuse for being unprepared for class).

Access to Computer with Matlab License: UAF provides networked Matlab licenses for all university computers, if you do not have a computer with Matlab, ask your graduate advisor or course instructors for the best solution. The Geology and Geophysics Computer Lab has computers with Matlab for your use. You will need a login for the Computer Lab, please see Chris Wyatt for this login before the first computing lab begins.

Journal Articles and Supplemental Readings: These will be supplied as .pdfs on Blackboard as available.

COMMUNICATION: We will use *Blackboard* to post all materials related to the course. You will receive regular emails when things are updated on blackboard or for other updates or changes to activities related to the course. You are responsible for being aware of due dates or updated material on blackboard.

ASSESSMENT: Students registered for 431 are expected to achieve essentially all of the primary learning outcomes for geophysical problem solving and content. The specific differences between 631 and 431 include

1. On all computing assignments, 631 students will receive one or two additional more challenging questions that go farther in depth on the topic.
2. 431 students do not have to complete the final computing assignment.
3. 431 students will receive double points for the equation dictionary.
4. On homework assignments, all problems (typically 6 per assignment) will be divided into two groups. Three problems will be *introductory problems*, which are intended to reinforce the basic concepts covered in class, and three will be *advanced problems*, which extend that knowledge and challenge the students. In grading, for example, if all problems are worth 4 points, 431 students will earn 12 out of 20 possible points on the three introductory problems and we will assign two of the advanced problems for the final 8 points; while 631 students will be assigned two of the introductory problems for 8 points total and earn 12 points total for completing all three of the advanced problems.
5. For the problem design part of the exams, the 431 students will have to create and solve a problem more similar to the introductory problems on their homework assignments; 631 students will have to create and solve a problem more similar to the advanced problems.
6. In-class exams will be assessed similarly to the homework assignments.

Computational Problems: Over the course of the semester, you will begin 7 longer computational problems (approximately one every other week) during class time. The completion of these will occur during the computational lab time. The seventh computational problem will be one of your own design. This final computational problem is not required for 431 students unless you would like to use it to replace one of the your other computational grades.

Written Problem Sets: We will assign biweekly problems sets or short written assignments. Unless otherwise stated, these will be due at the beginning of class the following week.

Geodynamics Equation and Process Dictionary: Over the course of the semester you will build a list of equations that describe conservation laws, geophysical processes, or material properties. You will create a typed list of these (We will supply a latex format for those who would like it). These will be assessed periodically for completeness. You are in charge of ensuring that the content is correct. These will also be your only notes acceptable during the in-class exams.

Exams: There will be two exams, one mid-way through the course and one at the end. The exams will each have two parts:

1. You will design a question similar to those in our problem sets that extend the learning of the concepts to a new application. You will supply the question and the solution (431 students only need to describe the method for solution). You may share your questions with each other, but you may not share your solutions. You will have some practice designing questions earlier in the semester and you will receive a rubric for how we will assess your question and your solution.
2. We will choose several of the questions from all those submitted by students (possibly slightly edited) as a two-hour timed exam during the three-hour class period (or the finals period).

Class Participation: This will be assessed by whether you have done the reading and prepared for class sufficiently to contribute to class activities (as part of this we may make random checks that you have taken notes or written questions as part of preparation for class). We will include both instructor and peer feedback in assessment of your contributions to group work and class discussions.

Grading:

	431	631
Biweekly Computational Problem Sets (6 or 7@20pts each)	=120	=140
Biweekly Written Problem Sets (6@20pts each)	=120	=120
Equation Dictionary	= 40	=20
Exam 1 Problem Design	=50	=50
Exam 1 In Class	=50	=50
Exam 2 Problem Design	=50	=50
Exam 2 In Class	=50	=50
Contributions during class activities (1pt per class)	=28	=28
Total	= 508	= 508

Your final grade will be determined by the total points you earn. Because of the small differences in the degree of difficulty in various problems from year to year and to ensure consistency of expectations from year to year, we adjust the minimum points required for earning each grade. That minimum number of points necessary for each grade, however, applies to *all* students taking the course in a given year. The number of points and percentages given here are based on the past distribution of student scores in Geophysical Fields (GEOS F602) and Geodynamics (GEOS F620).

Minimum Points Required:

	431 and 631
A	430 (85%)
B	355 (70%)
C	305 (60%)
D	250 (50%)

*note graduate students must receive a C minimum in this course and maintain a B average for graduate level courses

COURSE POLICIES:

1. In all aspects of this course, you are expected to follow ethical behavior. We encourage working with fellow students on assignments; however you must hand in your own work: you may not plagiarize or copy another student's work.
2. Because the nature of this course is hands-on and group learning oriented, you are expected to attend every class. You can miss one class and one computing session without penalizing your participation grade. After this you will receive 1 point off your participation grade for each missed class or computing session.
3. Late Written Assignments: You will receive 1 points (5%) off for each day your written assignment is late. If you anticipate missing a class when an assignment is due (for a conference for field work, for example), please and in the assignment before you leave if possible.
4. Late Computational Assignments: You will receive 1 point (5%) off for each day your computational assignment is late. If you anticipate missing a class when an assignment is due (for a conference for field work, for example), please and in the assignment before you leave if possible.
5. The problem design component of each exam will not be accepted late. If you anticipate being unable to attend class on that day, please make sure you turn in your problem ahead of time.
6. Only under extreme circumstances will we allow the exam to be taken early or late.

DISABILITY ACCOMMODATION:

The Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. UAF is committed to equal opportunity for all students. If you have a documented disability, please let us know AS SOON AS POSSIBLE, and we will work with the Office of Disabilities Services to make the appropriate accommodation(s). If you have a specific undocumented physical, psychiatric or learning disability, you will benefit greatly by providing documentation of your disability to Disability Services in the Center for Health and Counseling, 474-7043, TTY 474-7045. (For example: procrastination issues, dyslexia, ADHD...)

If you are the first in your family to attempt a four-year college degree, and/or eligible for Pell grants, you have opportunities for tutorial and other forms of support from the office of Student Support Services. We will collaborate with the Office of Disabilities and/or the Office of Student Support Services to make your educational experience in our class as positive as possible. Check the following website for further information: `http://www.uaf.edu/advising/learningresources/`