FOUNDATIONS OF GEOPHYSICS
FALL 2013 GEOS F431/631 Syllabus
4 Credits

INSTRUCTORS:

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COURSE LOGISTICS:

We will meet Tuesdays and Thursdays 11:30-1pm in Reichardt 306 (Geology Library) and Mondays 2:15-5:15 in Geology Computer Lab (Reichardt 316).

COURSE CATALOG TEXT:

GEOS F431/631 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. Prerequisites: GEOS F418, MATH 302 and 314, permission of instructor, or graduate standing.

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.

This is a seminar-style class, there will be some lecturing, but generally you will be expected to read material ahead of time and be prepared for in class discussions.

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 and geodynamics.
3. Determine which conservation laws are the most important 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 your own problems. 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 CONTENT The course will be divided into six units.

Unit 1: Intro to Continuum Mechanics and Conservation Laws

Unit 2: Conservation of Mass and Momentum and Fluid Flow

Unit 3: Conservation of Energy and Heat Transfer

Unit 4: Elasticity and Lithopsheric Flexure

Unit 5: Gravity and Potential Fields

Unit 6: Magnetics and Plate Tectonics

For each unit, there will be one computing assignment and one written problem set.

COURSE MATERIALS:

Book:

1. Required: Geodynamics by Turcotte and Schubert (2002)

2. Recommended: Geophysical Continua by Kennett and Bunge (2008)
3. Recommended: Div, Grad, Curl, and All That: An Informal Text on Vector Calculus by Schey (2004)
4. 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 (Reichardt Room 316) has computers with Matlab for your use. You will need to login with your university ELMO password.

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.

All assignments are due through uploading a pdf file to Blackboard. You may type (Latex is recommended to make equations easier) or hand write assignments (if they are legible) and scan them or take digital photos. If you take digital photos, it is your responsibility to convert the photos into a single pdf document (beware that digital photos create large pdf files, scanning is much better). The GI library copy machine can scan and email you your files, there is also a scanner in Reichardt room 316 (that you have access to whenever the Reichardt building is open, which is most of the time).

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 credit for all six assignments, 431 students will be allowed to drop their lowest score.
2. 431 students will receive double points for the equation dictionary.
3. On homework assignments, all problems will be divided into two groups. *Introductory problems*, which are intended to reinforce the basic concepts covered in class, and *advanced problems*, which extend that knowledge and challenge the students. 431 students will do all of the introductory problems and fewer of the advanced problems, while 631 students will be assigned fewer of the introductory problems and complete all three of the advanced problems. 631 students are free to do all of the introductory problems for practice.
4. For the problem-design take-home mid-term 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.

5. The final exams will have a 431/631 assessment structure similarly to the homework assignments.

Computational Problems: You will have one introductory computational problem to help familiarize yourself with Matlab. Then, you will complete one longer computational problem for each unit (approximately one every other week, 6 total). Most of the work towards completion of these will occur during the computational lab time, some work will be finished at home. You will do these assignments with partners in the lab, but you will each submit your own solutions. You and your partner may work together on these answers as much as you like, but you are not required to submit the exact same solution.

Written Problem Sets: We will assign one problems set or short written assignment for each unit (6 total). Unless otherwise stated, these will be due at the beginning of class the following Tuesday.

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 at the same time as your problem-design mid-term exam for completeness. You are in charge of ensuring that the content is correct. These will also be your only notes acceptable during the final exam.

Exams: There will be two types of exams, problem-design take-home exams and a final timed written exam:

1. There will be three **problem-design take-home exams**: one after units 1 and 2, one after units 3 and 4; and one after units 5 and 6. You will design a problem 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. 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 (431 students will be graded on a slightly different rubric than the 631 students).
2. There will be one **timed written exam** at the end of the semester. This is a cross between an in-class exam and a take home exam. You can take this exam from anywhere that has computer and internet access. You will "check out" the exam and have a limited time (2-3 hours most likely) to complete the exam within a 72 hour period. You will then upload the exam to submit it before the time period is up. We will discuss this in more detail as the time nears.

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
Introductory Computational Problem Sets	=10	=10
Biweekly Computational Problem Sets (6 or 7@20pts each)	=100	=120
Biweekly Written Problem Sets (6@20pts each)	=120	=120
Equation Dictionary	= 40	=20
Problem Design Units 1-2	=40	=40
Problem Design Units 3-4	=40	=40
Problem Design Units 5-6	=40	=40
Final Exam	=80	=80
Contributions during class activities (1pt per class plus 2 overall points)	=30	=30
Total	= 500	= 500

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 each year.* 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.

Minimum points for each grade

	431 and 631
A	425* (85%)
B	350* (70%)
C**	300* (60%)
D**	250* (50%)

* This is an approximate point value

**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 point (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 hand in the assignment before you leave if possible, or discuss with the instructors for an alternative solution.
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 turn it in on the due date, please make sure you turn in your problem ahead of time.
6. The final exam must be taken within the 72 hour period we define, please plan your schedule accordingly.

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/`