FORMAT 1

Submit original with signatures + 1 copy + electronic copy to Faculty Senate (Box 7500).

See http://www.uaf.edu/uafgov/faculty-senate/curriculum/course-degree-procedures-/ for a complete description of the rules governing curriculum & course changes.

TRIAL COURSE OR NEW COURSE PROPOSAL

SUBMITTED BY:

Department	**Geology and Geophysics**	College/School	**Natural Science and Mathematics**
Prepared by	**Erin Pettit and Jeff Freymueller**	Phone	**907-474-5389**
Email Contact	**pettit@gi.alaska.edu** **jeff.freymueller@gi.alaska.edu**	Faculty Contact	**Erin Pettit** **Jeff Freymueller**

1. ACTION DESIRED (CHECK ONE): Trial Course [ ] New Course Proposed #: [XXX]

2. COURSE IDENTIFICATION: Dept **GEOS** Course # **F631** No. of Credits **4**

Justify upper/lower division status & number of credits:

GEOS F631 will be the first course all incoming graduate students take in the Geophysics Program.

The course will consist of 3 regular credits for content and one lab credit for a computing applications.

3. PROPOSED COURSE TITLE: **Foundations of Geophysics**

4. To be CROSS LISTED? YES/NO **no** If yes, Dept: [ ] Course # [ ]

(Requires approval of both departments and deans involved. Add lines at end of form for such signatures.)

Course numbers to be approved. F4xx / F6xx

5. To be STACKED? YES/NO **yes** If yes, Dept. GEOS Course # **F431** proposed #.

6. FREQUENCY OF OFFERING: **Every Fall**

Fall, Spring, Summer (Every, or Even-numbered Years, or Odd-numbered Years) — or As Demand Warrants

7. SEMESTER & YEAR OF FIRST OFFERING (AY2011-12 if approved by 3/1/2012; otherwise AY2012-13) **Fall 2012**

RECEIVED
SEP 26 2011
Dean's Office
College of Natural Science & Mathematics

8. COURSE FORMAT:

NOTE: Course hours may not be compressed into fewer than three days per credit. Any course compressed into fewer than six weeks must be approved by the college or school's curriculum council. Furthermore, any core course compressed to less than six weeks must be approved by the core review committee.

COURSE FORMAT: (check all that apply) [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [XX] *6 weeks to full semester*

OTHER FORMAT (specify)

Mode of delivery (specify lecture, field trips, labs, etc) **Lecture/Seminar**

9. CONTACT HOURS PER WEEK: [3] LECTURE hours/weeks [3] LAB hours /week [ ] PRACTICUM hours /week

Note: # of credits are based on contact hours. 800 minutes of lecture=1 credit. 2400 minutes of lab in a science course=1 credit. 1600 minutes in non-science lab=1 credit. 2400-4800 minutes of practicum=1 credit. 2400-8000 minutes of internship=1 credit. This must match with the syllabus. See http://www.uaf.edu/uafgov/faculty-senate/curriculum/course-degree-procedures-/guidelines-for-computing-/ for more information on number of credits.

OTHER HOURS (specify type)

10. COMPLETE CATALOG DESCRIPTION including dept., number, title, credits, credit distribution, cross-listings and/or stacking (50 words or less if possible):

Governance
10/12/11 KA

GEOS F431 Foundations of Geophysics

Note: Final course numbers to be approved. F431 / F631 are proposed numbers.

4 Credits
Offered Fall

Applications of continuum mechanics, heat flow theory, and potential theory to geophysical, geologic and glaciological problems. Topics such as postglacial rebound, non-Newtonian fluid flow, thermal convection, stress-relaxation, rheology of earth materials, gravity, and magnetics will be discussed. 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 GEOS F631. Prerequisites: GEOS F418, MATH F302, and MATH F314 or permission of instructor.

GEOS F631 Foundations of Geophysics

4 Credits
Offered Fall

Applications of continuum mechanics, heat flow theory, and potential theory to geophysical, geologic and glaciological problems. Topics such as postglacial rebound, non-Newtonian fluid flow, thermal convection, stress-relaxation, rheology of earth materials, gravity, and magnetics will be discussed. 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 GEOS F431. Prerequisites: GEOS F418, MATH F302, and MATH F314 or permission of instructor.

11. ***COURSE CLASSIFICATIONS:*** Undergraduate courses only. Consult with CLA Curriculum Council to apply S or H classification appropriately; otherwise leave fields blank.

H = Humanities [ ] S = Social Sciences [ ]

Will this course be used to fulfill a requirement for the baccalaureate core? **If YES, attach form.** **YES:** [ ] **NO:** XX

IF YES, check which core requirements it could be used to fulfill:

O = Oral Intensive, **Format 6** [ ] W = Writing Intensive, **Format 7** [ ] Natural Science, **Format 8** [ ]

12. ***COURSE REPEATABILITY:***

Is this course repeatable for credit? **YES** [ ] **NO** [X]

Justification: Indicate why the course can be repeated (for example, the course follows a different theme each time). [ ]

How many times may the course be repeated for credit? [ ] **TIMES**

If the course can be repeated for credit, what is the maximum number of credit hours that may be earned for this course? [ ] **CREDITS**

If the course can be repeated with variable credit, what is the maximum number of credit hours that may be earned for this course? [ ] **CREDITS**

13. ***GRADING SYSTEM: Specify only one. Note: Later changing the grading system for a course constitutes a Major Course Change.***

LETTER: [X] **PASS/FAIL:** [ ]

RESTRICTIONS ON ENROLLMENT (if any)

14. PREREQUISITES

GEOS F418, MATH F302, F314 or permission of instructor

These will be *required* before the student is allowed to enroll in the course.

15. SPECIAL RESTRICTIONS, CONDITIONS

16. PROPOSED COURSE FEES $

Has a memo been submitted through your dean to the Provost for fee approval?
Yes/No

17. PREVIOUS HISTORY

Has the course been offered as special topics or trial course previously?
Yes/No **YES**

If yes, give semester, year, course #, etc.:

This course is a consolidation and combination of material previously taught as two separate courses: GEOS F620 and GEOS F602. All of the material presented, therefore, has been offered before. It has not previously been taught on the undergraduate level.

18. ESTIMATED IMPACT

WHAT IMPACT, IF ANY, WILL THIS HAVE ON BUDGET, FACILITIES/SPACE, FACULTY, ETC.

This course should have minimal impact on budget, facilities/space, and faculty because it replaces courses that will be eliminated, rather than adding to the number of courses taught. F631 will be taught each fall and is required for graduate students in Geophysics. It will replace the old requirement for graduate student (F620 *and* F602, each of which were taught only every other year). This course will be team taught by the faculty who previously taught F620 and F602, so there is no net change in the faculty workloads. F620 and F602 will be changed or dropped from the catalog after the transition to the new requirement of F631. Because F620 and F602 are current requirements for graduate students, we cannot drop these courses until the transition to F631 has been completed.

GEOS F431 will be required for undergraduate Geoscience majors concentrating Geophysics. As a stacked course, there is minimal additional impact on budget, facilities, and faculty.

We request use of the Geology and Geophysics Department Computer Lab once per week for 3 hours.

19. LIBRARY COLLECTIONS

Have you contacted the library collection development officer (kljensen@alaska.edu, 474-6695) with regard to the adequacy of library/media collections, equipment, and services available for the proposed course? If so, give date of contact and resolution. If not, explain why not.

No [XX] Yes [ ]

The Geophysical Institute Library already maintains a quality selection of introductory geophysics materials.

20. IMPACTS ON PROGRAMS/DEPTS

What programs/departments will be affected by this proposed action?
Include information on the Programs/Departments contacted (e.g., email, memo)

This course will be required for incoming Geophysics graduate students and for undergraduate students who are concentrating in Geophysics within the Geology and Geophysics Department. All faculty members of the Department of Geology and Geophysics, including research faculty affiliated with the Department have been notified of this change.

21. POSITIVE AND NEGATIVE IMPACTS

*Please specify **positive and negative** impacts on other courses, programs and departments resulting from the proposed action.*

POSITIVE IMPACTS:
GRADUATE: Currently, incoming graduate students take a different sequence of courses depending on which year they enter because the two required courses (GEOS F602 and GEOS F620) are taught every other year. F631 is a new course that will be taught *every* Fall, which combines the fundamental parts of

these two older courses in order to create a streamlined path for every entering graduate student. The older courses will be redesigned or dropped to minimize overlap with the content in this new course and to offer slightly more advanced topics than they had previously.

UNDERGRADUATE: Currently the opportunities to study geophysics on the undergraduate level are limited, yet geophysics is a useful background for many Alaskan jobs in oil, mining, and environmental consulting, as well as climate change impacts research. By offering this course stacked with the graduate course, Geology students who concentrate in Geophysics will take this challenging course as a "capstone" course to give them the solid skills they will need in a future job in geophysics related fields.

NEGATIVE IMPACTS: The instruction for this course will be shared between the two faculty who previously taught GEOS 620 and GEOS 602. Because they will be reassigned to this new course, these two older courses will either be dropped or not be taught as often.

JUSTIFICATION FOR ACTION REQUESTED

The purpose of the department and campus-wide curriculum committees is to scrutinize course change and new course applications to make sure that the quality of UAF education is not lowered as a result of the proposed change. Please address this in your response. This section needs to be self-explanatory. Use as much space as needed to fully justify the proposed course.

UAF is a world leader in Geophysical research and Geophysics graduate student training. The Geophysics graduate curriculum has not been updated for nearly two decades. In the process of reviewing and improving the graduate curriculum, it became apparent that a "streamlining" of the introductory graduate courses was necessary. In order to minimize content overlaps and to be able to offer a single foundation course for graduate students every Fall (rather than alternating two every-other year courses), we have taken two current courses (GEOS F602 and F620) and combined the most important content into a single course that all graduate students will take during their first year in our program. This simplifies the geophysics graduate program and provides every student will the same sequence of courses regardless of whether they enter during an odd year Fall or and even year Fall (previously, the students would end up taking a different sequence depending on the year they entered the program).

Additionally, since UAF is such a world leader in Geophysics, we would like to offer undergraduate students the opportunity to study geophysics in a more focused way than is currently offered. We are creating a new undergraduate geophysics concentration within geology. For the students in this concentration, GEOS F431 Foundations of Geophysics will typically be taken their senior year as a "capstone" course. The courses within the concentration that lead up to this course are designed to engage the students in the breadth of geophysics applications and concepts. This final course challenges them to more deeply study the mathematical and computational methods necessary to solve geophysical problems. With this final course, the students will be well prepared to enter a graduate Geophysics program such at the one at UAF or be prepared to enter the workforce as a geophysicist.

The stacked nature of this course will allow the undergraduate students the opportunity to get to know graduate students and to increase their confidence in their own abilities toward going to graduate school or entering the workforce.

APPROVALS: Add additional signature lines as needed.

Signature, Chair, Program/Department of: Geology + Geophysics	Date	9/26/11
Signature, Chair, College/School Curriculum Council for: CNSM	Date	10/5/11
Signature, Dean, College/School of: CNSM	Date	Oct 12, 2011
Signature of Provost (if applicable)	Date	

Offerings above the level of approved programs must be approved in advance by the Provost.

ALL SIGNATURES MUST BE OBTAINED PRIOR TO SUBMISSION TO THE GOVERNANCE OFFICE

Signature, Chair	Date	

Faculty Senate Review Committee: ___Curriculum Review ___GAAC

___Core Review ___SADAC

ADDITIONAL SIGNATURES: (As needed for cross-listing and/or stacking)

Signature, Chair, Program/Department of:	Date	
Signature, Chair, College/School Curriculum Council for:	Date	
Signature, Dean, College/School of:	Date	

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 continuum mechanics, heat flow theory, and potential theory to geophysical, geologic and glaciological problems. Topics such as postglacial rebound, non-Newtonian fluid flow, thermal convection, stress-relaxation, rheology of earth materials, gravity, and magnetics will be discussed. 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 GEOS F631. Prerequisites: GEOS F418, MATH F302, and MATH F314 or permission of instructor.

GEOS F631 Foundations of Geophysics

4 Credits
Offered Fall

Applications of continuum mechanics, heat flow theory, and potential theory to geophysical, geologic and glaciological problems. Topics such as postglacial rebound, non-Newtonian fluid flow, thermal convection, stress-relaxation, rheology of earth materials, gravity, and magnetics will be discussed. 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 GEOS F431. Prerequisites: GEOS F418, MATH F302, and MATH F314 or permission of instructor.

COURSE GOALS:

1. The primary goal of GEOS F631 course 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 F431 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 or 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 F431 are expected to achieve essentially all of the primary learning outcomes for geophysical problem solving and content. The specific differences between F631 and F431 include

1. On written problem sets and computing assignments, F631 students will receive one or two slightly different and more challenging problems that go farther in depth on the topic.
2. F431 students do not have to complete the final computing assignment.
3. On homework assignments, F431 students will be assessed more strongly on the problem setup and describing the approach to the solution than on the details of their mathematical solution.
4. For the problem design part of the exams, the F431 students will have to create a problem and explain their approach to solving it, but they do not have to complete the entire solution.
5. For the in-class exams the F431 students will have to set up and describe their approach to the solution for each problem; then choose one problem to solve all the way through. F631 students will be required to set up, describe their approach to the solutions, and then solve all problems. Therefore, F431 student will assess more on their problem set up and approach (which highlight their understanding of the overall concepts), rather than on their ability to work through the complete solution. F631 students will be assessed through a combination of their understanding of overall concepts *and* their ability to work through problem details, including recognizing when an aspect of their solution does not make physical sense.

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 F431 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 (F431 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:

	410	610
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 make subtle adjustments to the points required for earning each grade. *The percentages given here are based on the past distribution of student scores in Geophysical Fields (GEOS F602) and Geodynamics (GEOS F620)* .

		410 and 610
Minimum Points Required:	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. To be fair to all students this applies even if you miss the class for a conference, field work, or other excused absence (1 point is a very small part of your final grade). You will be expected to make up all work promptly.
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/`

Foundations of Geophysics 2012
GEOS F431/631 Schedule

Week	Reading and Homework	Topics	Computing Assignments
1	T&S Chapter 1	Expectation is that this material is partially review Structure of the Earth Plate Tectonics	Matlab Tutorial: structured tutorial that students unfamiliar with matlab can work through step by step. Tutorial will use Plate Tectonics concepts.
2	Pettit Notes (based on Greve Ch 1&2 and others)	Intro to Continuum Mechanics Overview of Conservation Laws Overview Equations of State, Constitutive Laws Continuum approach to problem solving.	Complete Matlab Tutorial
3	T&S Chapter 2 T&S Chapter 3.1-3.8 Pettit Notes *Problem Set # 1 due*	Stress and strain Intro to Linear Elasticity	*Matlab Tutorial assignment due* Relation between stress, strain, and geometry using linear elastic material and built in PDE solver. Have students explore different geometries and different elastic parameters to answer specific questions.
4	T&S Chapter 3.9-3.18 T&S Chapter 7.1-7.2 Additional notes	Elasticity Lithosphere and Flexure	Complete Stress-strain exploration questions from previous week.

5	T&S Chapter 6.1-6.2 T&S Chapter 7.10 Additional notes *Problem Set # 2 due*	Lithosphere and Flexure Viscolasticity	*Stress-strain matlab assignment due* Matlab problems to model plate bending.
6	T&S Chapter 6	Conservation of Momentum Fluids	Complete plate bending model
7	T&S Chapter 7 *Problem Set # 3 due*	Rheoogy More Fluids	*Plate bending matlab assignment due* Fluid flow matlab assignment.
8	Selected advanced Readings on fluid flow and rheology problems T&S Chapter 4.1-4.10	Advanced Fluid Flow Concepts Introduction to Heat Flow	Continue Fluid Flow Matlab Assignment
9	T&S Chapter 4.11 to end of chapter *Problem Set # 4 due*	Conservation of Energy/Heat Transfer	*Fluid flow matlab assignment due* Matlab Problem on heat flow
10	T&S Chapter 5.1-5.8	Scalar and Vector Fields Gravity and Potential Gravity Field of Earth Geoid and Shape of Earth Gravity Anomalies	Continue Heat flow problem

11	T&S Chapter 5.9 to end of chapter *Problem Set # 5 due*	Gravity Spherical Harmonics Satellite Gravity Compensation and Isostasy	*Heat Flow matlab assignment due* Gravity matlab assignment
12	Glatzmaier and Olson (2005) Additional notes	Magnetics	continue gravity matlab assignment
13	Selected paper, including Matsuo and Heki (2010) Wu and others 2010 *Problem Set # 6 due*	Exciting recent research bringing together multiple aspects of course	*Gravity matlab assignment due* Final Matlab project (design their own problem and solve it)
14	No Reading	Review	continue working on Final Matlab project
15		Final Exam	

FOUNDATIONS OF GEOPHYSICS
FALL 2012 GEOS F431/631 Examples for In Class Activities

WEEK ONE:

Introductions

Earth structure activity 1: Gallery Walk: Big sheets with unlabeled diagrams of subduction zone, earth slice, mid ocean ridge, other tectonic feature. Rotation 1, label parts/contacts/properties. Rotation 2: write down processes occurring and where they mostly occur in diagram.

Earth structure activity 2: Small Group or Gallery Walk style: Locations on earth - what are active processes occurring at these sites, what geological features might you expect to find there? Iceland, Alps, East Africa, SE Alaska, Lake Baikal, Himalaya. Small group discussion, then present to class what they decided - rest of class - was anything left out?

As time is left, have students working in teams to solve some simple "warm up" problems.

WEEK THREE:

Discuss and answer questions that came from readings

Stress/Strain hands on activity: using stress boxes, including special states of stress

Identifying stress regimes/principal stresses using examples and small group work (possible gallery walk style or jigsaw).

Problem solving activity to calculate strains based on real data from GPS observations.

Other weeks The other weeks will have somewhat similar structure. Typically beginning with a discussion of the reading based on questions the students have from the reading. Then small group discussions or problem solving, often with one group checking and correcting another group's work (the "Gallery Walk") model. Finally, the last part of the class will be used to set up and begin each of the problems that will later be completed as a written or computational assignment.

Problem Set #5

1. Flux of a lava in a circular lava tube. Assume the velocity v of lava flowing down a circular tube with radius R_1 varies with radius as

$$v = v_o \frac{(R_1^2 - r^2)}{R_1^2} \tag{1}$$

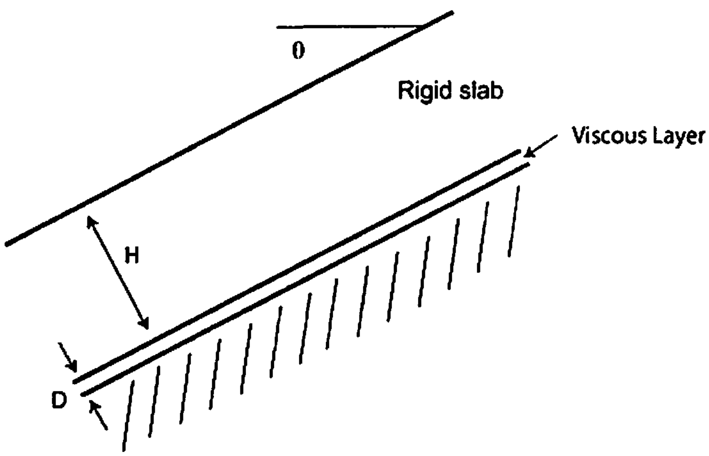
where v_o is the velocity in the center. Assume the density is constant.

a) Calculate the flux of lava down the tube, Q. What are the units?

b) What is the mean velocity of the cross section?

c) If the conduit narrows to a radius of $R_2 = R_1/2$ and the flux remains the same, what is the mean speed in the narrower conduit?

2. Consider a rigid slap of thickness H and density ρ resting on a thin layer of material of thickness $D << H$ of linearly viscous material with viscosity η, all on a slope of angle θ. The substrate under the viscous layer is fixed.



a) What is the shear stress at the top of the viscous layer?

b) What is the shear strain rate at the top of the viscous layer?

c) What is the velocity of the slab?

d) Assume that $D << H$ such that the shear stress and shear strain rate in the viscous layer are uniform across the layer, calculate the energy dissipation per unit volume due to viscous heating within the slab and within the viscous layer.

e) Calculate the energy dissipation due to strain heating per unit *area* for the viscous layer (the area we are interested in is an area with normal in the x_2 direction). Units?

f) Assuming the substrate is a perfect insulator (thermal conductivity =0) and the slab has a thermal conductivity k, calculate the steady state temperature distribution in the slab in terms of it's upper surface temperature T_s and the energy dissipation per unit area in the viscous layer (from d). Give an explicit formula for the temperature T_o at the top of the viscous layer.

g) Assume now that the viscosity η in the viscous layer depends on temperature:

$$\eta(T) = \eta_o[1 - a(T - T_o)] \quad (2)$$

for temperatures T close to T_o. Also assume that the heat capacity of the slab is much smaller than the heat capacity of the viscous layer (so that a quasi-steady temperature distribution is achieved very rapidly in the slab). Find an upper limiting value for parameter a in order for the slab to be stable against runaway heating or cooling in the viscous layer.

3. In Owens Valley near Mammoth Lakes, California between 1975 and 1980, researchers measured an increase in the surface elevation by a small amount (<25cm) over a broad area that they believe to be the result of the inflation of a magma chamber (see the data shown in the attached figure). If we can model this as a 2-D laccolith, where material is injected upward along a fracture at the center of the laccolith and then spreads horizontally over an area of width L (see diagram on page 120 in T&S).

a) What is the plate equation for this situation in terms of a pressure *in excess* of the overburden ("overpressure") in the magma chamber and the problem geometry?

b) What are the boundary conditions?

c) Solve the plate equation for this situation for vertical deflection of the layer $u_2(x_1)$ (x_1 is in the horizontal direction and x_2 is in the vertical direction).

d) What is the bending moment within the overlying layer as a function of x_1?

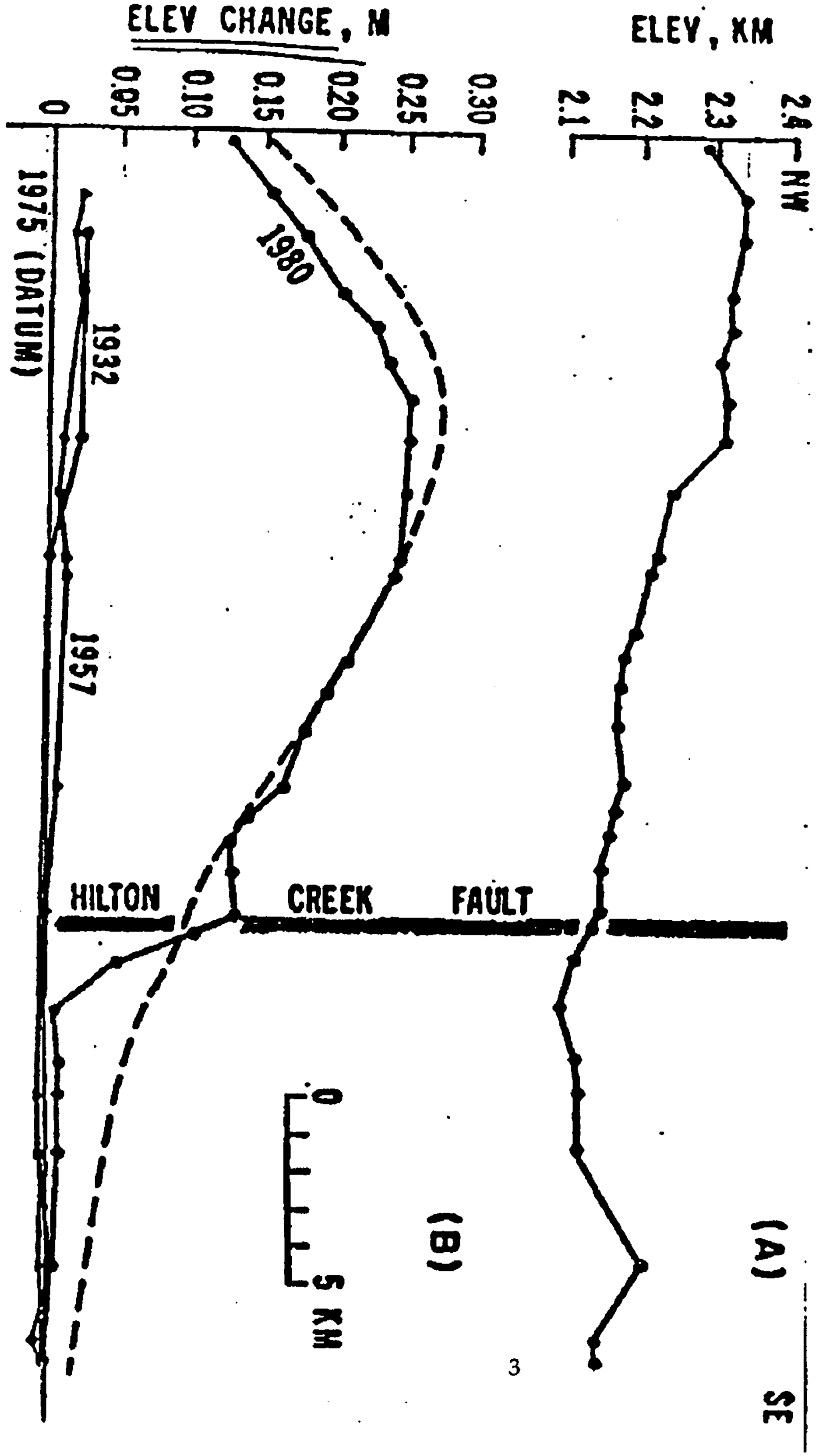
e) Determine the elastic bending stress within the layer ($\sigma_{11}(x_1, x_2)$), also called the "fiber stress" by T&S).

f) Given the displacement profile described by the data from Owens Valley, and assuming the surface layer being uplifted has a thickness $h = 2000$m, plot vertical deflection $u_2(x_1)$ as a function of position and the elastic bending stress at the top and bottom surfaces of the layer (i.e. plot $\sigma_{11}(x_1, +h/2) and \sigma_{11}(x_1, -h/2)$. Assume that $E = 8 \times 10^10$Pa, $\nu = 0.25$, and $\rho = 2700$kg/m^3. Plot the displacement and the top and bottom bending stresses as a function of position using matlab.

g) Use your results to estimate the total pressure, the overburden, and the "overpressure" within the magma chamber.

h) Where would you expect fractures to form in the overlying layer? Does the inferred fault shown in the data make sense with your results? What type of fault would you expect this to be?

NOTE: In this figure, the data are shown as dots connected by a line. This is what you should fit your model to (the dashed line is some other researchers model, ignore that!).


ELEV CHANGE, M
0
0.05
0.10
0.15
0.20
0.25
0.30
ELEV, KM
2.1
2.2
2.3
2.4
NW
SE
1980
1932
1957
1975 (DATUM)
HILTON CREEK FAULT
0
5
5 KM
(A)
(B)

GEOS F431/631
Equation Dictionary Project

*note: Based on project designed by Jackie Caplan-Auerbach at Western Washington University

GOAL:

To increase student confidence in their quantitative abilities and improve their understanding of the relationship between equations and the physical processes that they describe.

DESCRIPTION:

Over the course of the semester, the students will create a dictionary of the key most useful equations used in geophysics. When equations are presented in class or in the context of textbook reading, students will first evaluate whether the equation is appropriate for use in the dictionary (is it useful in many situations or specific to one problem? Is it a "final" version of an equation, or can it be simplified? Is it likely to be used in solving geohysical problems?) Once an equation is selected for the dictionary, students add a "definition" that includes (a) a short description of each variable and relevant constants, including appropriate units, (b) a short written description of the process or relationships presented within the equation, (c) the assumptions built into the particular equation, and (c) 1-2 sentences of additional notes that help them understand the equation. The dictionary may be used on homework and exams, which encourages students to describe the equations in a manner that is meaningful to them. This activity allows students to evaluate their understanding of equations and the underlying physical processes.

INTRODUCTION:

Geophysics is fundamentally based on mathematics – you will be seeing a lot of equations in this class. Many students approach equations simply by memorizing them, rather than focusing on what they tell you about geophysical processes. A common question is which equation should I use? or can I use this equation? These questions suggest to your instructors that you are not sufficiently connecting the equation with the underlying physical process it is describing. Our goal is for you to think of the equation as a story that describes a physical process as the relationship between variables which each have a physical meaning (such as time, space, or a physical property). In order to help you make the connections between the mathematical equation and the physical process, you will each put together a personal "equation dictionary" for this class.

This dictionary will be yours to bring to exams (and it is the only thing youll be allowed to bring, other than your calculator), so it is to your benefit to use your own descriptions and to keep it organized and clear.

It is your responsibility to decide which equations are important enough to include in the dictionary. Too many equations and it will not be useful for you during an exam. Too few and you will be missing major important equations.

METHOD:

Each entry in your dictionary will contain the equation and equation name and then 3 columns of information.

1. The first column will explain each of the variables in the equation.
2. The second column will be a short written description of what physical process equation is describing. and how it is useful.
3. The third column is the assumptions built into the equation.

Finally, you can add additional information in the next row.

We highly suggest creating a digital version of your equation dictionary rather than a hand written one, so that you may edit and modify easily over the course of the semester. We suggest either creating a word document creating a table for each equation and becoming familiar with the Word equation editor. Or alternately you can use latex. We are happy to provide a template for either of these to get you started.

ASSESSMENT:

You you will receive one grade for your dictionary at the first exam and one grade at the second exam. Your grade with be calculated according to this rubric (for 410 students each category points are doubled):

Number of Equations (4pts): are all of the most important equations there? are there too many equations of minor importance or equations that are variations on the major ones?

Completeness (4pts): are all of the variables defined? a succinct short description provided? are the assumptions outlined clearly?

Timeliness (2pts): is the dictionary kept up to date? we will do random checks on the dictionary during the semester in addition to grading it after each exam.

Total Points per assessment: 610: 10 ponts; 410: 20 points

EXAMPLE:

<table>
<tr><td colspan="3">General Conservation Law</td></tr>
<tr><td colspan="3">$$\frac{\mathrm{D}}{\mathrm{D}t}\int_V \phi \mathrm{d}V = \underbrace{\int_V k\mathrm{d}V}_{\text{production}} - \underbrace{\int_S \vec{Q}\cdot\vec{n}\mathrm{d}S}_{\text{transport}}$$</td></tr>
<tr><td>ϕ → property you are conserving (mass, salt, etc)
V → Volume of interest
S → Surface containing the volume
k → Production of ϕ within the volume (amount as a function of time)
$\vec{Q}$ → Flux of ϕ through the surface (amount as a function of time)</td><td>This equation equates the time rate of change of a quantity contained within a boundaryt (left side) with the amount produced by sources with that volume (right side, first term) and the amount lost or gained by transport over the boundary of the volume (right side, second term).</td><td>This is a very general equation, few assumptions except those basic to continuum mechanics</td></tr>
<tr><td colspan="3">Example of a specific version of this equation for the concentration of salt...</td></tr>
</table>

Foundations of Geophysics GEOS F431/631
Computational Methods for Heat Flow
September 23, 2011

Thermal perturbation due to an ice age

(based on T&S Problem 4-34)
this version of the problem and the solution by Carl Tape

Determine the effect of a glacial epoch on the surface geothermal gradient as follows. At the start of the glacial epoch $t = -\tau$*, the subsurface temperature is* $T_0 + \beta y$*. The surface is* $y = 0$*, and* y *increases downward. During the period of glaciation the surface temperature drops to* $T_0 - \Delta T_0$*. At the end of the glacial period,* $t = 0$*, the surface temperature again rises to* T_0*.*

Find the subsurface temperature $T(y, t)$ *and the surface heat flow for* $t > -\tau$*. If that last glaciation began at 13,000 years BP and ended 8000 year BP and* $\Delta T_0 = 20$ *K (*$\kappa = 1$ *mm*^{2} *s*$^{-1}$*,* $k = 3.3$ *W m*$^{-1}$ *K*$^{-1}$*), determine the effect on the present surface heat flow.*

Solve the problem as far as possible analytically (without using Matlab). Then complete the solution using Matlab to answer the questions posed during the class. *Questions will be based on the following solution as well as other aspects of the question that arise during discussion*

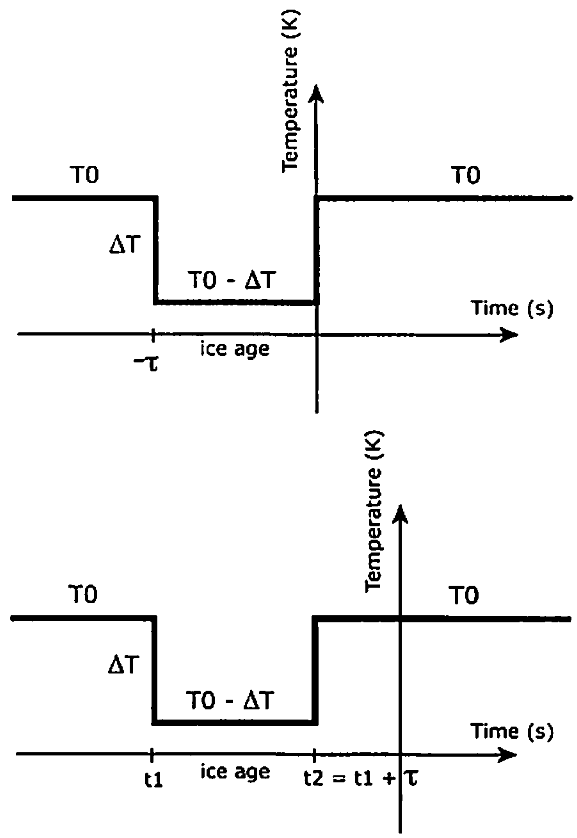


Figure 1: Temperature perturbation for the ice age problem. The time shift (bottom plot) can be applied at the end of the problem.

Solution

You solved the solution to the 1D heat conduction problem of instantaneous heating of a half-space in a written assignment, this can be rearranged slightly as following:

$$T(y,\, t) \;=\; T_1 + (T_0 - T_1)\,\mathrm{erfc}\left(\frac{y}{2\sqrt{\kappa t}}\right)\,, \tag{1}$$

where T_1 is the initial temperature (of the half-space) and T_0 is the temperature of the (cooled) surface.

We apply the diffusive cooling of a half-space model to determine the effect of a glacial epoch on the surface geothermal gradient. At the start of the glacial epoch (and beforehand), time $t = -\tau$, the subsurface temperature is given as $T_1 = T_0 + \beta y$. The onset of the perturbation signal occurs not at $t = 0$ but at $t = -\tau$, which requires the time shift $t \to t-(-\tau) = t+\tau$. Hence our solution for time $t = [-\tau,\, 0]$ is given by

$$T(y,\, t) \;=\; T_0 + \beta y - \Delta T_0\,\mathrm{erfc}\left(\frac{y}{2\sqrt{\kappa(t+\tau)}}\right)\,. \tag{2}$$

The "before" surface temperature T_1 is now T_0, the "after" surface temperature (i.e., during glaciation) is now $T_0 - \Delta T_0$, and thus the term $(T_0 - T_1)$ in Equation (1) becomes

$(T_0 - \Delta T_0 - T_0) = -\Delta T_0$.

Evolving this to time $t = 0$, we get the temperature profile at the end of glaciation:

$$T(y,\,0) \;=\; T_0 + \beta y - \Delta T_0 \operatorname{erfc}\left(\frac{y}{2\sqrt{\kappa\tau}}\right) \,. \tag{3}$$

This now becomes our new T_1 to compute the evolution for time $t > 0$, representing the spike at the end of glaciation. Inserting Equation (3) as T_1 into Equation (1), we obtain

$$T(y,\,t) \;=\; T_0 + \beta y - \Delta T_0 \operatorname{erfc}\left(\frac{y}{2\sqrt{\kappa\tau}}\right) + \Delta T_0 \operatorname{erfc}\left(\frac{y}{2\sqrt{\kappa t}}\right) \,. \tag{4}$$

The "before" surface temperature (i.e., during glaciation) T_1 is now $T_0 - \Delta T_0$, the "after" surface temperature is now T_0, and thus the term $(T_0 - T_1)$ in Equation (1) becomes $T_0 - (T_0 - \Delta T_0) = \Delta T_0$.

We combine the solutions for the three time intervals to obtain the general solution:

$$T(y,\,t) \;=\; \begin{cases} T_0 + \beta y & (t < -\tau) \\ T_0 + \beta y - \Delta T_0 \operatorname{erfc}\left(\dfrac{y}{2\sqrt{\kappa(t+\tau)}}\right) & (-\tau < t < 0) \\ T_0 + \beta y - \Delta T_0 \operatorname{erfc}\left(\dfrac{y}{2\sqrt{\kappa(t+\tau)}}\right) + \Delta T_0 \operatorname{erfc}\left(\dfrac{y}{2\sqrt{\kappa t}}\right) & (t > 0) \end{cases} \tag{5}$$

Note that $t \neq -\tau$ and $t \neq 0$.

As shown in Equation (??), we can readily compute the analytical derivative of Equation (5) with respect to y:

$$\frac{\partial T}{\partial y}(t) \;=\; \begin{cases} \beta & (t < -\tau) \\ \beta + \dfrac{\Delta T_0}{\sqrt{\pi\,\kappa(t+\tau)}} \exp\left[\dfrac{-y^2}{4\kappa(t+\tau)}\right] & (-\tau < t < 0) \\ \beta + \dfrac{\Delta T_0}{\sqrt{\pi\,\kappa(t+\tau)}} \exp\left[\dfrac{-y^2}{4\kappa(t+\tau)}\right] - \dfrac{\Delta T_0}{\sqrt{\pi\,\kappa t}} \exp\left[\dfrac{-y^2}{4\kappa t}\right] & (t > 0) \end{cases} \tag{6}$$

Heat flow is then computed as $q(y,t) = -k\frac{\partial T}{\partial y}(t)$. Heat flow at the surface is $q_0(t) = q(0,t)$.

Time intervals (Figure 1)

The equations are written such that $t_1 = -\tau$ represents the start of glaciation, and $t_2 = 0$ represents the end of glaciation. We are interested in choosing dates with respect to present-day ($t = 0$), such that $t_2 = t_1 + \tau$. The glaciation then occurs over the interval $t = [t_1,\, t_1 + \tau]$. This requires applying the time shift $t \to t - (t_1 + \tau)$.

In our problem, $t_1 = -13.00$ kyr and $t_2 = -8.00$ kyr. For the computations we choose a start time before the start of the glaciation (-14.25 kyr), and an end time some time after the glaciation (+1.00 kyr). (Note that $t = 0.00$ kyr represents present day.)

Graphical representation and discussion of solution

Using the values specified in TS, I plot the solution in various forms in Figures 2–4. The graphical solution is quite beautiful and provides good support for basic intuition: the box-car boundary condition of temperate at the surface depresses the isotherms, which then return gradually to the initial levels (but never quite reaching them).

As expected, there are two singularities, at $t_1 = -13$ kyr and $t_2 = -8$ kyr. These times correspond to the instantaneous perturbation applied at the surface due to the starting and stopping of glaciation. The plots in Figure 3 correspond to the surface profiles of the plots in Figure 2. Immediately after the onset of glaciation at -13 kyr, the heat flow upward is strongly positive. The glaciationsignal propagates downward with time, which is best indicated in the middle plot in Figure 2. By the end of glaciation, the near-surface has sufficiently cooled, such that when the ice age ends at -8 kyr, the heat flows strongly *downward* because the new surface temperature is greater than the cooled surface. In fact, the heat flow is downward from -8 kyr until -6.37 kyr, the exact time at which there is zero heat flow at the surface. From -6.37 kyr to present, the surface heat flow gradually approaches the pre-glaciation value of 0.0825 W m^{-2}. The deep orange region at $(t, y) = (-7\,\text{kyr}, 0.7\,\text{km})$ in the middle plot of Figure 2 indicates that, at this moment, the deeper regions have not yet "seen" that glaciation has ceased, and heat continues to flow upward.

Below we list the values at the surface for the start and end times of the computation:

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Surface temperature:
At time t = -14.25 kyr, T = 273.0000 K
At time t = 1.00 kyr, T = 273.0000 K

Surface thermal gradients:
At time t = -14.25 kyr, dT/dy = 25.0000 K/km
At time t = 1.00 kyr, dT/dy = 20.8032 K/km

Surface heat flow upward:
At time t = -14.25 kyr, q = 0.0825 W/m^2
At time t = 1.00 kyr, q = 0.0687 W/m^2
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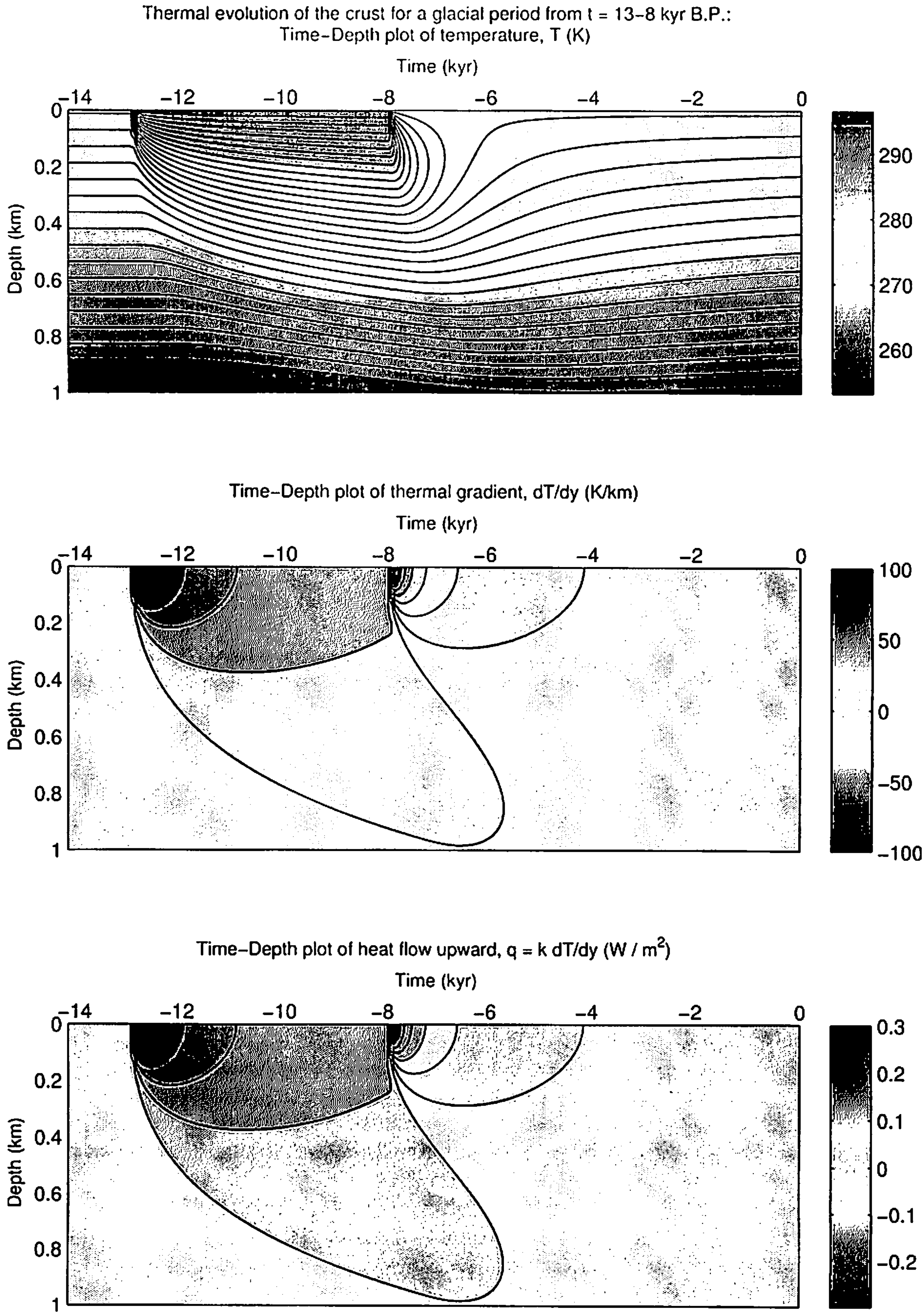

Figure 2: Plots for glaciation perturbation problem.

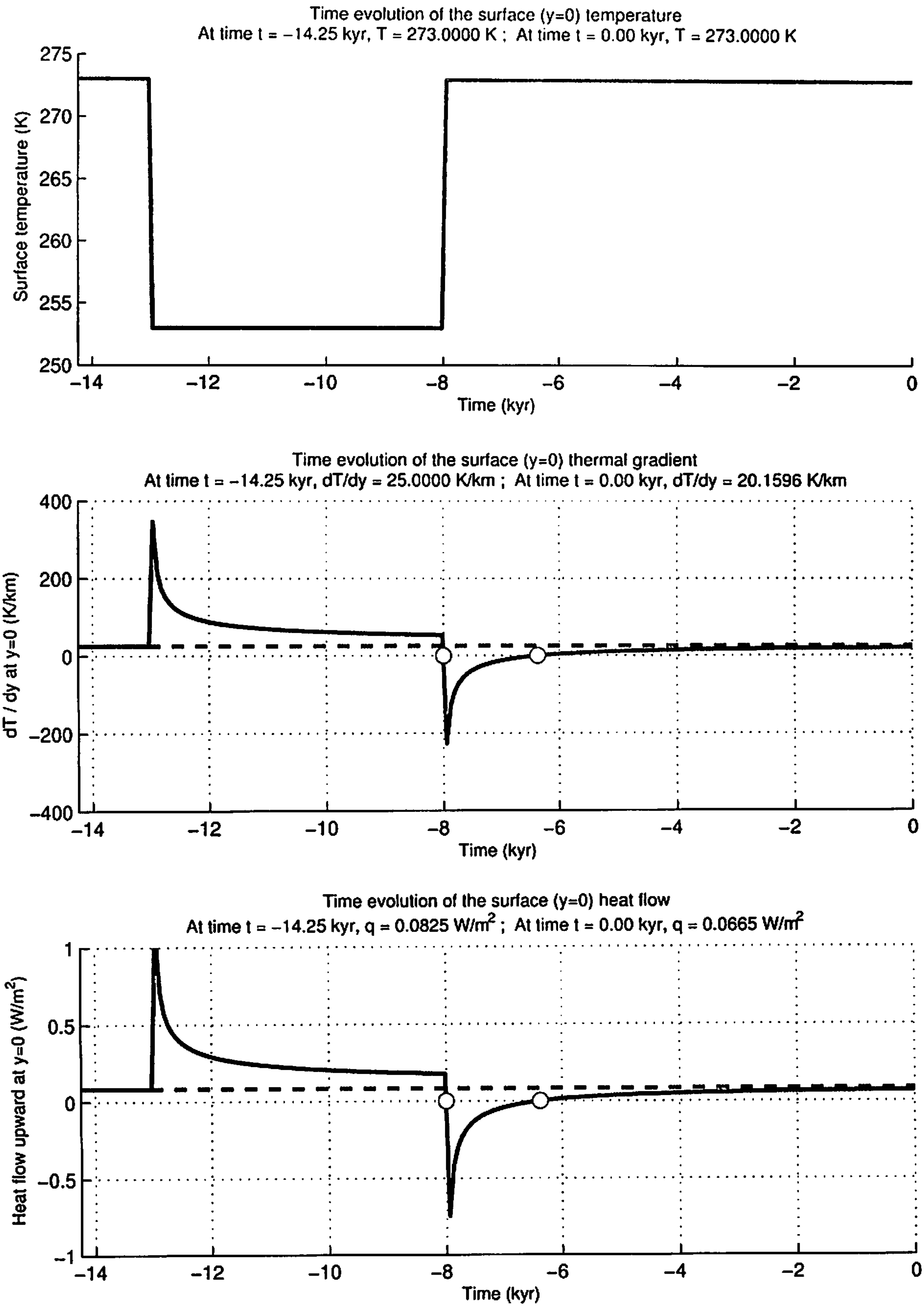

Figure 3: Plots for glaciation perturbation problem.

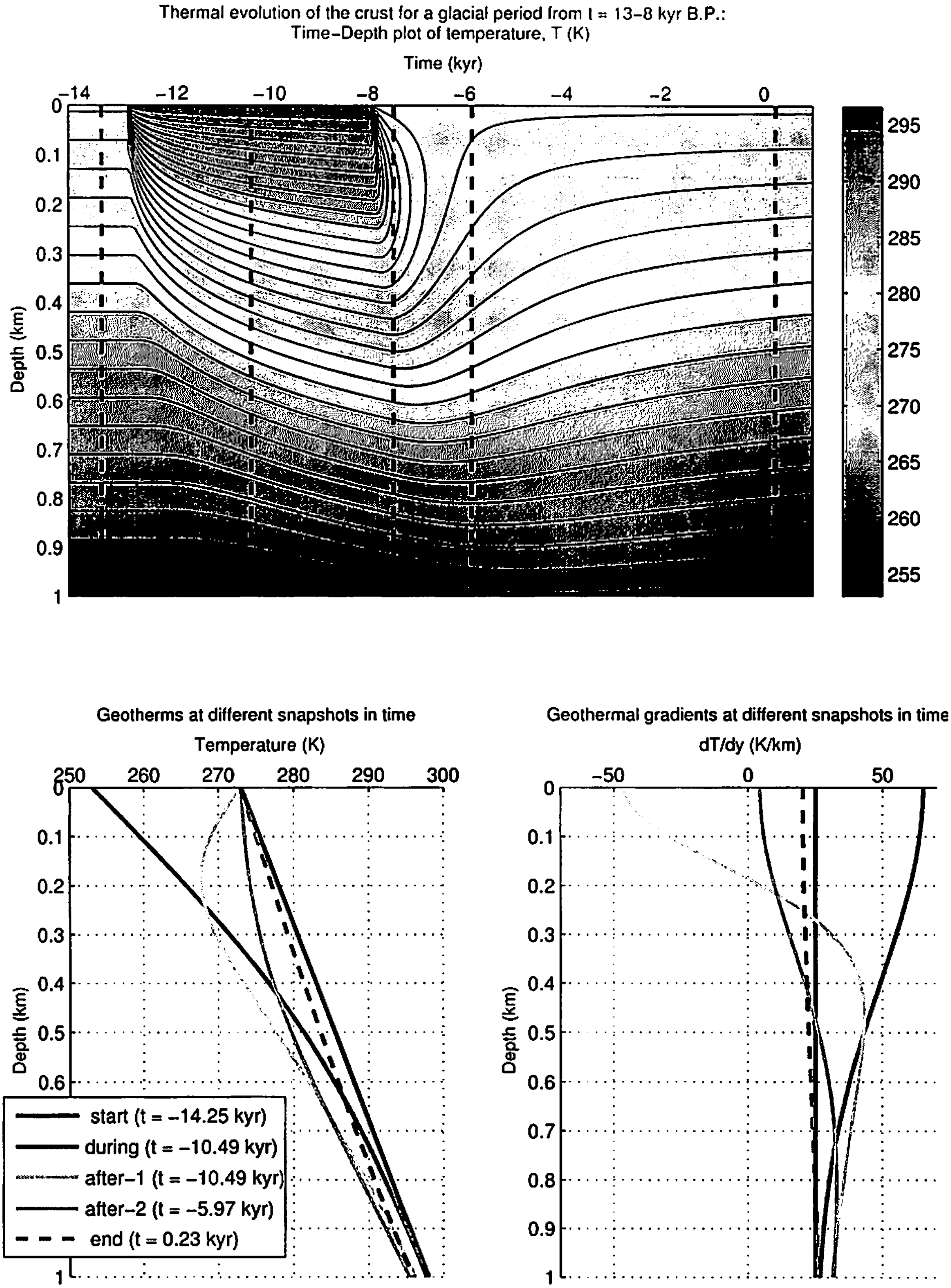

Figure 4: Plots for glaciation perturbation problem