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	**Faculty Contact**	**Erin Pettit**

Proposed #:

Course numbers to be approved. F4xx / F6xx

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

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

[redacted]

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

[redacted]

APPROVALS:

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

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

	Date	

Signature, Chair
Faculty Senate Review Committee: ___Curriculum Review ___GAAC

___Core Review ___SADAC

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

	Date	

FOUNDATIONS OF GEOPHYSICS

[redacted]

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

[redacted]

[redacted]

[redacted]

Office hours: long questions are by appointment

[redacted]

[redacted]

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 fun-

   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

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

1. basic linear [illegible]
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 [illegible]

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 (how euler

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

[redacted]

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 differ-

[redacted]

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

[redacted]

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.

[redacted]

[redacted]

[redacted]

Minimum Points Required:

	410 and 610
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

dyslexia, ADHD...)

If you are the first in your family to attempt a four-year college degree, and/or eli-

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 Gross Ch. 1&2 and	Intro to Continuum Mechanics	Complete Matlab Tutorial

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	Rheology	*Plate bending matlab assignment due*

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)	Magnetics	continue gravity matlab assignment

FOUNDATIONS OF GEOPHYSICS

FALL 2012 GEOS F431/631 Examples for In-Class Activities

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 [illegible]

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

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

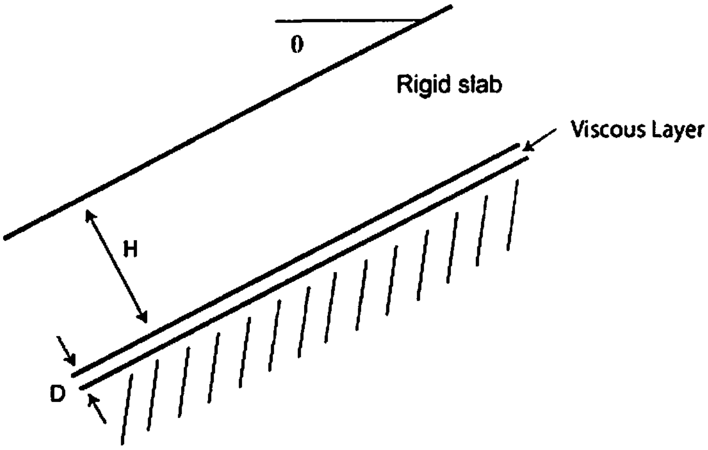
where v_o is the velocity in the center. Assume the density is constant.

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.



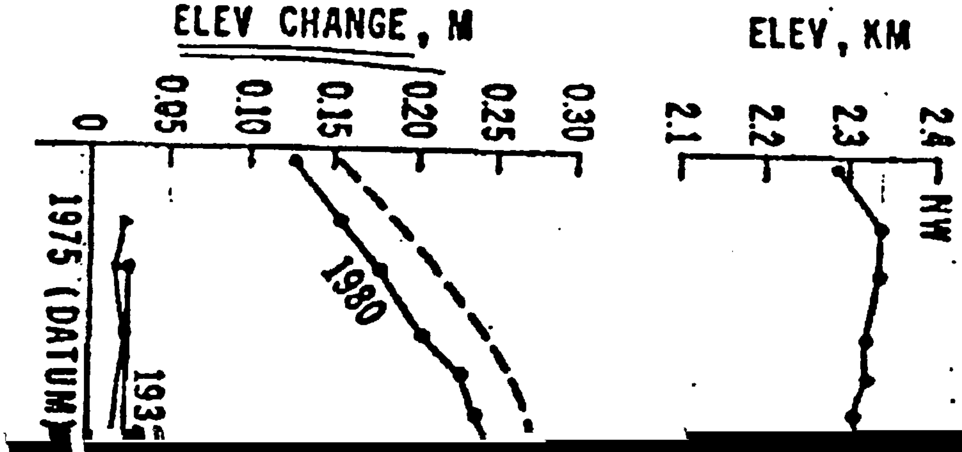
a) What is the shear stress at the top of the viscous layer?

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

c) What is the velocity of the slab?

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 [illegible]

of it's upper surface temperature T_s and the energy dissipation per unit area in the viscous [illegible]


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
1980
1975 (DATUM)
193

GEOS F431/631
Equation Dictionary Project

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 [illegible]

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

is describing, and how it is useful.

3. The third column is the assumptions built into the equation.

[illegible]

EXAMPLE:

General Conservation Law		
$$\frac{\mathrm{D}}{\mathrm{D}t}\int_V \phi \mathrm{d}V = \underbrace{\int_V k \mathrm{d}V}_{\text{production}} - \underbrace{\int_S \vec{Q}\cdot\vec{n}\mathrm{d}S}_{\text{transport}}$$		
) property you are con		

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 [illegible]

to T_0.

Find the subsurface temperature [illegible]

[illegible]

glaciation began at 13,000 years BP and ended 8000 year BP and $\Delta T_0 = 20$ K ($\kappa = 1$ mm^2 [illegible]

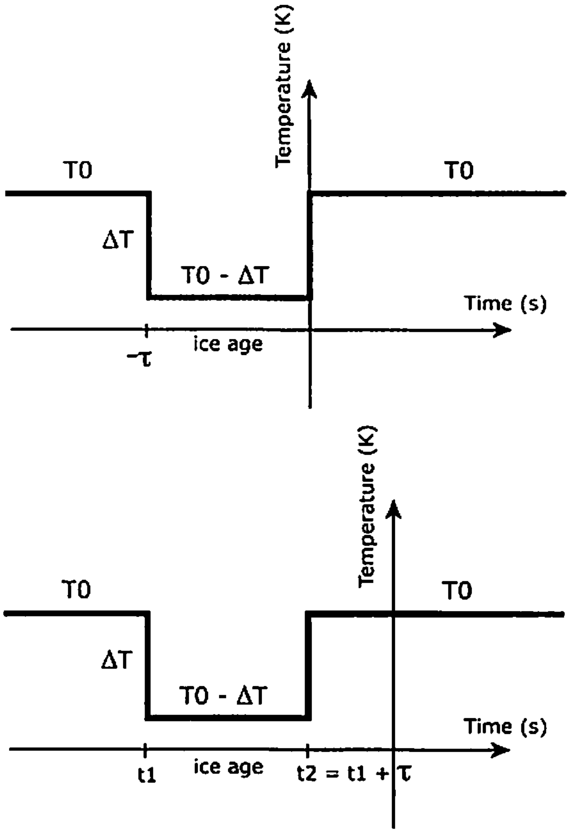


Figure 1: Temperature perturbation for the ice age problem. The time shift (bottom plot)

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.

[illegible]

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

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

[redacted]

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

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

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

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:

[redacted]

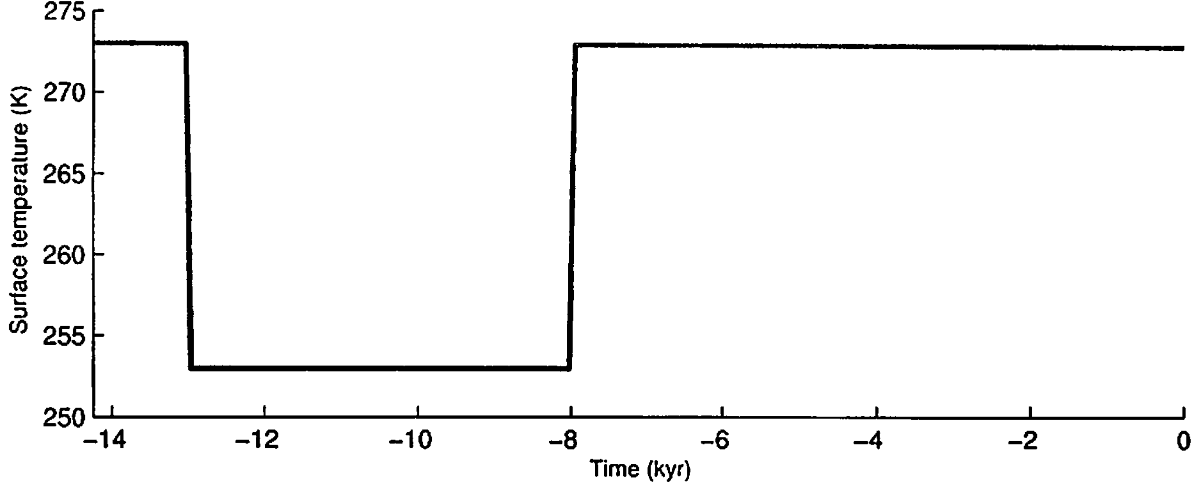
As expected, there are two singularities, at $t_1 = -13$ kyr and $t_2 = -8$ kyr. These times correspond to the instantaneous perturbation applied at the surface due to the starting and stopping of glaciation. The plots in Figure 3 correspond to the surface profiles of the plots in Figure 2. Immediately 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

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


290
280
270
260
100
50
0
−50
−100
0.3
0.2
0.1
0
−0.1
−0.2
0
0
0

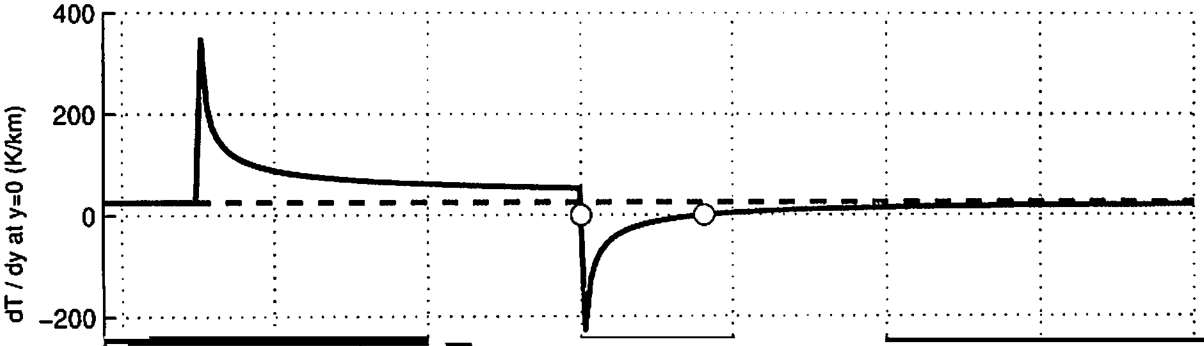
Time evolution of the surface (y=0) temperature

At time t = −14.25 kyr, T = 273.0000 K ; At time t = 0.00 kyr, T = 273.0000 K



Time evolution of the surface (y=0) thermal gradient

At time t = −14.25 kyr, dT/dy = 25.0000 K/km ; At time t = 0.00 kyr, dT/dy = 20.1596 K/km



Time evolution of the surface (y=0) heat flow

At time t = −14.25 kyr, q = 0.0825 W/m^2 ; At time t = 0.00 kyr, q = 0.0665 W/m^2

Thermal evolution of the crust for a glacial period from t = 13-8 kyr B.P.:
Time-Depth plot of temperature, T (K)