FRANKLIN & MARSHALL COLLEGE

Department of Geosciences

ENE/PHY 237 - Physics of the Earth Spring, 2016

Instructor: Prof. Sternberg *Class*: MWF 10:00-10:50, F 1:30-3:20, HAC 131
Office: HAC 128 *Office hours:* HAC 128, T Th 9-11:20, by appt.
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Text: *Looking Into the Earth: An Introduction to Geological Geophysics*
Alan E. Mussett and M. Aftab Khan
Cambridge University Press, Cambridge, 470 p., 1997

Prerequisites: GEO 110/114, and PHY 111 (which has a co-requisite of MAT 109)

Course objectives:

To gain a basic understanding of physics applied to the solid Earth. (For this course, the "solid Earth" will exclude the atmosphere, ionosphere, and hydrosphere, although these could be included in a broader definition of geophysics.) The emphasis will be on applications to problems of global and regional geophysics and geology, but applications to smaller-scale problems will also be included. We should bear in mind that what geologists observe on the surface of the Earth must be related to what we can "see" on and below the surface using geophysical techniques. I hope you will come to understand that math and physics do indeed help us to understand the nature of the Earth. In the words of the great geophysicist Sir Harold Jeffreys, "If geophysics requires mathematics for its treatment, it is the Earth that is responsible, not the geophysicist."

Grading:

Homework	25 %
Labs	15 %
Class participation	5 %
Exam with highest score	17.5 %
Exam with second highest score	17.5 %
Exam with lowest score	10 %
SERC submissions	10 %
TOTAL	100%

Class Structure:

We have a small class, and a decently written textbook that is not very quantitative. You are expected to do the assigned reading before class. Class will generally run as follows: We will start with questions from me to you about the assigned reading for the day. I will call on students who volunteer, or at random. Your answers are the basis for your class participation grade. Then I will typically do some development of ideas or math to explain or augment the material in the assigned reading. We will try to leave time at the end of the class to begin work on the homework. I will also provide guidelines to the most important material in the reading and things I might question you about at the beginning of the next class.

Homework:

Problems from the text or my personal collection are assigned for nearly every class. These will be collected and graded. If you have had significant help/advice/collaboration on an assignment, you must acknowledge it on the assignment. Many problems are amenable to being solved with *Excel*. If you do so, you should submit spreadsheets as files through Canvas. Otherwise, written homework must be legible, neatly laid out, and structured as shown at http://www.wikihow.com/Solve-Any-Physics-Problem. Your answer should always include metric units, decimal notation or scientific notation for large and small numbers, and proper use of significant figures (see, e.g., https://en.wikipedia.org/wiki/Scientific_notation).

Lab Assignments:

Lab exercises will emphasize the *doing* of geophysics. Lab work will typically be done in groups. Short write-ups of various types will be done for most labs.

We will write up and submit three labs to On the Cutting Edge (http://serc.carleton.edu/NAGTWorkshops/geophysics/activity-submission.html). We will have two semester-long projects, construction of models for the geomagnetic field, which will be written up for this web site. Each class member will be primary author of one of these write-ups, with peer editing.

Extensions:

Homework is preferably due at the beginning of class, but may be submitted for full credit until 4:30 pm that day. Once a graded assignment is returned (generally the next class), it will no longer be accepted for credit.

Extensions of due dates for labs/assignments may be occasionally granted if you talk to me before the due date. This is to allow for emergencies, or the possibility that you will have multiple major assignments from different courses due on the same day. Extensions will normally be for only one or two days.

Exams

There will be three hourly exams on seismology, gravity, magnetism, and heat flow. The exams cover lecture material, textbook and any other readings, and lab material, with an emphasis on solution of problems and mathematical derivations. The questions will be similar to the homework problems and the proofs covered in class. There are generally 3-4 problems and maybe one derivation on my exams. These exams will be open book and open notes. You will be able to use your calculator and/or a computer with Excel for solving problems in Excel; we will use the computer workroom so that you can't retrieve previous spreadsheets or go online. There will be no cumulative final exam.

Class attendance:

Because of the special format for our small class, lecture attendance is expected. After three unexcused absences, your course grade will drop by two percentage points for each additional missed class, so two excess absences guarantees a drop of 1/3 letter grade. Lab attendance is required; unexcused absences from lab will subtract 1/3 of a letter grade per absence off your final course grade. Excused absences are generally only for College certified reasons.

CLASS	DATE	TOPIC	READING FOR TODAY	PROBLEM FOR NEXT TIME
1 W	13-Jan	Course introduction	ch. 1	St 1-5
2 F	15-Jan	Geophysical surveys	ch. 2	magnetic profile
LAB 1 F	15-Jan	Magnet in a box	ch. 3	
3 M	18-Jan	Elastic moduli, seismic velocity	Box 4.1	4.15*; St 29
4 W	20-Jan	Waves	4.1-4.2	St 30
5 F	22-Jan	Homogeneous Earth	4.3	St 34
LAB 2 F	22-Jan	Apps and apparatuses		
6 M	25-Jan	Ray parameter	4.4	4.2,4.8,4.10
7 W	27-Jan	Seismic waves	4.5	4.4; St 31,32
8 F	29-Jan	Seismic waves and Earth's interior	4.5-4.6	St 35-36
LAB 3 F	29-Jan	Earthquake travel-time curves (SERC)		
9 M	1-Feb	Locating a quake	5.1-5.2	5.1; St 37,38
10 W	3-Feb	Fault-plane solution	5.3-5.4	5.10-5.12
11 F	5-Feb	Earthquake size	5.5-5.10	St 40, 41
LAB 4 F	5-Feb	Earthquake magnitudes (SERC)		
12 M	8-Feb	Refraction surveys	6.1-6.3,6.7	St 42
13 W	10-Feb	EXAM 1	Classes 1-11	
14 F	12-Feb	Reflection surveys	ch. 7	St 44
LAB 5 F	12-Feb	Seismic refraction		
15 M	15-Feb	Newton's law	8.1-8.2	8.8,8.17; St 10
16 W	17-Feb	Gravity anomalies	8.3-8.4	8.2
17 F	19-Feb	Measuring gravity	8.5-8.7	8.6; St 12
LAB 6 F	19-Feb	Gravity with pendulum and free-fall (SERC)		
18 M	22-Feb	Gravity surveys and interpretation	8.8-8.10	St 13
19 W	24-Feb	Isostasy	9.1	St 14
20 F	26-Feb	Isostasy	9.1	9.9,9.10
LAB 7 F	26-Feb	Vertical gradient of gravity 1	Box 8.1	
21 M	29-Feb	Gravity and Earth's Interior	9.2-9.4	St 47, 48
22 W	2-Mar	Shape of the Earth	9.5	St 11,46,47
23 F	4-Mar	Physics of magnetism	10.1	St 20,22,23
LAB 8 F	4-Mar	Vertical gradient of gravity2		
24 M	7-Mar	EXAM 2	Classes 12,14-22	
25 W	9-Mar	Earth's magnetic field	10.1	St 17,18
26 F	11-Mar	Paleomagnetism	10.2-10.2.1	St 19
LAB 9 F	11-Mar	No lab		
	SPRING BREAK			
27 M	21-Mar	Polar wandering	10.2.2-10.2.3	10.13-10.14
28 W	23-Mar	Magnetism of rocks	10.3-10.4	St 21,24
29 F	25-Mar	Magnetic reversals	10.5	St 26
LAB 10 F	25-Mar	Paleomagnetic measurements 1		
30 M	28-Mar	Mineral magnetism	10.6-10.7	St 25
31 W	30-Mar	Magnetic surveying	11.1-11.2	11.1
32 F	1-Apr	Magnetic surveying	11.3-11.8	TBA
LAB 11 F	1-Apr	Paleomagnetic measurements 2		
33 M	4-Apr	Geothermics	17.1-17.2	TBA
34 W	6-Apr	Heat flow and temperature	17.3-17.5	TBA
35 F	8-Apr	Archaeological geophysics	19,28	
Lab 12 F	8-Apr	Magnetic survey - 12:30-6:30		
36 M	11-Apr	EXAM 3	Classes 23,25-34	
37 W	13-Apr	Plate tectonics and plate boundaries	20-1-20.4	St 45
38 F	15-Apr	Plate tectonics, transform boundaries	20.5-20.9	
LAB13 F	15-Apr	Magnetic survey - data reduction		
39 M	18-Apr	Hydrocarbon exploration	22	
40 W	20-Apr	Chicxulub structure	25	SERC projects due