Geology 352—Introduction to Geophysics

MTW, 11:00-11:50, Th 10:00-11:50, ES 213.

Text: The Solid Earth, 2nd ed. by C. M. R. Fowler

Instructor: Jackie Caplan-Auerbach

Office: ES 236, Lab: ES 105

Office hours: TF 1-2 p.m. or by appt.

Office phone: 360-650-4153

Email: caplanj@wwu.edu

DATE	TOPIC	READ FOR TODAY!	HOMEWORK
Wed., 9/21	Introduction to class	Read the whole syllabus (Front page on Canvas, also downloadable from files/course files)	
Thurs., 9/22	Structure of the Earth	Chapter 1, ch. 8, sections 8.1.1 and 8.1.5	MATLAB onramp tutorial at (https://matlabacademy.mathworks.com/)
Mon., 9/26	Plate tectonics		**HW 1 due** Review vector addition at http://hyperphysics.phy-astr.gsu.edu/hbase/vect.html
Tues., 9/27	Plates in motion (Jackie out of town)	Ch. 2, sections 2.1, 2.2, 2.5	
Wed., 9/28	Plates in motion on a flat Earth(Jackie out of town)		
Thurs., 10/29	Intro to MATLAB (meet in computer lab)		
Mon., 10/3	Plates in motion on a spherical Earth	Ch. 2, sections 2.3, 2.4, 2.7	**HW 2 and Eq. Journals due**
Tues., 10/4	Plates in motion on a spherical Earth		
Wed., 10/5	Discuss paper	Wessel and Kroenke, 1997 (on Canvas)	
Thurs., 10/6	Hot spots and mantle plumes Intro to magnetism	Chapter 3, through 3.1.1, 3.2	**HW 3 and Eq. Journals due**
Mon., 10/10	Magnetism and magnetic reversals	Ch. 3, 3.1.2, 3.1.3	
Tues., 10/11	Magnetism and plate tectonics	Ch. 3, section 3.2, 3.3	
Wed., 10/12	Magnetism and plate tectonics		
Thurs., 10/13	NOVA: Magnetic Storm Paleomagnetism		**HW 4 and Eq. Journals due**
Mon., 10/17	Paleomagnetism		
Tues., 10/18	Discuss paper	Tarduno et al., 2003 (on Canvas)	**HW 5 and Eq. Journals due**

Wed., 10/19	Stress and strain	No specific reading, but equations are provided in Appendix 2 of your text	
Thurs.,10/20	**FIRST MIDTERM EXAM**		
Mon., 10/24	Elastic waves and earthquakes	Chapter 4, section 4.1	
Tues., 10/25	Earthquakes and Earth structure	Ch. 4, section 4.2.7	
Wed., 10/26	Earthquakes and Earth structure	Ch. 8, sections 8.1.1-8.1.4	
Thurs., 10/27	Tomography/discuss paper	French and Romanowicz, 2015	**HW 6 and Eq. Journals due**
Mon., 10/31	Focal mechanisms	Ch. 4, section 4.2.8	
Tues., 11/1	Focal mechanisms and plate tectonics	Ch. 4, section 4.3 through 4.3.2	
Wed., 11/2	Refraction		
Thurs., 11/3	Refraction seismology		**HW 7 due (no journals)**
Mon. 11/7	Refraction seismology		
Tues., 11/8	Reflection seismology		
Wed., 11/9	Gravity	Ch. 5, sections 5.1	
Thurs., 11/10	Gravity	Ch. 5, sections 5.3-5.4	**HW 8 and Eq. Journals due**
Mon. 11/14	Gravity anomalies	Section 5.5.3	
Tues., 11/15	Gravity and isostasy	Ch. 5, sections 5.5.2, 5.5.4	**HW 9 and Eq. Journals due**
Wed., 11/16	Isostasy		
Thurs., 11/17	**SECOND MIDTERM EXAM**		
Mon., 11/21	Heat flow	Ch. 7, sections 7.1-7.2	
Tues., 11/22	Heat flow	Section 7.3.4-7.3.5	
Wed., 11/23	THANKSGIVING HOLIDAY		
Thurs., 11/24			
Mon., 11/28	Formation of oceanic lithosphere	Ch. 7, section 7.5	
Tues., 11/29	Oceanic lithosphere	Ch. 9, sections 9.1-9.2	

Wed., 11/30	Discuss paper	Von Herzen et al., 1989	
Thurs., 12/1	Hot spot/mantle plume summary		**HW 10 and Eq. Journals due**
Wed., 12/7	**FINAL EXAM: 8-10 a.m.**		

Class goals: There are a number of methods that we use to determine what the Earth is like, how it has evolved, and how it behaves. Geophysics is the study of Earth processes using physics and physical techniques. In this class we will investigate a wide variety of geophysical processes, including seismology, magnetism, heat flow and gravity. We will determine how plates move, how one can determine the fault plane for an earthquake, how one can identify a magma reservoir beneath a mid-ocean ridge and whether ocean island volcanoes are really formed by mantle plumes. We will investigate topics from a mathematical perspective as well as with more descriptive methods. Techniques emphasized in class include manipulating and solving equations, interpreting geophysical data, graphing and data presentation, and understanding how science progresses and works. More information about course outcomes may be found at the end of this syllabus where the formal course outcomes are listed.

Prerequisites: Please note that this course has several prerequisites. You are expected to have taken Geology 211, Physics 161, and Physics 162. Because Math 124 is a prerequisite to the physics courses, is also assumed that you have taken Math 124 (or the equivalent). *If you do not have these prerequisites you will have difficulty passing this class.*

Grades: Your grade in this class will be based off of a combination of homework and exam scores. Homework will be worth ~40% of your grade, with 30% based on 2 mid-term exams and 20% for the final. The remaining 10% will be split between on the "equation dictionary" project (5%), for which there is a description posted on Canvas, and 5% for the broad category of "participation". This is a measure of how engaged you are in class, whether you attend class regularly, whether you speak up when confused, contribute when confident and whether you visit my office hours if you have questions outside of class. There will be more-or-less weekly homework assignments which will be a combination of problem sets, written assignments and the reading of scientific papers. *Unless you have spoken with me in advance, late assignments will be marked down 10% if late on the date it was due, 20% per additional day, and will not be accepted once I have turned back graded copies to your classmates*. If there is a problem and you are unable to attend one of the exams *it is your responsibility to tell me in advance and work out an alternative. Failure to do so will result in a zero on the exam.* If you do miss an exam with a valid excuse you are expected to make up the exam as soon as you are able to return to class.

Note that although problem sets may be worth different numbers of points they are all weighted equally in your final grade. Thus your quarter grade will be calculated according to the following equation:

$$Quater\ grade = (Avg.homework\ grade \times 0.4) + (Avg.exam\ grade \times 0.3) + (Final\ exam \times 0.2) + (Eq.dict. \times 0.05) + (participation \times 0.05)$$

A: >92.4% A-: 90.0-92.4%:

B+:	87.5-89.9%	C-:	70.0-72.4%
B:	82.5-87.4%	D+:	67.5-69.9%
B-:	80.0-82.4%	D:	62.5-67.4%
C+:	77.5-79.9%	D-:	60.0-62.4%
C:	72.5-77.5%	F:	<60.0%

AM IMPORTANT CAVEAT!! Canvas weights assignments differently than I do (it is unable to assign equal weight to assignments worth different numbers of points). As a result, your Canvas grade *should not be trusted*. You can calculate your real grade using the equation above. If you have questions about doing this please see me and I can confirm your actual percentage.

Assignments: In general, we'll be following many of the discussions and derivations in the text (and augmenting them). This means that the text is a good parallel to the class and a great source of complementary information. I have noted on the syllabus what chapter we will be discussing each day, but I'm going to leave it to you to decide when you want to read the chapter. Some people prefer to read the text in advance of lecture, while others prefer to use it as a reminder of what we did in class. I strongly recommend that you do read it, however, since it is always helpful to see material presented in multiple ways. Note that the mathematics presented in this text occasionally assumes a familiarity with types of math not required for this course (e.g. vector calculus, multivariable calculus, linear algebra). Don't worry if you can't follow the derivations in the text…I'll explain equations in ways that should make sense using principles of introductory calculus.

You are *required to show your work on all problem sets*. In general, I care much less that you get the right answer than that you go through the correct process to get there. You will be graded on your methodology first, followed by the reasonableness (if that's a word) of your answer. For example, if you are asked to calculate the velocity of a tectonic plate, understand the formalism but accidentally hit the wrong number on your calculator and get 5 cm/yr rather than 2 cm/yr, you will not be graded down. If, however, you get an answer that it unreasonable, such as 2 m/s, you will lose points for not recognizing that this answer is obviously incorrect. I'm exceptionally fussy about units, so you'll want to make sure that you always include units on your answers (a plate can't move at a speed of "2"—we need to know if it's 2 cm/yr or 2 mph). And finally, you need to put the proper number of significant digits on your answers. Your answer can only be as precise as your least precise measurement, so even if your calculator tells you the answer out to 8 decimal places, unless your input data had that same level of precision, those numbers are meaningless. If you don't understand significant digits and how to determine how many significant digits to use, please see me or read a great summary here: http://www.physics.uoguelph.ca/tutorials/sig_fig/SIG_dig.htm

MATLAB: Some of the problem sets assigned in this class will make use of the mathematical software MATLAB. MATLAB is an immensely powerful program that allows you to analyze and plot quantitative data. Because most, if not all of you are new to MATLAB, we will include an introduction to the software and I will post a tutorial on Canvas. I'll also provide some MATLAB scripts for some of the problems and will be happy to help guide you in the use of the software. MATLAB is available on computers in the geology department computer room and a host of other computer labs on campus (please see http://west.wwu.edu/labsoftware/user.aspx to access a list of labs with MATLAB).

Integrity and professionalism: Part of your job as a Western student is to behave in a manner that is professional and exhibited integrity. This is not simply an academic matter: most professions also include a code of ethics by which its members are bound, and geology is no exception (you can read a few geology codes of ethics at http://www.agiweb.org/workforce/ethics.html and http://www.geosociety.org/aboutus/ConductCode.htm). Thus you are expected to behave in a professional manner in this class.

With respect to academics, you are responsible for knowing the university policies on Academic honesty and plagiarism (these may be found at www.wwu.edu/integrity). I will expect that you understand what plagiarism is, and how to avoid it, but if you have any questions, please ask me rather than risk accidentally committing an act of academic dishonesty. In a nutshell, any ideas or phrasing that are not your own must be properly cited. Use direct quotations only when absolutely necessary (there is no possible way to say the thing better), provide citations when discussing others' work and use your own words when paraphrasing. Note that it is not sufficient to change a few words or the order of clauses. Paraphrasing involves completely rewriting someone else's ideas in your own words. If you are uncertain as to how much rewriting is necessary to avoid plagiarism please see http://owl.english.purdue.edu/owl/resource/563/02/ or http://www.indiana.edu/~wts/pamphlets/plagiarism.shtml.

Integrity also means that the work you turn it should be your own. ***This means that although you and a friend may discuss the assignment, you must write them up completely separately. Again, see me if this is not clear.*** Assignments that are found to be non-original will earn a zero and can result in your failing the course. Formal paperwork will be written up on the episode and will be sent to the student, department chair, dean and registrar, per university policy).

Professionalism also means being respectful to others in the class. You can exhibit respect by attending class, arriving on time (or entering quietly if you must be late), listening to your peers, and engaging in polite discussion (even when you disagree). Please do not distract your classmates by using your phone or going on the web during class. Behavior such as this does not just affect you: it can be distracting and frustrating to your peers. If you cannot attend a class, please get notes from your classmates. I'll be happy to answer any questions you have about the notes but I will not supply you with my own. Nor will I review what you missed unless you get a classmate's notes first.

Regarding cell phones…under no circumstances should a cell phone ring or ever be answered in class. The same goes for texting—there is no reason for you to send or receive texts during class. If you are waiting for an important call, please let me know, but recognize that I may ask you to wait for your call outside. If there is a circumstance that requires you to be in cell phone or text contact (if, for example, you moonlight as an EMT or you're awaiting the birth of your first child), please discuss this with me in advance of class. If your phone rings or you are found to be texting in class, you will be asked to leave. If you have something to do that is more important than lecture, by all means please go do it. But don't waste our time by doing it during class.

Office hours and contact: Please do not hesitate to contact me during my office hours or by appointment if those hours do not work with your schedule. You may also email me at the

address shown above. I try to respond to all emails as soon as possible, but please recognize that I may not check email frequently on weekends. I am very flexible with meeting times, so if my office hours don't fit with your schedule, I promise that we will find a way to meet if need be. If there is a problem and you are unable to attend one of the exams, *it is your responsibility to tell me in advance and work out an alternative.*

Academic success and support services: Please feel free to talk to me anytime about your performance in the course or possible ways you can improve it. Academic support services are also available if you need them. Tutors are available for a fee through the Tutorial and Academic Skills Center (TASC) at 650-3855 or http://www.wwu.edu/depts/tutorialcenter/home.htm . If you need disability-related accommodations, please notify Student Support Services at 650-3083 (phone) or 650-3725 (TTY) or http://www.wwu.edu/depts/drs/. Other important and useful resources include the Counseling Center (http://www.wwu.edu/counseling/), and the Veteran's Outreach Center (http://as.wwu.edu/voc/). If you need any guidance as to which services can be helpful to you, please don't hesitate to contact me or the Office of Student Life (http://www.wwu.edu/dosoffice/index.shtml)

Geology 352 Outcomes	Geology 352 Objectives
1. Understand the structure and composition of Earth	1.1 Sketch the internal layers of Earth in terms of both compositional and rheological boundaries 1.2 Describe changes in Earth's physical properties, such as seismic velocity, elastic moduli and density, as a function of depth.
2. Understand the theory of plate tectonics and how it relates to processes such as volcanoes and earthquakes	2.1 Calculate relative velocities between tectonic plates 2.2 Describe the location and type of earthquakes occurring at different plate boundaries
3. Understand how to integrate the physical principles and experimental data into the study of geologic processes on Earth and other planets	3.1 Solve quantitative problems related to Earth processes using mathematical techniques such as graphing, algebra, trigonometry, and calculus. 3.2 Utilize theoretical models to evaluate and interpret geophysical data 3.3 Determine which geophysical tools are best used to address a specific geologic question
4. Understand scientific methodology, scientific standards, and how to evaluate sources of scientific information	4.1 Distinguish between the different forms of scientific literature, including peer reviewed articles, abstracts, textbooks, popular media, and web resources. 4.2 Understand scientific publications and discuss their merits and limitations.
5. Students will be comfortable using Excel spreadsheets, and/or MATLAB, and/or Mathcad for quantitative analysis	5.1 Create and interpret graphs of geophysical data. 5.2 Apply appropriate statistical techniques to evaluation geophysical data 5.3 Propagate geophysical data and results through multiple phases of analyses toward a integrated solution.
6. Students will develop problem-solving skills.	6.1 Identify whether a result is physically meaningful and realistic and if not, determine the nature of the discrepancy.

Geology 352 provides information for the following degree/program outcomes:

	B.A. Geology	B.S. Geology	B.S. Geophysics
Outcomes	*1 Earth's surface is affected by dynamic processes on a range of timescales.* *4. Earth's interior is dynamic and drives plate tectonics.* *7. Graduates have developed their observational, analytical and quantitative skills (field, lab, computer, and classroom)*	*1 Earth's surface is affected by dynamic processes on a range of timescales.* *4. Earth's interior is dynamic and drives plate tectonics.* *7. Graduates have developed their observational, analytical and quantitative skills (field, lab, computer, and classroom)* *9. Will be able to apply physics, chemistry, and mathematic concepts to the study of Earth.*	*1 Earth's surface is affected by dynamic processes on a range of timescales.* *4. Earth's interior is dynamic and drives plate tectonics.* *7. Graduates have developed their observational, analytical and quantitative skills (field, lab, computer, and classroom)* *9. Will be able to apply physics, chemistry, and mathematic concepts to the study of Earth.* *11. Will be able to demonstrate general proficiency with concepts and quantitative problems involving Newtonian mechanics, energy and momentum*