Geology and Geophysics 303: Structural Geology
Fall Semester, 2010, 3.0 Units
Lectures: MW 10:30-11:20
Lab: W 1:30-4:20
http://www.soest.hawaii.edu/martel/Stevem.html

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Texts: Basic Methods of Structural Geology, by Marshak and Mitra (MM)

Class Themes

The crust of the earth is deformed at many scales, locations, and times; this deformation produces identifiable structures in the crust such as fractures and folds. An appreciation of earth structures has both enormous practical value and profound intellectual implications for how we view this planet. This class deals with ways to recognize and characterize major structures in the earth's crust and ways to gain insight into how these structures form. The course develops skills in three-dimensional thinking that are essential for understanding crustal structures. It also explores techniques for determining the sequence in which structures form. Geometric and time-sequence information is integrated with fundamental material from course pre-requisites in mathematics and physics to introduce students to how the earth's crust can be viewed as a mechanical system. The class will focus on macroscopic structures but will also introduce students to some of the fascinating structures that form at the microscopic scale. The course has a laboratory and includes a field trip to the Big Island.

Our ability to understand geologic structures depends in large part on how we perceive them. Few geologic structures form by trivially simple processes, but depending on how we view geologic structures, they can appear horribly complicated or amenable to understanding; perspective is critically important. One key thread throughout the class will be ways of viewing the geometry, mathematics, and physics of geologic structures such that the underlying essential forms emerge clearly.

A second key thread is the usefulness of integrated knowledge. We can think of unrelated pieces of knowledge as unconnected nodes of a net. A cut-up net is not very useful for catching fish. However, if the nodes of a net are connected, a net is a wonderful device for catching fish. It is also light, strong, and flexible. The outstanding feature of a net that makes it so useful then is the connection of the nodes. Similarly, concepts are vastly more powerful when they are connected rather than isolated. The knowledge connection process is not easy to master, but it is a key part of thinking, problem recognition, and problem solution. For these reasons, integrating pieces of knowledge can be very satisfying. Links are forged here between disciplines (e.g., structural geology, mathematics, and physics) and between observations made at different scales, but the fundamental focus is on the connection process rather than the particular concepts that are linked.

Mathematical equations show how physical quantities and physical concepts relate formally. Equations are derived in this class to get insight into these relationships and to illuminate the principles behind the equations. Don't view equations just as something one "plugs into". This is the 21st century, and we will use mathematics and computers in quantitative analyses.

The notes for this class are in outline form, not in the form of a finished book. They allow students to concentrate on the main themes in class rather than on frantically scribbling down everything that is said or written. Also, in some ways the outlines highlight key points better than a book; key points don't get lost in a jumble of words. The notes will be most useful, however, if students annotate the notes as they use them.

Schedule

Week	Day	Date		Lecture Subject	Reading	Lab	Lab Topic	Reading
1	M	8/23/10	1	Intro/Course Philosophy	Notes		Strike & dip	MM Ch.1
							Trend & plunge	MM p. 105
	W	8/25/10	2	Eqns. of lines & planes	MW Ch. 1	1	Poles to planes	
2	M	8/30/10		Orthographic projections	MM Ch. 3			
	W	9/1/10	3	Maps (Geol. & contour)	MM Ch. 2,9	2	Orthographic Projections	MM Ch.3
3	M	9/6/10	4	Holiday (Labor Day)				
					Append 3, 1		3 pt problems	
	W	9/8/10	5	Geologic map patterns	MM Ch. 2	3	X-sections 1	MM Ch.3
4	M	9/13/10	6	Scalars, Vectors,Tensors	Notes		X-sections 2	MM Ch.3
							True dip	MM Ch.9
	W	9/15/10	7	Vectors,Tensors,Matrices	Notes	4	Apparent dip	Notes
5	M	9/20/10	8	Spherical Projections I	MM Ch.5		Stereonets I	MM Ch.5
							Lines & planes	
	W	9/22/10	9	Spherical Projections II	MM Ch.6	5	Dip/apparent dip	Notes
6	M	9/27/10	10	Coord. transformations I	Notes			
							Stereonets II	MM Ch. 6
	W	9/29/10	11	Coord. transformations II	Notes	6	Rotations	MM Ch. 7.1
7	M	10/4/10	12	Kinematics I	MW Ch. 7		X-sections 3	
							X-products	
	W	10/6/10	13	Kinematics II	MW Ch. 7	7	Line-plane int.	MM Ch.13.9
8	M	10/11/10	14	Finite strain	MW Ch. 7			
	W	10/13/10	15	Eigenvalues	MW Ch. 7	8	Midterm Exam	

Week	Day	Date	Lecture Subject		Reading	Lab	Lab Topic	Reading
9	M	10/18/10	16	Stress I	Notes			MM Ch. 11.4, 15
	W	10/20/10	17	Stress II	Notes	9	Strain/fabrics	
10	M	10/25/10	18	Stress III	Notes			
	W	10/27/10	19	Stress IV	Notes	10	Stress	Notes
11	M	11/1/10	20	Rheology; elasticity	Notes			
	W	11/3/10	21	Stress around a hole 1	Notes	11	Elasticity	Notes
12	M	11/8/10		Open				
	W	11/10/10	22	Stress around a hole 2	Notes	12	Photoelasticity	Notes
13	M	11/15/10	23	Dislocations	MM Ch. 12.1-12.3			
	W	11/17/10	24	Faults I	MM Ch. 11.3	13	Dikes in gelatin	Notes
14	M	11/22/10	25	Faults II	MM Ch. 11.3			MM Ch.4.6
	W	11/24/10	26	Folds I	MM Ch. 11.2	14	Faulting	MM Ch. 11.3
15	M	11/29/10	27	Folds II	MM Ch. 16.4			MM Ch.13
	W	12/1/10	28	Joints and fractures	MM Ch. 11.3	15	Folding	MM Ch.16.4
16	M	12/6/10	29	Open	Notes			
	W	12/8/10	30	Open	Notes	16	LAB FINAL	
17	M	12/17/04		FINAL EXAM 9:45-11:45				

Laboratory Items

The course involves a substantial amount of graphical work. Good drafting equipment and good paper are essential. Good quality materials, although somewhat expensive, are durable and make the work easier to do, much less time-consuming, and will yield pleasing results in the hands of diligent students. This equipment can be purchased from a drafting or art supply store. Examples can be found, for example, at http://www.reuels.com/reuels/index2.html

Required Equipment (Bring to each lab)
0.5 mm mechanical pencil or drafting pencils with a pencil pointer
Soft rubber eraser ("Jet" erasers are good)
Pad of engineering paper (the green ones with light green gridlines)
Pad of 8.5"x11" Clearprint tracing paper (preferably with light blue "fadeout" grid lines).
    Clearprint is excellent paper. Other brands of tracing paper have yielded poor results.
Clipboard
Protractor (preferably 6" [15 cm] in diameter)
6" pencil compass
30-cm metric triangle scale with scales of 1:10(0), 1:20(0), and 1:50(0)
    (Note: this is NOT an engineer's scale!)
30° and 45° acrylic triangles (diagonal edges ~11.5" long are best)
Drafting tape

Recommended Equipment
French curve

Nice-to-have (but not required) equipment
Technical drawing pen (e.g., Rapidograph 000) if you like to ink in your work
Good black drafting ink

Grading

The lecture and laboratory material is tightly integrated in this course. The course requires students to "learn by doing", so the laboratory exercises (which also constitute "homework") are heavily weighted.

Final for lecture	25%
Final for Lab	20%
Lecture midterm	15%
Laboratories/homework	30%
Class participation	10%
TOTAL	100%

Students are encouraged to work together on the homework; note that "working together" is not the same as "copying". Neatness, clarity of expression, and completeness are essential in order for full credit on the exams, laboratories, and homework. Exams are open note.