Structural Geology – Review Questions and Practice Exam

Short Answer Definition (use drawings where necessary)

13. Slickensides (3 pts)

14. En echelon fractures (3 pts)

15. Vein (3 pts)

16. Normal Fault (3 pts)

17. Thrust Fault (3 pts)

18. Cataclasis (3 pts)

19. Listric (3 pts)

20. Graben (3 pts)

1. What is structural geology? What are the essential questions that are asked in this scientific specialty? (5 Pts)

2. Explain the statement that "structural systems commonly display fractal behavior". (5 pts)

3. Discuss, with examples, the difference between primary and secondary rock structure
(examples are required). (5 pts)

4. What is the difference between "stress" and "strain"? (5 Pts)

5. Differentiate between Mode I, II and III fractures (drawings are required). (6 Pts)

6. In each of the map sketches below, draw a line showing the anticipated strike of the mode I fractures that would likely develop. (5 Pts)

7. In each of the cross-sections below, draw arrows on each side of the faults to show the relative sense of displacement. (5 pts)

8. Discuss the net stratigraphic effect commonly produced by a thrust fault (a diagram is required) (5 Pts)

9. List 5 pieces of evidence commonly used to identify faults in the field. (5 Pts)

10. Draw and label a diagram depicting the difference between synthetic and antithetic faults. (5 Pts)

11. Draw and label a geologic map depicting the difference between sinistral and dextral wrench faults. (5 Pts)

Lecture Part I. Short Answer: define the following terms using 1-2 sentences and diagrams where appropriate (remember a picture is worth a thousand words)
(2 pts each x 11 = 22 pts total).

1. Cylindrical fold-

2. Overturned anticline

3. Monocline

4. Dip isogon

5. Kink fold

6. Penetrative Rock Fabric

7. Crenulation

8. Boudinage

9. Force

10. Stress

11. Negative normal stress

4. List three geometric elements that can be used to describe fold patterns in rock. (3 pts)

5. Compare and contrast between ductile deformation and brittle deformation (discuss processes and products of each). (3 pts)

6. Discuss the difference in meaning that is implied between the terms "antiform" and "anticline". Diagrams are required. (3 pts)

7. What are the two primary geometric components that form the basis for Ramsay's fold classification scheme? (2 Pts)

8. Discuss the difference between the fold processes of "bending" and "buckling". (4 pts)

9. Discuss the difference between flexure slip folding and flow folding processes. (2pts)

A. What is the difference between a similar and parallel fold (Ramsay's fold type 2 and 1B respectively)? (2 Pts)

B. Which type of the above fold processes and fold types would be dominant in the deformation of a shale layer vs. a sandstone layer? AND WHY? (2 Pts)

10. Discuss (with examples) the difference between foliation and lineation rock fabric. (4 pts)

11. Draw a 2-D diagram of an upright, non-plunging antiformal structure with several layers. With a colored pencil, draw a series of lines throughout the folded layers depicting the likely orientation of axial plane cleavage, if developed. (3 Pts)

12. What is the difference between a slickenside and a slickenline? Discuss the process of forming slickenlines on a fault plane. (4 pts)

13. What is the difference between a scalar quantity and a vector quantity?(3 pts)

14. Draw a 2-D diagram depicting a fault plane with a dip of 45 degrees. Draw an arrow representing a positive, vertical maximum principle stress (σ_1) acting on the fault plane. Perform a visual, generalized stress resolution showing the components of shear stress (σ_s) and normal stress (σ_n) operating on the fault plane (i.e. draw arrows and label the orientations of shear and normal stress). (4 pts)

15. Draw a generalized 2-D diagram of the stress "ellipse" with $\sigma_1 > \sigma_3$. (2 pts)

16. Draw a generalized 2-D diagram of the stress "ellipse" with $\sigma_1 = \sigma_3$. (2 Pts)

17. Draw a generalized schematic of the Mohr diagram. Label the axes of the diagram.

Draw an example Mohr circle on the diagram, labeling the points at σ_1 and σ_3 (depict σ_3 as negative and σ_1 as positive). (2.5 Pts) Drawing Here

Based on your diagram, answer the following:

A. Is σ_1 compressional or tensional? (0.5 Pt)

B. Is σ_3 tensional or compressional? (0.5 Pt)

C. By definition, what is the value of shear stress at σ_1 and σ_3 on the Mohr circle? (0.5 Pt)

D. In terms of shear stress, is a clockwise sense of rotation positive or negative? (0.5 Pt)

E. In terms of shear stress, is a counterclockwise sense of rotation negative or positive? (0.5 Pt)

Matching. Match the phrase on the right with the term on the left (25 Pts).

___ 1. Columnar joints	A. Ratio: stress/strain
___ 2. Pure shear strain	B. Term meaning perpendicular to
___ 3. Pi diagrams	C. Thermal contraction fractures
___ 4. Positive σs	D. Non-rotational, homogeneous deformation
___ 5. Paleomagnetism	E. Change in shape per unit time
___ 6. Hydrostatic Pressure	F. Active tension perpendicular to a surface
___ 7. North magnetic pole	G. Erosion / release fractures
___ 8. Young's Modulus	H. Involves plot of poles to beds on folds
___ 9. σ1	I. Example: a cube deformed into a rhombohedron
___ 10. Sheet Joints	J. Magnetic inclination = 90 degrees upward.
___ 11. Beta diagram	K. Force oriented parallel to axis of rock core
___ 12.Orthogonal	L. Ratio: extension/shortening
___ 13. Positive σn	M. Stress beyond which=permanent deformation.
___ 14. Brittle Failure	N. Active compression perpendicular to surface
___ 15. Simple shear strain	O. Magnetic inclination = 90 degrees downward.
___ 16. Negative σs	P. Deformation by loss of cohesion
___ 17. σ3	Q. Equal to σn, defines right edge of Mohr circle
___ 18. Ductile Failure	R. Counterclockwise shear sense
___ 19. South magnetic pole	S. Involves plot of great circles to beds on folds
___ 20. yield stress	T. Permanent deformation without loss of cohesion
___ 21. Polar wandering	U. Tectonic reconstruction in which plate = static
___ 22. Radial Stress	V. ratio: (L2/L1) - 1

___ 23. strain rate
___ 24. negative σn
___ 25. Axial stress

W. $\sigma 1 = \sigma 2 = \sigma 3$
X. Fossil magnetism acquired by rock at origin
Y. Clockwise shear sense
Z. Equal to σn, defines left edge of Mohr circle
AA. Force oriented perpendicular to axis of rock core
BB. Stress applied parallel to plate motion vectors
CC. Tectonic reconstruction in which mag. pole = static
DD. Term meaning parallel to
EE. $(\sigma 1 - \sigma 2)$

Essay. Succinctly answer the following questions. Use illustrations where necessary (50 Pts).

26. What is "compressive rock strength"? (4 Pts)

27. Define homogeneous strain and provide an example. (4 Pts)

28. What are the rheologic characteristics of plastic deformation? (4 Pts)

29. Define linear strain and provide examples. (4 Pts)

30. Using stress-strain diagrams, show the difference in deformation response between elastic and linear viscous (newtonian) materials. Label your diagrams (5 pts).

31. List three types of material objects that may be used to delineate strain in the geologic environment.

What is the basic assumption in using deformed material objects to determine the amount of strain? (5 pts)

32. Discuss the effect temperature has on the rheology and style of deformation that rocks will experience. (4 pts)

What is the primary controlling factor of rock temperature beneath the earth's surface?

33. With drawings, differentiate between the stress ellipse and the strain ellipse. How are the two interelated? (5 pts)

34. What is the difference between Mode I extension fractures and Mode I tension fractures? (5 Pts)

Draw a diagram for each showing the fractures in relation to sigma 1 and sigma 3. Include the sign and orientation of the stress fields with respect to the mode I fractures.

35. Draw a diagram showing the relative orientation of sigma 1 and sigma 3 to a set of conjugate shear fractures. Show the angle at which the conjugate shears form, and place the sign (+ or -) on each showing the sense of shear (5 pts).

36. Discuss two types of natural stress conditions that would influence rock bodies along a convergent (subduction) tectonic margin (5 pts).

True / Fasle. Place an "A" for True and "B" for False in the space to left of number (15 Pts)

___37. Axial surfaces of upright folds will be oriented perpendicular to the short axis of the strain ellipse, with the long axis of the strain ellipse parallel to the fold axis.

___38. Mode I extension fractures form parallel to $\sigma 1$.

___39. Mode I tension fractures form perpendicular to $\sigma 3$, and parallel to the short axis of the strain ellipse.

___40. Folding of rock is generally associated with brittle loss of cohesion, while fracturing is related to ductile transformation.

___41. "Stick-slip" deformation refers to the periodic build-up and release of stress along fracture planes (faults).

___42. If stress conditions of σs and σn lie outside of the Mohr Envelope, the rock mass will generally be stable, and not undergo brittle rupture.

___43. σ1 will be oriented parallel to the longest axis of the strain ellipse.

___44. Negative normal stress conditions are the most common in the natural rock environments below about 5 km depth.

___45. High internal pore fluid pressure in rocks effectively shift the Mohr circle to the left of the Mohr diagram.

___46. Tensile stress generally results in shortening of geologic reference lines.

___47. Volumetric strain is equivalent to linear strain in 3-dimensions.

___48. Water may behave as a plastic material at temperatures below 0 C (e.g. flowing glacial ice), and as a newtonian viscous fluid above 0 C (but below boiling point).

___49. This class was a royal pain in the ass from the word "go", but I know Mohr now than before I started.

___50. A mode I fracture may form from either positive or negative normal stresses.

___51. A perfect plastic material is one that will undergo permanent, recoverable deformation.

Lab Exam (63 Pts)

1. (5 Pts) Perform the following unit conversions Given:

1N = 0.225 lb1 N/m^2 = 1 Pascal (Pa) 1 MPa = 10^6 Pa 1MPa = 10 bars
1 Ft = 3.281 m 1 Ft = 12 in

A. 5 x 10^7 N = _____ lb
B. 3x 10^{14} N/m^2 = _____ Mpa
C. 3.8 x 10^3 mb = _____ bar
D. 53 N/m^2 = _____ lb/in^2
E. 1 x 10^{15} mb = _____ Mpa

2. (5 Pts) A steel cylinder with a mass of 6.5 x 10^{22} Kg is placed on a concrete pad with dimensions of 8m x 8m. g = 9.8 m/sec^2 . (show all your work)

A. What is the force exerted on the pad in N?

B. What is the normal stress applied by the steel cylinder to the concrete pad in Mpa?

4. (5 pts) Consider a fault plane with a dip of 90 degrees. The maximum principle stress operating on that plane (σ_1) is oriented vertical with a value of 200 MPa. The minimum principle stress operating on that plane (σ_3) is oriented horizontal with a value of 50 Mpa. Determine the resulting normal and shear stress components on that plane.

given equations:

Normal Stress Component: $\sigma_n = [(\sigma_1 + \sigma_3)/2] + ([((\sigma_1 - \sigma_3)/2) \text{ Cos } 2\theta]$
Shear Stress Component $\sigma_s = [(\sigma_1 - \sigma_3)/2] \text{ Sin } 2\theta$

5. (5 pts) Given a situation similar to 4 above, with a fault plane dipping 30 degrees, a shear stress of 150 Mpa, and a σ_1 = 50 Mpa. What is σ_3 in this situation???

8. (6 pts) A granite is in contact with a sequence of horizontal sedimentary layers (see map sketch below). In the spaces provided, draw three generalized cross-sections depicting the three different types of contacts that may exist between the granite and the sedimentary layers.

9. (5 pts) Use your stereonet to solve the following problem. A fault plane has a strike of 340 and dip of 60 SW. The fault intersects a sandstone bed that has a strike of 55 and dip of 70 NW. What is the trend and plunge of the line of intersection formed by the fault and sandstone bed? (show-label your work on tracing overlay).

trend _____ plunge_____

10. (5 pts) Use your stereonet to solve the following problem. A sandstone bed has a

known strike of N. 40 E. A quarry wall is oriented S 26 E, and the apparent dip of the sandstone on the quarry wall is 40 to the SE. Determine the true dip of the fault plane (show-label your work on separate tracing overlay).

true dip _____

11. (5pts) Use your stereonet to solve the following problem. A tilted meta-quartzite (metamorphosed sandstone) has a well-defined mineral lineation developed as a penetrative fabric. The strike of the quartzite is N 60 W, with a dip of 40 NE. The trend of the mineral lineation is N 30 W, with a plunge of 80 SE. What was the trend and plunge of the mineral lineation prior to tilting of the quarzite bed? (i.e. rotate the dip of the quarzite bed to horizontal and see what the orientation of mineral lineation was prior to folding). (show-label your work on separate tracing overlay).

trend _____ plunge _____

4. Along a railroad cut, a bed has an aparent dip of 35 degrees in a direction of N30W.

The bed strikes N50E. Using the trig. solution technique, find the true dip. (hint: here's

the formula...) (5 pts).

5. Using the graphical approach, complete the following exercise in the space below. A

sandstone bed has a strike of 70, and a dip of 45 NW. Draw and label a north line pointing to the top and parallel to the edge of the page. Draw a strike line with an azimuth of 70 degrees. Draw a dip line corresponding to a dip direction of NW. Use the dip line as a fold line. Fold the bed into the plane of the page and show the top of the bed with a dip angle of 45 degrees (6 pts).

6. Complete the following stereoplots using tracing paper and stereonets (12 Pts)

A. Strike: N 60 E Dip: 35 SE Plot plane as great circle.
B. Strike 327 Dip 78 SW Plot plane as great circle.
C. Strike N 60 E Dip: 75 SE Plot as pole to plane.
D. Trend: 185 Plunge: 35 S Plot as line.