National Exams

04-Geol-A4, Structural Geology

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. FOUR questions constitute a complete exam paper.
   There are choices in each main question (read instruction line)

4. Some questions require an answer in short answer or short essay format with figures as appropriate. Clarity and organization of the answer are important.

NAME:_____

QUESTION A 15 Marks

(1 mark per correct answer -0.5 marks for an incorrect answer blanks = 0)

Answer all of the following T (True) or F (False) <u>in the answer booklet</u> next to the number.

Answer 15 of these 20 questions (leave others blank) - First 15 answers will be marked.

1. A higher fracture frequency results in a decreased RQD
2. A Mohr circle represents the state of stress on one unique plane.
3. A viscous material continues to deform over time without an increase in stress..
4. At great depth, apparent friction angle decreases with increasing pressure.
5. Bedding thickness does not need to be preserved in a balanced section
6. Blocky veins indicate gradual and trans-tensional strain
7. Coaxial strain does not involve shear
8. Continental crust is normally thinner than oceanic crust
9. Dislocation creep is a viscous mechanism of volume reduction.
10. Elongation strain does not require the presence of tensile stress.
11. Flexural slip lineations are normally perpendicular to the fold axis
12. Fold thrust belts are associated with very high grade metamorphism
13. In a single outcrop, continuous joints are older than offset, discontinuous joints.
14. In active folding regions gold prospecting focusses on the fold limbs for ore potential.
15. Normal and reverse faults dip approximately parallel to the syntectonic σ_2
16. Softer rock units within a sequence will have fewer joints than stiff rock units
17. The apparent thickness of layered strata can be less than the true (normal) thickness.
18. The dip of the axial surface is normally less than the plunge of a fold axis.
19. Volcanic arcs are associated with subduction.
20. In overturned folds the younging direction is always up.

QUESTION B (2 marks each + 0.5 for style and clarity = 20 marks)

For **ANY and ONLY 8** of the following, in two ot three sentences (you may use clear sketches or stereonets where appropriate) describe and distinguish clearly between:
Answer in the answer booklet

1. Allocthon and Autocthon
2. Anticline and Monocline
3. Brittle and Ductile
4. Cleavage and Stretch Lineation
5. Cohesion and Friction
6. Equal Angle and Equal Area Projection
7. Fault Breccia and Cataclasite
8. Fault-Bend Fold vs Fold-Thrust Belt
9. Fold Plane and Hinge Line
10. Horst and Graben
11. Parallel Folding and Similar Folding
12. RQD and RMR
13. Simple Shear and Pure Shear
14. True Dip and Apparent Dip

QUESTION C (4 marks each + 1 for style and clarity 25 marks)

Answer **ANY and ONLY 5** of the following questions in reasonable detail (1/3 to 2/3 of a page in the answer booklet)

In addition, use Sketches where appropriate.

1. Describe four different primary structures which can be used for determining the younging direction. Explain with a figure how this is determined in each case.
2. Describe four types of structural traps key to the formation of hydrocarbon reserves.
3. Describe four typical components of a rockmass classification scheme for engineering geology. How does each element impact on excavation support requirements.
4. Describe four failure modes in slopes or tunnels associated with joint sets or intersecting joints. How would you mitigate each mode?
5. Describe and illustrate with a diagram at least 4 types of brittle structures associated with simple active folding of competent strata
6. Describe how confining pressure (depth), temperature, strain rate, and the presence of fluids affects the strength and ductility of geomaterials.
7. Describe two large scaled structural features and one small scale or microscopic feature of extensional, compressional, and strike slip shear terrain.
8. Explain with text and figures the formation of undulose extinction, subgrain boundaries and mechanical twinning.
9. Using a Mohr diagram and a complete Mohr-Coulomb strength envelope, illustrate the mechanics of cyclical fault pumping due to fluid pressure. Describe the nature of the resultant vein infilling.

QUESTION D (15 marks)

ONE and ONLY ONE of the following (D-I or D-II)

Place Answers here and in Answer Booklet as appropriate.

D-I

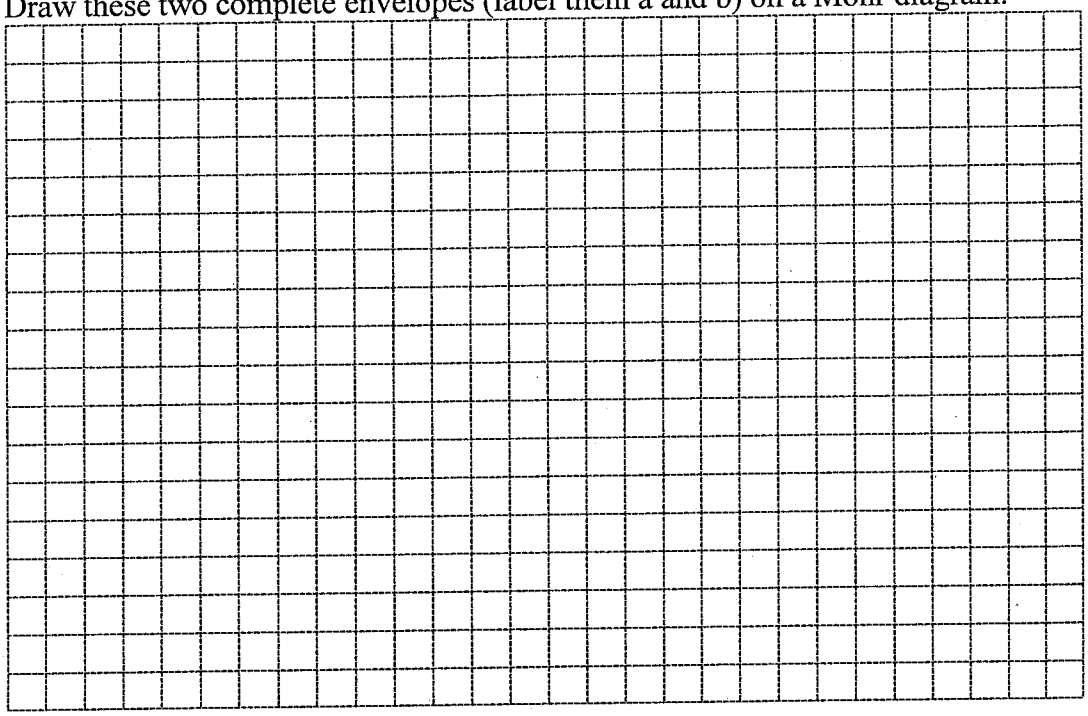
A typical granite (S.G. = 2.7) has a Mohr-Coulomb strength envelope corresponding to

a) $\tau_{max} = 50MPa + \sigma_n \tan 45°$, Tensile strength is tested to be 10 Mpa

Rough pre-existing joint surfaces dipping 45 degrees to the north in this limestone have been tested in direct shear to have the following strength:

b) $\tau_{max} = 5MPa + \sigma_n \tan 30°$

1) Draw these two complete envelopes (label them a and b) on a Mohr diagram.



The stresses at depth are anisotropic isotropic (k=2). Consider a point in the centre of a horizontal tunnel roof. Due to stress concentration, the maximum stress (σ_1) parallel to the roof and oriented perpendicular to the tunnelling direction is known to be (3k-1) times the initial rock vertical stress (existing before the tunnel is built).

2) For a tunnel situated at 400m depth, draw the Mohr circle for the in situ (initial) stress state (label c), for a vertical plane striking perpendicular to the tunnel (label d)

3) What is the depth at which <u>new</u> fractures will form near the wall of a horizontal circular tunnel in this rock?

4) At what depth would the existing fractures be remobilized in the centre of the roof.

Show work here or in your workbook.

NAME:_____

D-II Answer the questions below with words, numbers or a sketch as requested:

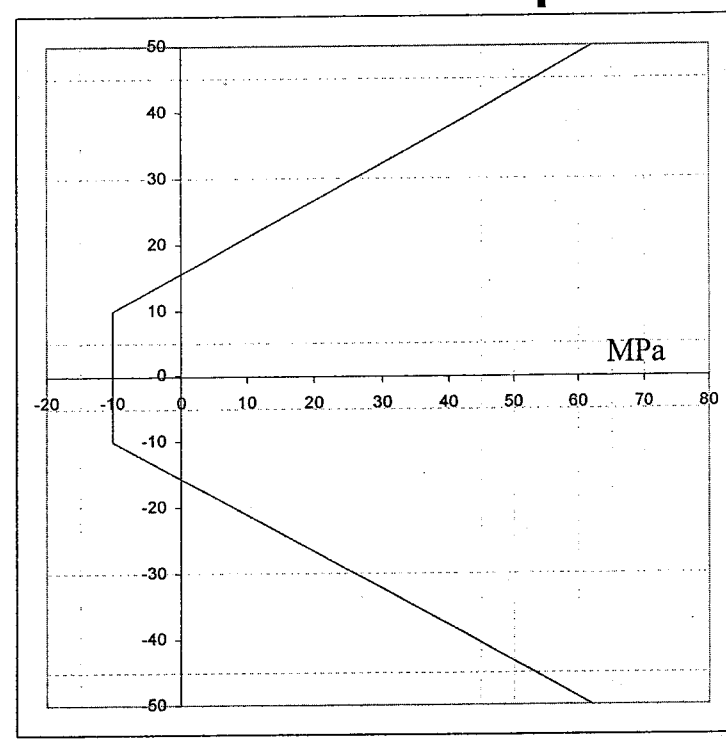
The following plot shows a complete Mohr-Coulomb Yield Criteria for Intact Rock (Dry).

a) **Estimate or Calculate (give numbers), Illustrate** on the figure and **Label** on the plot, the 3 KEY STRENGTH PARAMETERS (material strength constants).

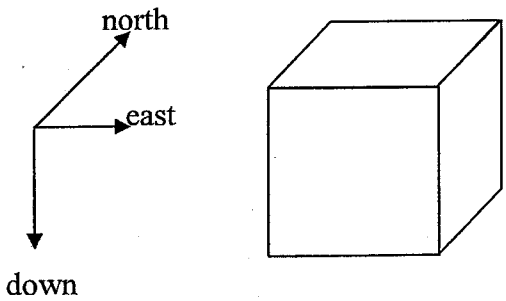
b) Sketch one Mohr circle for <u>rock failure</u> under Uniaxial Tension 

c) Sketch one Mohr circle for <u>rock failure</u> under Confined ("Triaxial") Compression 

d) Draw the shear strength envelope for a continuous and fully formed planar joint surface with the same frictional strength as the intact rock.



e) For a limestone rockmass with a N-S horizontal principal stress $0.5x\sigma_{vertical}$ and a E-W principal stress equal to the average volumetric pressure at this point. DRAW the and label Principal 3D stress tensor at a depth of 3000m.
Label the calculated stresses:



f) i) What is the maximum shear stress (MPa) on any planes through this point? _____?

ii) What is the common dip of these (maximum shear) planes? _____?

g) What is likely to form if the pore water pressure here is 45 MPa_____?
Give a likely orientation for these structures (sketch above)

NAME:_____

QUESTION E (10 marks)

ONE and ONLY ONE of the following (E-I or E-II) Place Answers here

E-I On the following stereoplot, DRAW, IDENTIFY and SOLVE for :

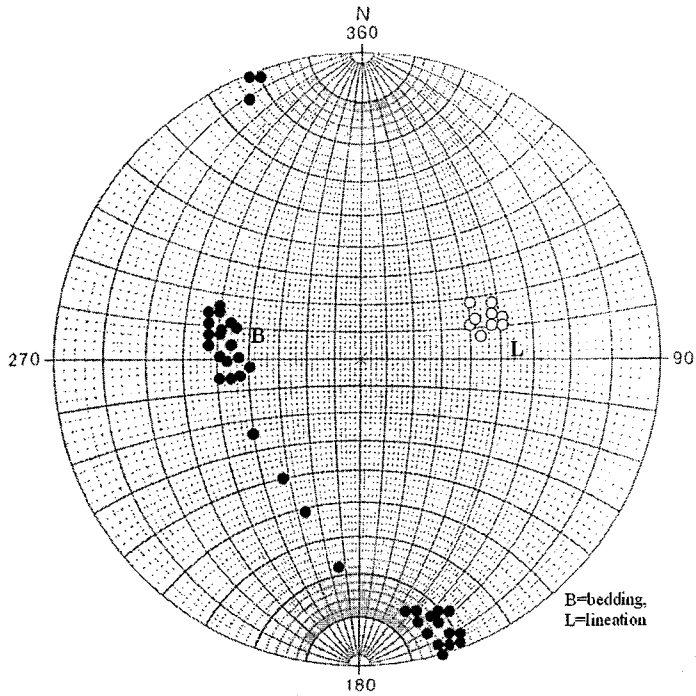
a) Fold Axis: label and give approximate <u>trend</u>

b) Profile plane: label and give approximate <u>strike and dip (estimate)</u>

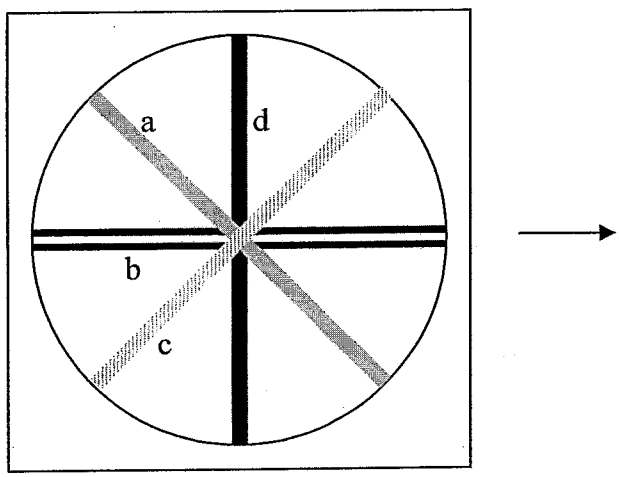
c) Axial plane: label and give approximate <u>strike</u>

d) Apparent dip of the profile plane on a vertical cliff striking 180

e) Describe the fold completely (using three standard terms)



E-II a) Sketch the following reference object (square, circle, lines) <u>AFTER</u> deformation.
b) Label all lines and illustrate the most likely deformed states
Folding, Boudinage, Stretching, etc
The deformation can be described as: Plane strain (in the plane of the page)
Simple shear of 45 degrees (dextral) about the horizontal.
Assume: Lines a, b and c represent dykes that are more competent than the ductile Host and that Line d represents a material that is identical to the host.
c) After deformation label the axis of minimum finite stretch (Label accordingly)



BEFORE AFTER

NAME:_____