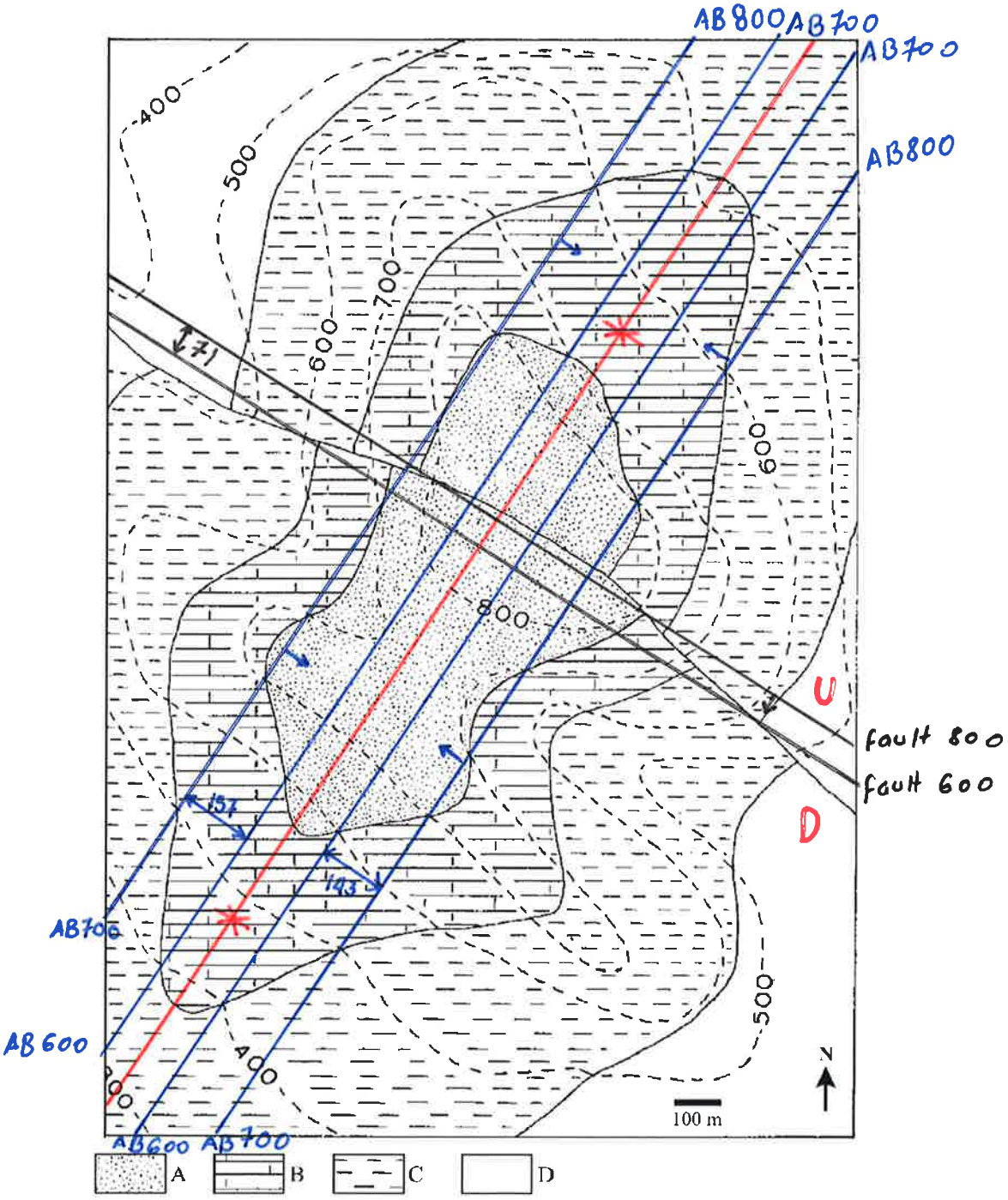
Student Name: NESTOR

GEO210 Structural Geology
Final test. November 21, 2018

This test is closed book and closed notes. You have two hours to complete the test. Please be sure to show all your work. The total value of the test is 100 points. The point value of each question is shown.

Question 1 (20 points) The map below shows four conformable lithological units A, B, C, and D. Contours are elevation.



: syncline

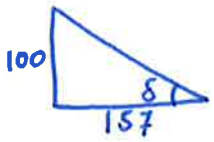
→ : Dip Direction

Student Name: Nestor

As you can tell from the outcrop pattern, the units are folded and faulted.

a. What is the strike and dip of the western limb of the fold?

033/32° (RHR)

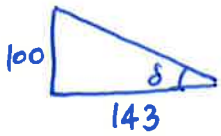


$\delta = \text{atan}\left(\frac{100}{157}\right)$

$\delta = 32°$

b. What is the strike and dip of the eastern limb of the fold?

213/35° (RHR)



$\delta = \text{atan}\left(\frac{100}{143}\right)$

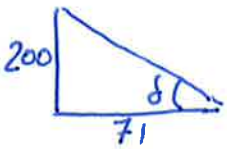
$\delta =$

c. What kind of fold is this? Mark the axial trace of the fold on the map together with the correct symbol to indicate the kind of fold.

Syncline. Axial trace ✳ in map.

d. What is the strike and dip of the fault?

122/70° (RHR)



$\delta = \text{atan}\left(\frac{200}{71}\right)$

$\delta = 70°$

e. Mark the Up (U) and Down (D) thrown blocks of the fault on the map. What kind of fault is this?

Northern block is up (older units)
Southern block is down
Fault dips south

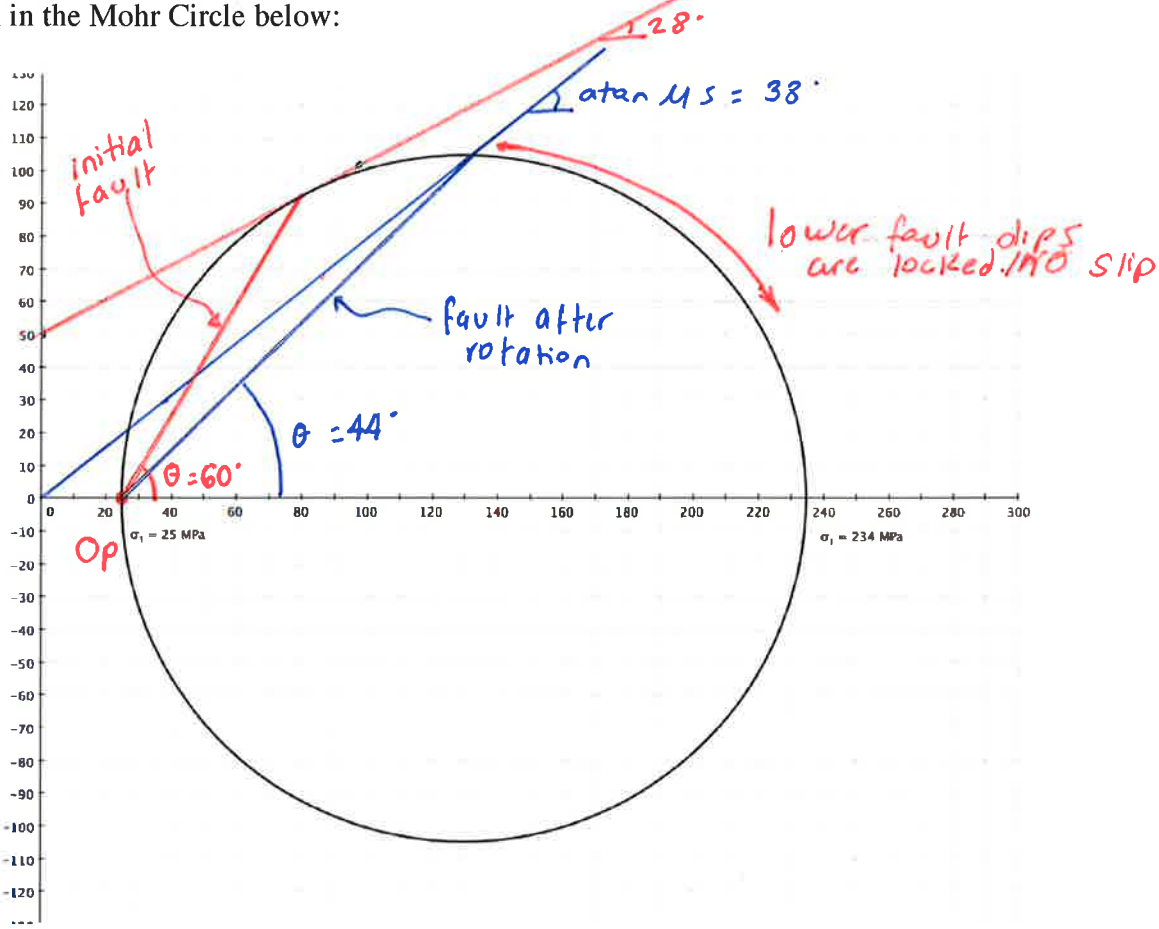
} The fault is normal
i.e. Normal fault

f. What is the throw of the fault?

100 m (the southern block is 100 m downthrown)

Student Name: Nestor

Question 2 (20 points): In a region of intracontinental rifting, the extension occurs via domino faulting. In this area, the angle of internal friction ϕ_i is 28°, the coefficient of sliding friction μ_s is 0.8, the density is 2600 kg/m^3 and the cohesion c is 50 MPa. The state of stress is shown in the Mohr Circle below:



a. How deep in the crust would you expect to find the vertical stress represented on the Mohr Circle? **(5 pts)**

The vertical stress is 234 MPa = $\rho g z$

$234 e^6 Pa = 2600 \cdot 10 \cdot z$

$9 Km = z$

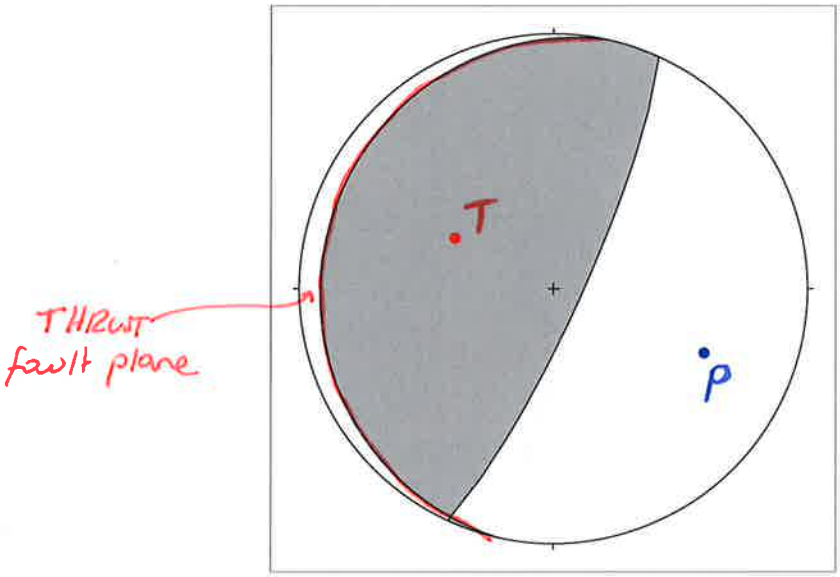
b. Using the Mohr circle, determine how much the domino faults will rotate before they become inactive and new sets of faults begin to form **(15 pts)**. **Hint:** *You need to draw the two failure envelopes on the Mohr circle, one for the formation of new faults, and another one for sliding on pre-existing faults (zero cohesion). From the intersections of these two envelopes with the Mohr circle, you can extract the dip angle at fault formation, and the minimum dip angle after domino rotation.*

In rifting, normal fault regime, σ_1 is vertical and σ_3 is horizontal. The pole of planes for this situation is at σ_3. O_p

At fault formation the dip angle is ≈ 60°. After max fault rotation, the dip angle is 44°. Therefore the domino faults will rotate 16° before they become inactive.

Student Name: Nestor

Question 3 (20 points): The figure below shows the focal mechanism solution for the 2011-03-11, M9.1, Tohoku, Japan earthquake, at the subduction zone interface between the subducting Pacific plate and the overriding Eurasia plate. This was a devastating earthquake with a least 17,703 people killed.



a. What style of faulting is depicted by the beachball diagram?

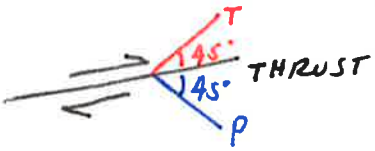
Thrust regime
Reverse fault

b. Mark the fault plane in the figure. What is its approximate orientation (strike/dip)?

Since this is the interface of the subduction zone, I would expect the fault to be low angle (THRUST). This also fits the large earthquake magnitude. Approximate orientation: 190/10 (RHR)

c. Label the P and T axes in the figure. In a cross section perpendicular to the strike of the fault, what are the angles that the P and T axes make with the fault plane?

T and P make 45° with the fault plane.



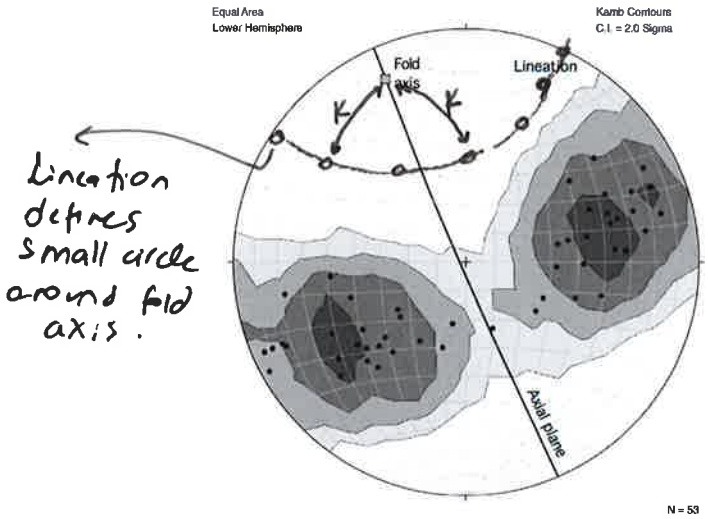
d. Earthquake seismologist refer to the P and T axes as pressure and tension, respectively. But what are exactly these axes in terms of strain?

These are the maximum (T) and minimum (P) axes of the infinitesimal strain tensor.

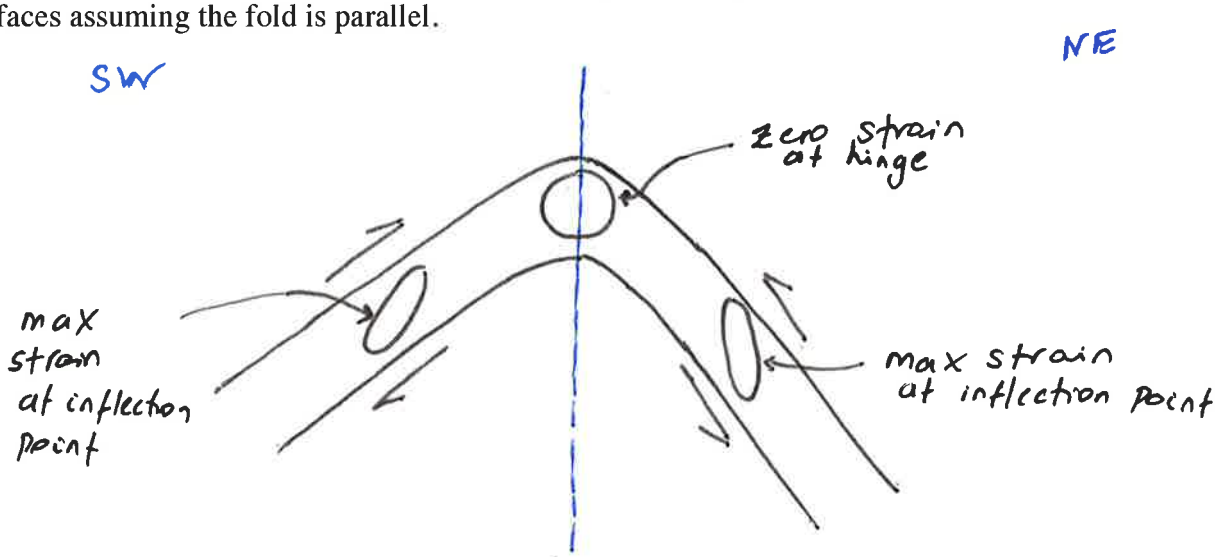
T: infinitesimal extension
P: infinitesimal shortening

Student Name: Nestor

Question 4 (20 points): The stereonet below shows Kamb contours of poles to bedding in an anticline. The anticline's fold axis (square) and axial plane (great circle) are also shown.



a. Sketch the profile view of the anticline including its axial plane. Do these for two bed surfaces assuming the fold is parallel.



b. Minor fault planes with striae and sigmoidal veins indicate layer parallel slip in the anticline. In your diagram above indicate the sense of slip in the limbs of the anticline.

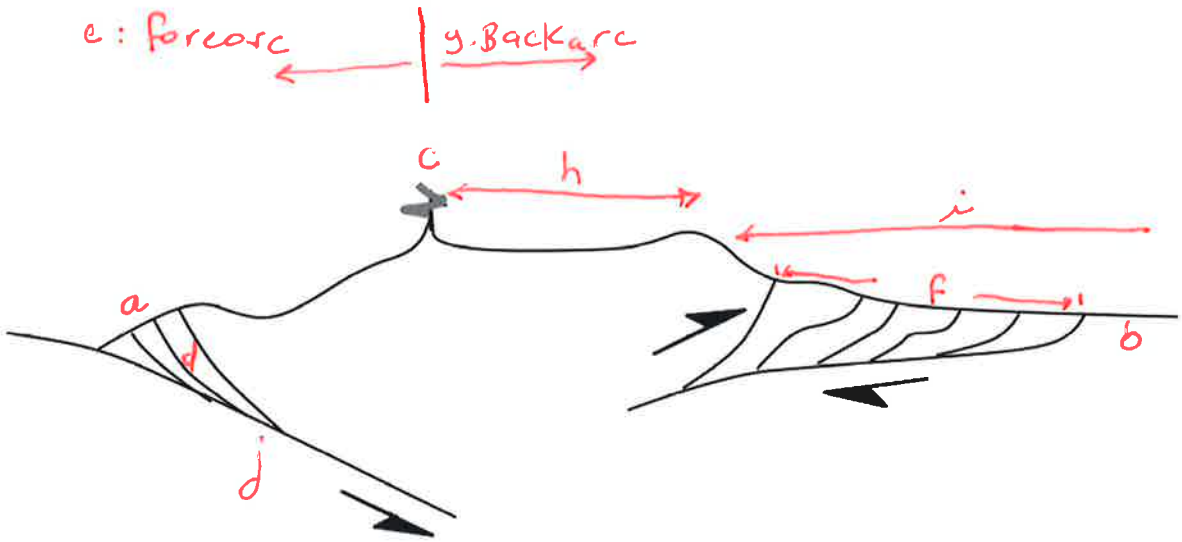
c. Using strain ellipses indicate the distribution of strain in your diagram above.

d. A pre-folding lineation (diamond in stereonet) was measured in one bed of the anticline. How would you expect the orientation of that lineation to be throughout the anticline?

If layer parallell slip, there is no strain on the bed surface. The angle between the lineation and the fold axis should be constant on the bed. The lineation will define a small circle with center in the fold axis. See Stereonet.

Student Name: Nestor

Question 5 (20 points): The Central Andes are the type example of a mountain belt formed at a plate boundary where oceanic crust is being subducted beneath continental crust. The figure below is a sketch cross section of this area.



Show in the cross section above the following elements:

a. Trench
b. Foreland basin
c. Arc
d. Accretionary wedge
e. Forearc
f. Foreland fold and thrust belt
g. Backarc
h. Hinterland
i. Foreland
j. Oceanic plate