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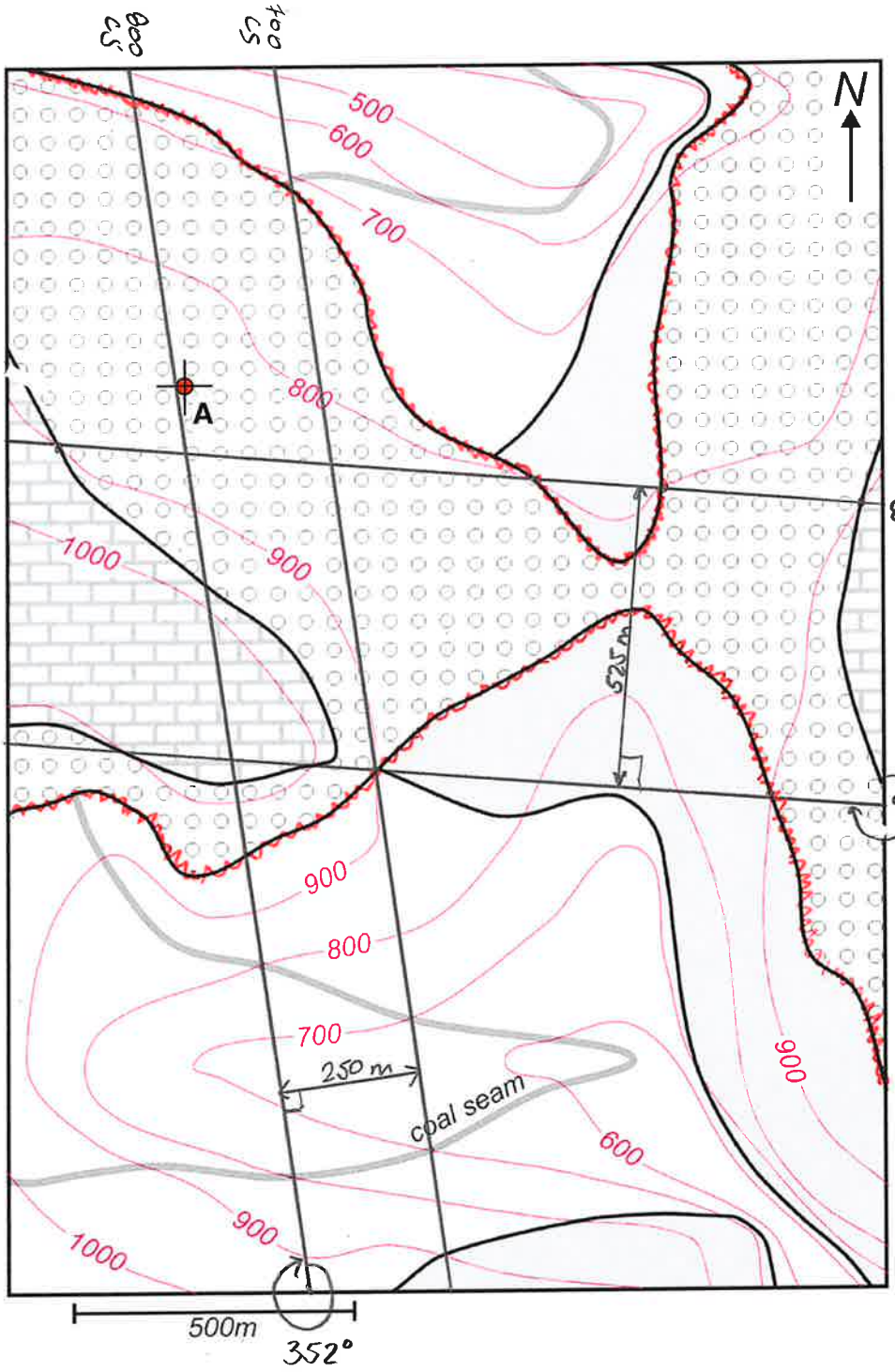
GEO210 Structural Geology
Midterm test. October 6, 2020

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

Question 1 (20 points): From the geologic map and elevation contours below:



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a. Indicate on the map the outcrop of the unconformity.

See figure ~~~ = unconformity

b. Determine the strike and dip of the coal seam.

Strike: 352

Right hand Rule

Dip: $\text{atan}\left(\frac{100\ m}{250\ m}\right) = 22°$

c. Determine the strike and dip of the unconformity.

Strike: 273

Right hand Rule

Dip: $\text{atan}\left(\frac{100\ m}{525\ m}\right) = 11°$

d. Would borehole A encounter the coal seam? If so, at which depth? If not, why not?

No, Unconformity is LOWER than coal seam

The coal seam is eroded at this location!

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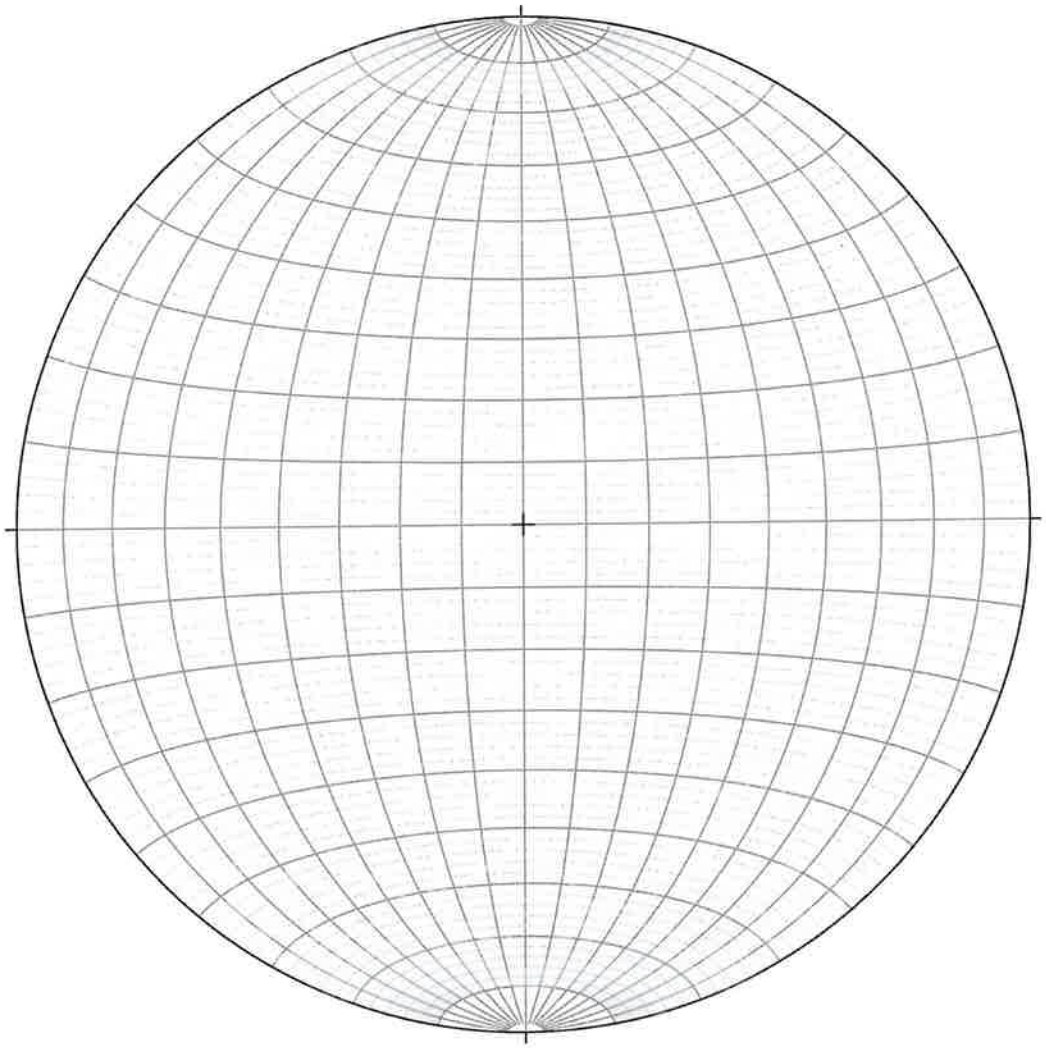
Question 2 (20 points): Solve the following problem with the stereonet: On an **overturned** bedding plane with strike and dip 310/70 (right hand rule), groove casts[1] have a trend and plunge of 341/54. Determine the original trend of the groove casts when the bed was deposited (this is the paleocurrent direction).



Equal area net

[1] Groove casts are straight parallel ridges on the bedding surface. They are formed by the filling in of grooves (narrow cuts or depressions) in the sediment. They are parallel to the current direction.

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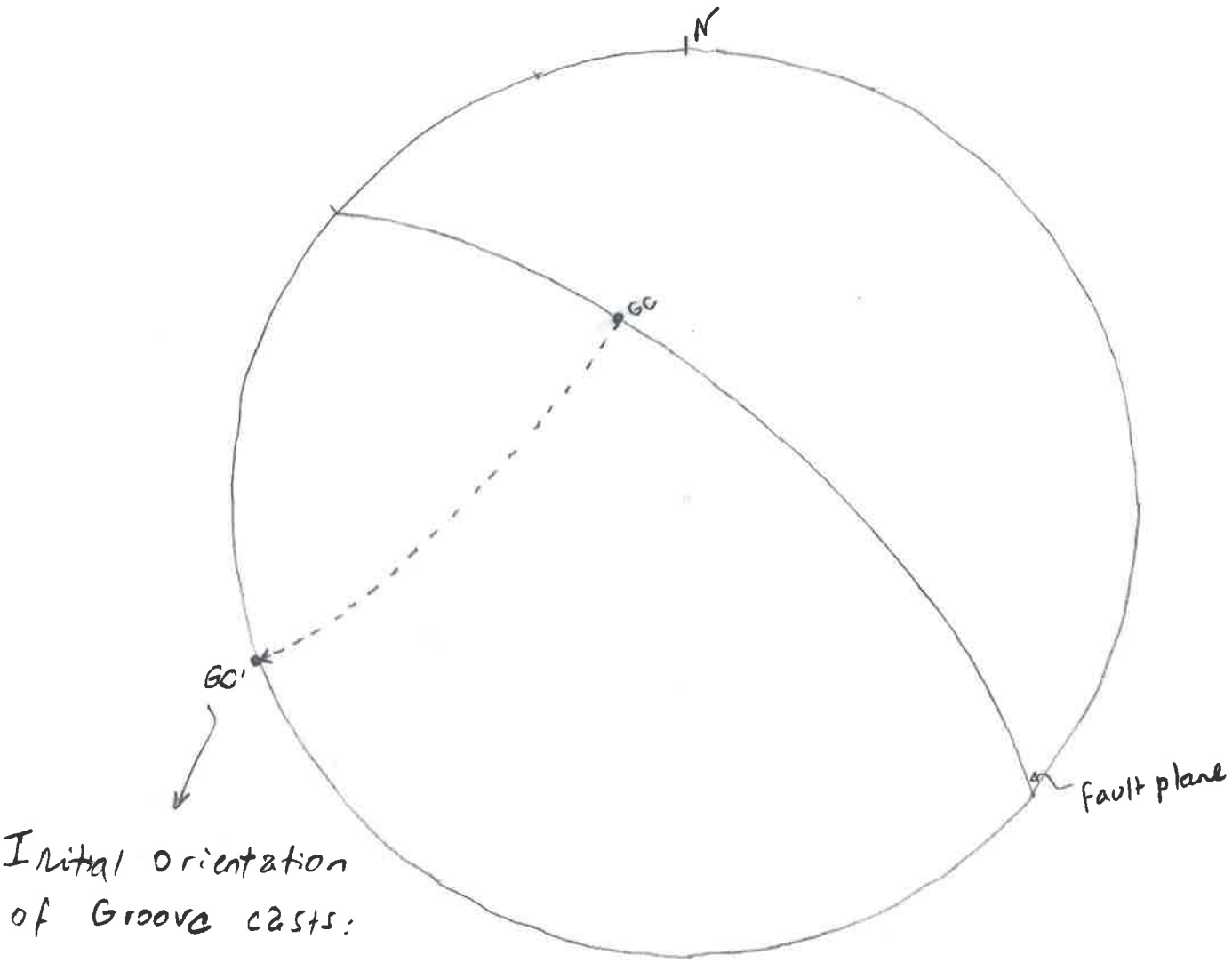

Initial orientation of Groove casts:

070 - 250.

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Question 3 (20 points): Explain how to solve the following problems using linear algebra. Use maximum four sentences in each case.

(a) Stratigraphic thickness of a unit given points with geographic coordinates (e.g. east, north, up) on the top and base of the unit.

- Convert points from ENU to Strike-Dip-Pole (SDP) coordinate system
- The thickness of the unit is the difference in P coordinates of points on top and base of the unit.

(b) Outcrop trace of a bedding contact given the strike and dip of the contact, the coordinates of a point where the contact outcrops, and a digital elevation model (DEM) of the terrain.

- Convert ENU coordinates of outcrop point to Strike-Dip-Pole (SDP) coordinates
- Do the same for every point of the DEM grid
- Compute difference between Pole coordinate of outcrop point and pole coordinate of every point in DEM grid
- The plane outcrops where this difference is Zero. i.e. Contour the Zero value of this difference

(c) Rotation of groove casts (GC) on a dipping bed, to determine the orientation of the current at the time of deposition of the bed.

- Rotate GC about the strike line of the bed, an amount equal to the bed's dip, to bring the bed and the GC to the horizontal
- The transformation matrix a for this rotation depends on the trend and plunge (T & P) of the strike line, and the amount of rotation (w = bed's dip)
- Transform the groove casts vector $g'_i = a_{ij} g_j$
- Return g' to spherical coordinates: Trend and plunge

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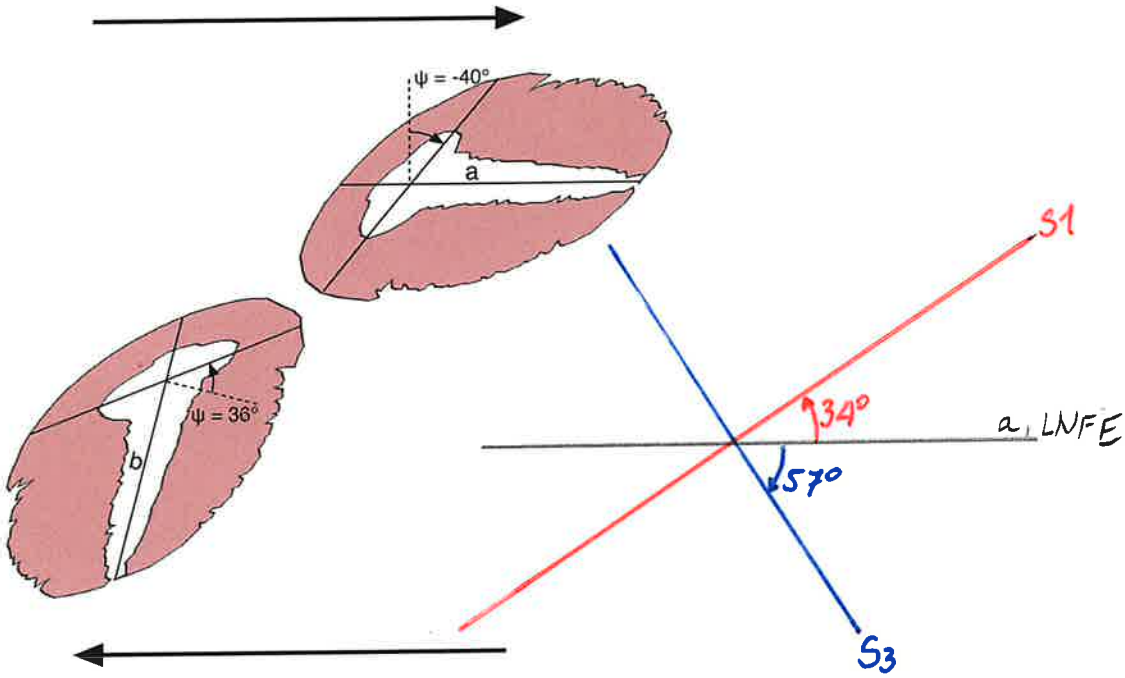
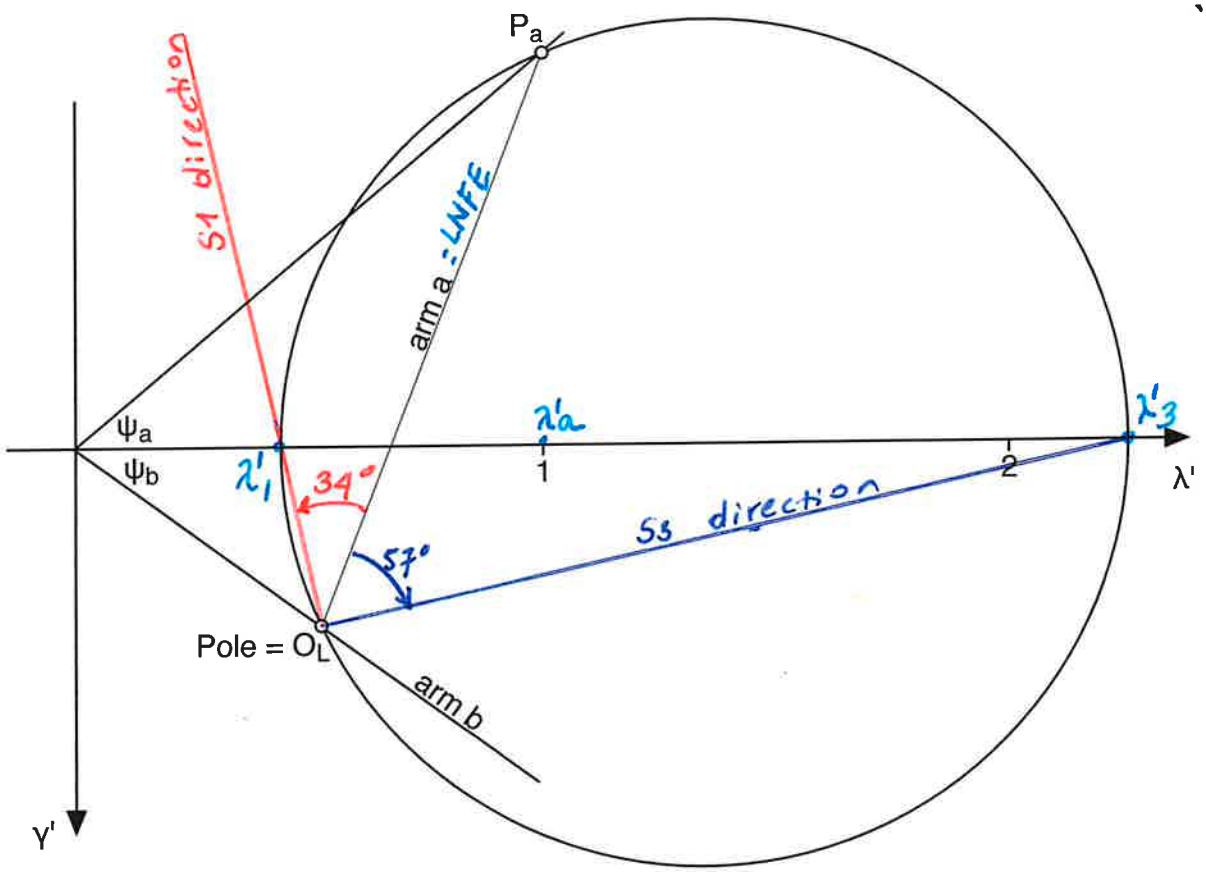
Question 4 (20 points): Two trilobites (figure below) have experienced angular shear (ψ) that has distorted the symmetry typical of undeformed specimens. The Mohr circle for this deformation is also shown.





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a. If the trilobites were deformed by right-lateral (clockwise) simple shear and if the median line of trilobite **a** is parallel to the shear zone (see figure), what is the stretch of line **a**?

line a is a line of no finite elongation (LNFE). It's stretch is 1.0

b. What are the values of the maximum and minimum principal stretches (S_1 and S_3)?

From the Mohr circle $\lambda'_1 = 0.44$ and $\lambda'_3 = 2.24$

Therefore: $\lambda_1 = \frac{1}{\lambda'_1} = 2.27$ $\lambda_3 = \frac{1}{\lambda'_3} = 0.45$

$S1 = \sqrt{\lambda 1} = 1.51$

$S3 = \sqrt{\lambda 3} = 0.67$

c. Draw on the plane of the trilobites the S_1 and S_3 directions.

See Drawing on previous page

d. Suppose that there is not strain in the direction perpendicular to the plane of the trilobites. What is the volumetric stretch Δ[2]? Is the deformation volume constant?

$\Delta = S1 \times S2 \times S3$

$\Delta = 1.51 \times 1.0 \times 0.67 = 1.01$

This is approximately equal to 1, so the deformation is volume constant.

[2] Recall that $\Delta = S_1 * S_2 * S_3$

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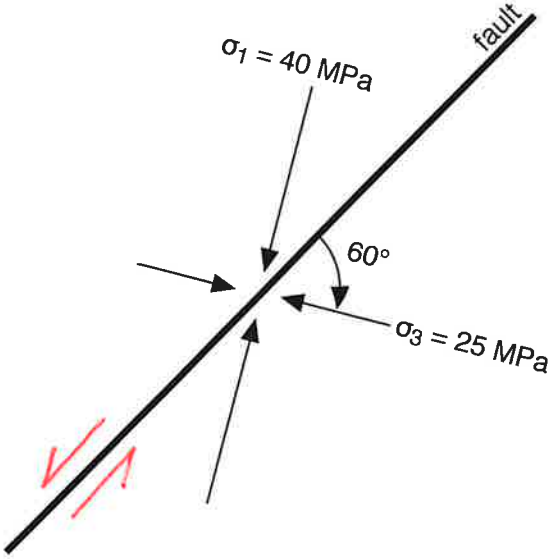
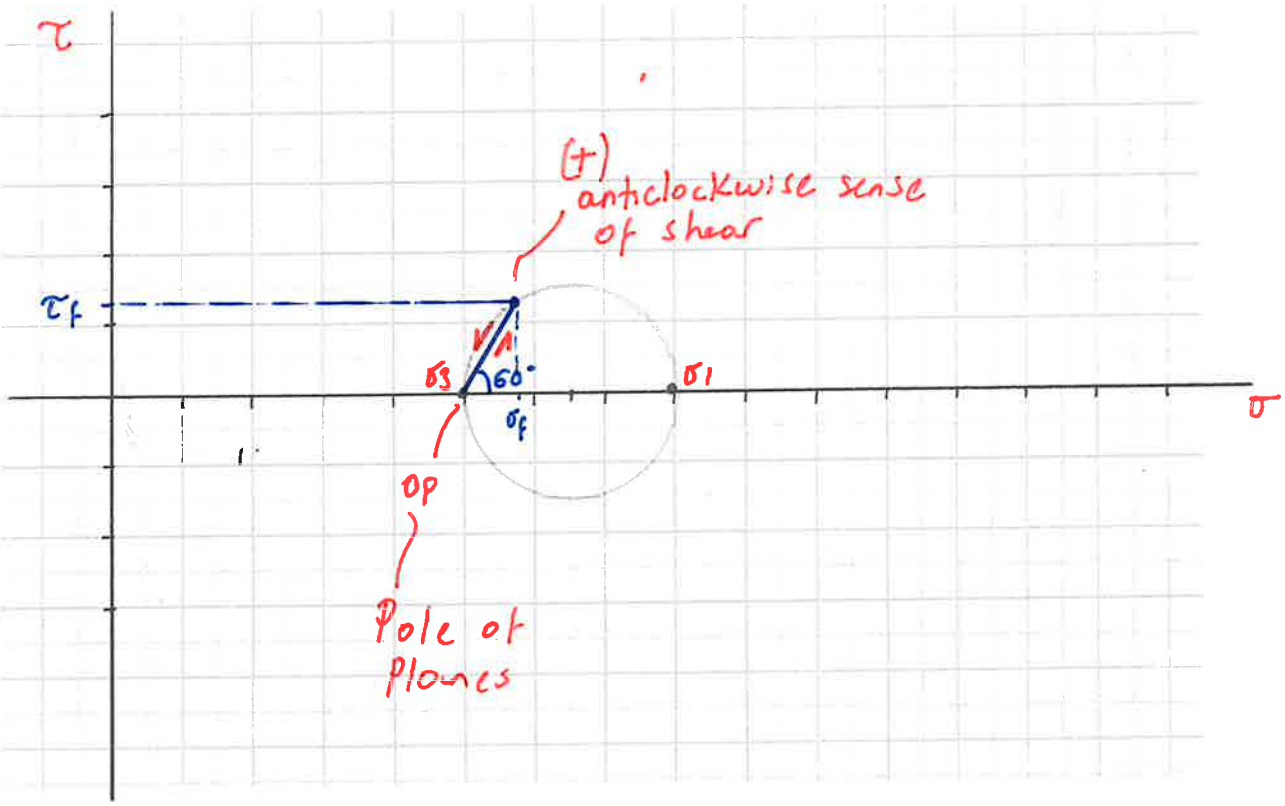
Question 5 (20 points): a. Using the Mohr Circle, determine the normal and shear tractions acting on the fault plane below. Use the graph paper below to draw the Mohr Circle . **b.** If the fault blocks move, what kind of fault is this?



Normal fault



σ_f = 28 MPa
τ_f = 7 MPa