Lab 5 Spherical Projections

Use a separate piece of paper for each exercise, and include printouts of your Matlab work. 103 pts for Ex. 1-4; 124 points for Ex. 1-5.

Exercise 1: Plots of lines **(30 points total)**

Plot and neatly label the following lines on an equal angle projection:

Line	Trend **(1 point each)**	Plunge **(1 point each)**
A	320° (N40°W)	4°
B	210° (S30°W)	10°
C	85° (N85°E)	30°

Draw with a light line the cyclographic traces of the three planes containing the three pairs of lines (**1**), determine the angles between the lines (**1**), and label the angles on the stereographic plot (**1**).

Lines	Angle in degrees **(3 points each)**
A & B	
B & C	
C & A	

Now check your results using dot products of unit vectors along the lines. First find the direction cosines for each line using Matlab.

Line	α **(1 point each)**	β **(1 point each)**	γ **(1 point each)**
A			
B			
C			

Now take the dot products of the vectors (as represented by their direction cosines) and use the arccosine function to find the angles between the lines (remember to convert to degrees)

Lines	Dot product **(1 point each)**	Angle (°) **(1 point each)**
A & B		
B & C		
C & A		

<u>Exercise 2: Plots of planes</u> **(29 points total)**

Plot and neatly label the following planes (strike and dip follow right-hand rule convention) and the poles to those planes on an equal angle projection. Use a fairly heavy line to designate the planes. 2 pts for each pole calculation, 2 pts for each feature plotted, 1 pt for each label; 16 pts total.

Plane	Plane strike (°)	Plane dip (°)	Pole trend (°) **1 pt each**	Pole plunge (°) **1 pt each**
F	256°	22°		
G	68°	72°		

Plane	Plane plot **2 pts each**	Pole plot **2 pts each**	Plane label **1 pt each**	Pole label **1 pt each**
F				
G				

Draw with a light line the cyclographic trace of plane Q, which containing the poles (**1 pt**), determine the strike and dip of plane Q (**2 pts**), the angle between the poles (**1 pt**), and label the angle on the stereographic plot (**1pt**). 5 pts total.

Trace of Q 1 pt	Strike of Q (°) 1 pt	Dip of Q (°) 1 pt	Angle between poles (°) **1 pt**	Angle label 1 pt

Now check your results using dot products of unit vectors along the lines. First find the direction cosines for each pole using Matlab. 6 pts total.

Line	α **(1 point each)**	β **(1 point each)**	γ **(1 point each)**
Unit pole to plane F			
Unit pole to plane G			

Now take the dot products of the unit normals, and use them with Matlab's acos function to find the angles between the lines (remember to convert to degrees). 2 pts total.

Poles to planes...	Dot product **(1 point)**	Angle (°) **(1 point)**
F & G		

Exercise 3: Intersection of planes problem (fold axes) **(19 points total)**

Using a β-plot (direct intersection of planes), determine the trend and plunge of the fold axis for a cylindrical fold by plotting the bedding attitudes listed below and finding the trend and plunge of the line of intersection.

Bed	Strike **(1 point each)**	Dip **(1 point each)**
E1	84°	60°S
E2	117°	90°

Fold axis trend **(1 point)**	Fold axis plunge **(1 point)**

Now check your results using vector algebra. First find the direction cosines for each pole using Matlab

Line	α **(1 point each)**	β **(1 point each)**	γ **(1 point each)**
Pole to E1 **(n1)**			
Pole to E2 **(n2)**			

Now take the cross product of the unit normals, and find the trend and plunge of the vector that is produced. Give the three Cartesian (xyz) components of the cross product. Then use cart2sph to convert the Cartesian coordinates to spherical coordinates (trend, plunge, radial distance). Do not give an answer with a negative plunge, and give the angles in degrees, not radians.

n1 x n2 **(3 points total)**	Cross product trend (°) **(2 points)**	Cross product plunge (°) **(2 points)**
, ,		

Exercise 4 **(25 points total)**

First find the orientations of the poles to bedding, plot the poles, and then use a π-plot (poles to bedding) to determine the trend and plunge of the fold axis for a cylindrical fold. Show the cyclographic trace of the plane containing the poles in a light line

Plane	Strike	Dip	Trend of pole **2 points each**	Plunge of pole **2 points each**
F1	345°	40°E		
F2	213°	68°W		

Fold axis trend **(2 point)**	Fold axis plunge **(2 point)**

Now check your results using vector algebra. First find the direction cosines for each pole using Matlab (you can use

Line	α **(1 point each)**	β **(1 point each)**	γ **(1 point each)**
Pole to F1 **(n3)**			
Pole to F2 **(n4)**			

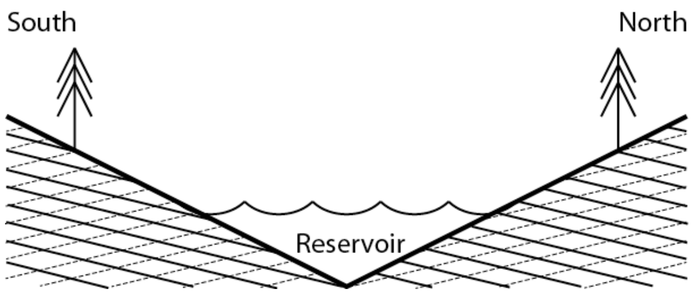
Now take the cross product of the unit normals, and find the trend and plunge of the vector that is produced. Give the three Cartesian (xyz) components of the cross product. Then use cart2sph to convert the Cartesian coordinates to spherical coordinates (trend, plunge, radial distance). Do not give an answer with a negative plunge, and give the angles in degrees, not radians.

n3 x n4 **(3 points total)**	Cross product trend (°) **(2 points)**	Cross product plunge (°) **(2 points)**
, ,		

Exercise 5 (**21 points total**)

Slope stability sliding block problem

Bedding or fractures that dip parallel to a slope form what is called a "dip slope" and commonly pose slope stability problems. When the weak surfaces dip in the same direction as the slope but at a slightly shallower angle, they intersect the slope and are said to "daylight". The cartoon cross-section below shows two sets of weak surfaces that daylight. The dashed surfaces inclined to the south daylight on the north slope, but not on the south slope. In contrast, the (solid) surfaces inclined to the north daylight on the south slope but not on the north slope. So one set of weaknesses poses a slope stability hazard on one side of the reservoir, and the other set poses a potential hazard on the other side.



In a wedge failure, a fracture-bounded block slides down along the direction where weak surfaces intersect. A wedge failure can occur where the plunge of the line of intersection is less than the apparent dip of a slope as seen in a cross section along the trend of the intersection of the weak surfaces (see diagram on the next page).

Suppose three sets of fractures are present in the bedrock along the shores of a reservoir.

Set	Strike	Dip
1	0°	40°E
2	96°	30°S
3	264°	22°N

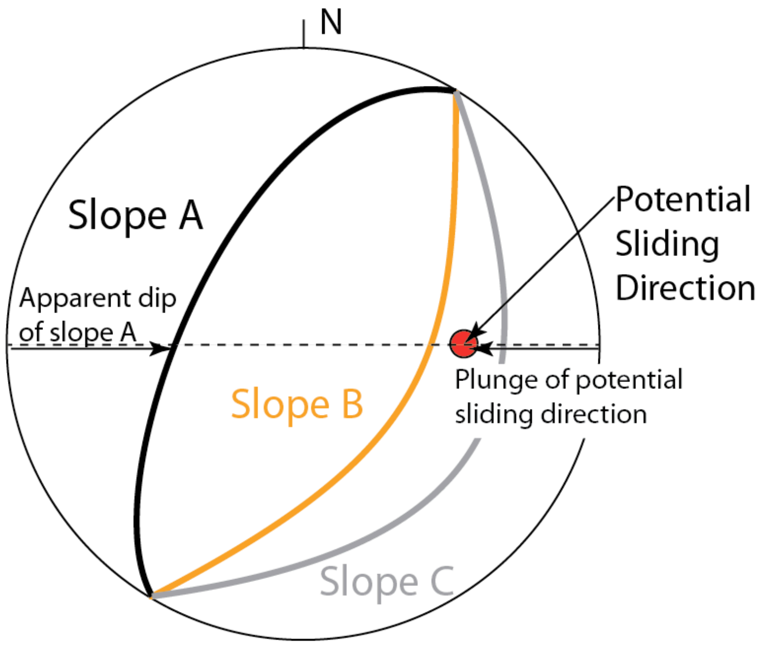
On the north side of the reservoir the ground surface slopes due south at 30°. On the south side of the reservoir the ground surface slopes due north at 45°. Plot the orientations of (a) the valley slopes, (b) the fractures, and (c) the fracture intersections on an equal-angle projection. After considering the geologic and topographic information, do any of pose a potential wedge failure hazard to the reservoir? Which ones? On which slopes? Why?

Scoring: **2 points for slope planes for the valley walls = 4 points total**
2 points for each of the three weak surfaces = 6 points total
2 points for each of the three intersections = 6 points total
5 points for discussion

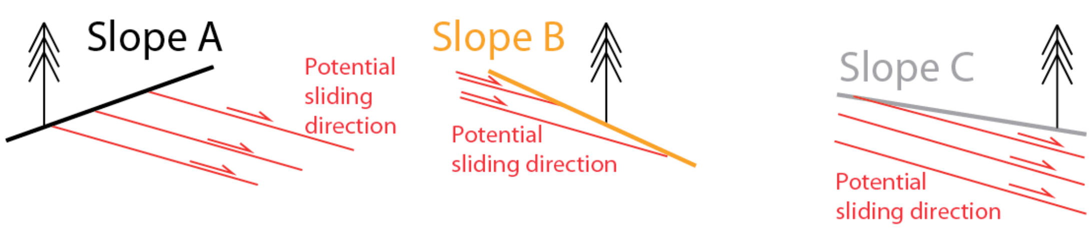
The following diagram might be helpful for visualizing the problem. In the diagram, the potential sliding direction is assumed to be to the east. Three slopes are considered:

A) Slope A (slopes to the northwest).
B) Slope B (slopes to the southeast, with an apparent dip to the east that is greater than the plunge of the potential direction of sliding).
C) Slope C (slopes to the southeast, with an apparent dip to the east that is less than the plunge of the potential direction of sliding).

Of these cases, only slope B has conditions that pose a potential sliding hazard, as the three cross sections show.



East-West Cross Sections Showing Apparent Slopes and a Potential Sliding Direction



Apparent dip of slope A is opposite potential slide direction (red). Sliding would be into slope. Not a sliding problem.

Apparent dip of slope B is in slide direction (red) and is steeper than plunge of slide direction. Sliding would be out of slope. Potential sliding problem.

Apparent dip of slope C is in slide direction (red) and is gentler than plunge of slide direction. Sliding would be into slope. Not a sliding problem.

EQUAL-ANGLE NET
(WULFF NET)