FOLDS

I Main Topics

- A Curvature
- B Some causes of folding
- C Fiber strains
- D Classification of folds

II Curvature

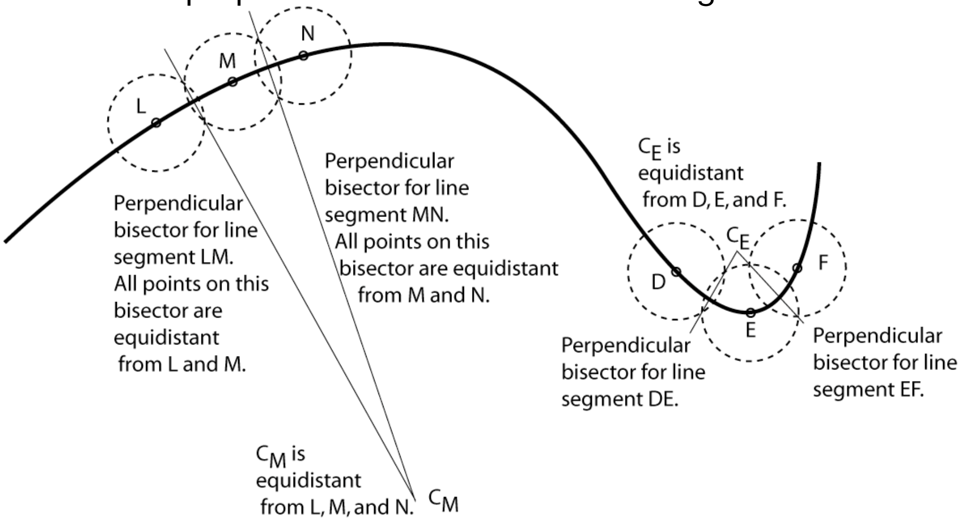
- A Folds: surfaces along which the curvature has <u>changed</u>, at least locally
- B Curvature (K) of a plane curve (dimensions of length^{-1})
  - 1 Plane curve: all points contained in the same plane
  - 2 Curvature: departure from a straight line
  - 3 K = 1/r, where r = radius of curvature (see figure)
  - 4 Curvature of a function y = f(x)
    - a $K = |y''|/[(1+\{y'\}^2)^{3/2}]$ ($y' = dy/dx$; $y'' = dy'/dx$; from calculus)
    - b For curves with small slopes $K \approx |y''|$
    - c Inflection point: where concavity changes and K = 0.

III Some causes of folding (see figure)

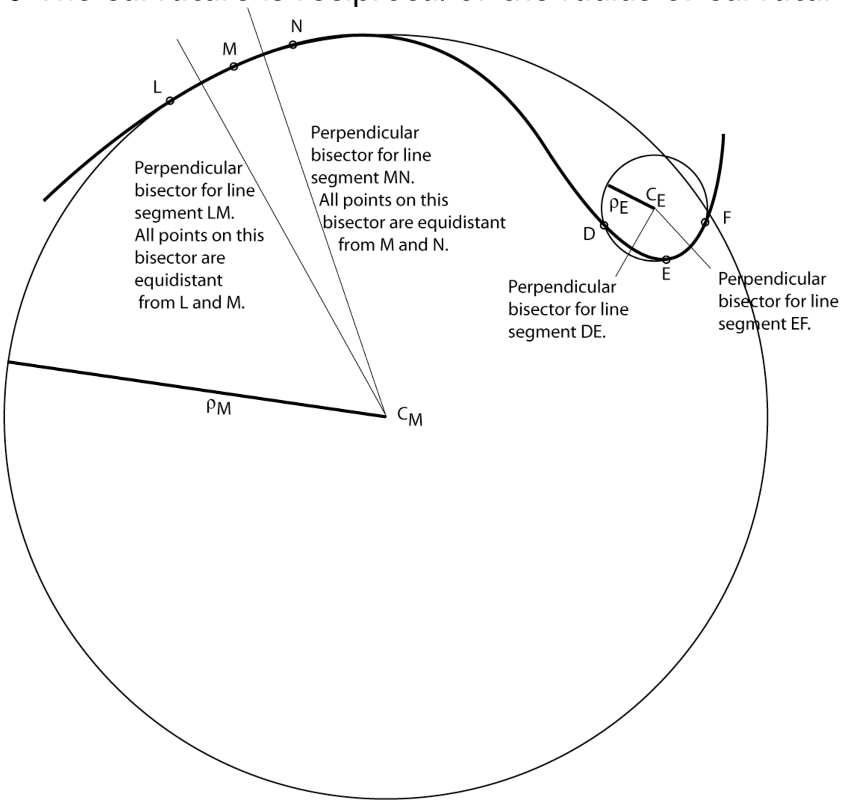
- A Buckling (end loading)
  - 1 Commonly yields fold trains with sinusoidal forms
  - 2 Example: Appalachian Mountains
- B Faulting
  - 1 Occur (for example) past tip(line) of fault
  - 2 Example: Koae fault system monoclines
- C Intrusions (bottom or top loading)
  - 1 Commonly yields folds shaped like modified half-ellipses
  - 2 Example: Henry Mountain laccoliths

Method for Finding Curvature From Three Discrete Points

1 Three (non-colinear) points define a plane – and a circle.
2 Locate three discrete non-colinear points along a curve (e.g., L, M, N)
3 Draw the perpendicular bisectors to line segments LM and MN

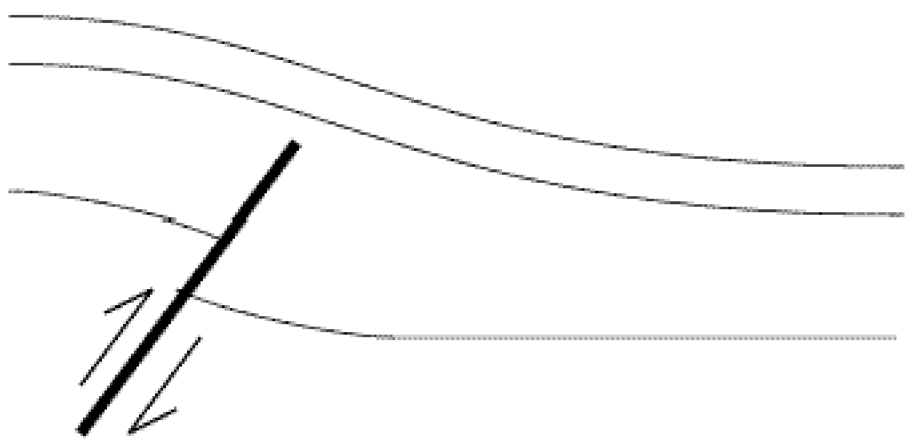


4 The perpendicular bisectors intersect at the center of curvature C.
5 The radius of curvature (ρ) equals to the distance from C to L, M, or N.
6 The curvature is reciprocal of the radius of curvature.

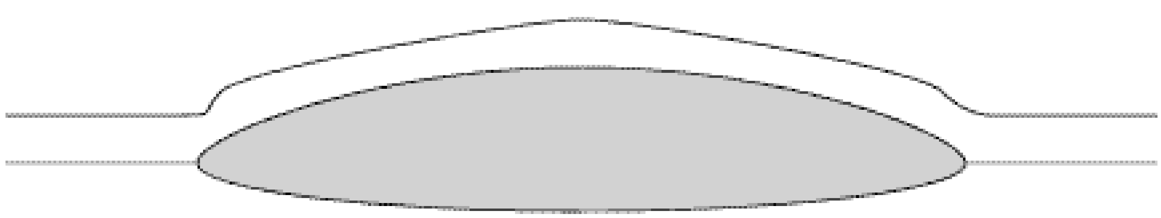


Some Causes of Folding

Folding by buckling



Folding with faulting



Folding adjacent to an intrusion

IV Fiber strains

A Layer-parallel normal strains (extensions or contractions)

B The inside surface of a folded layer (the side closer to the center of curvature) is contracted.

C The outside surface of a folded layer (the side farther from the center of curvature) is extended. Fractures perpendicular to the layer can open if the extension and associated normal stress are sufficient.

V Classification of folds

A Fleuty's Classification of folds (see figure 28.5)

1 Based on orientation of fold axis and axial surface

2 Fold axis: a line that sweeps out the surface of a fold if moved parallel to itself

3 Axial surface: a surface connecting the points of greatest curvature through a folded sequence

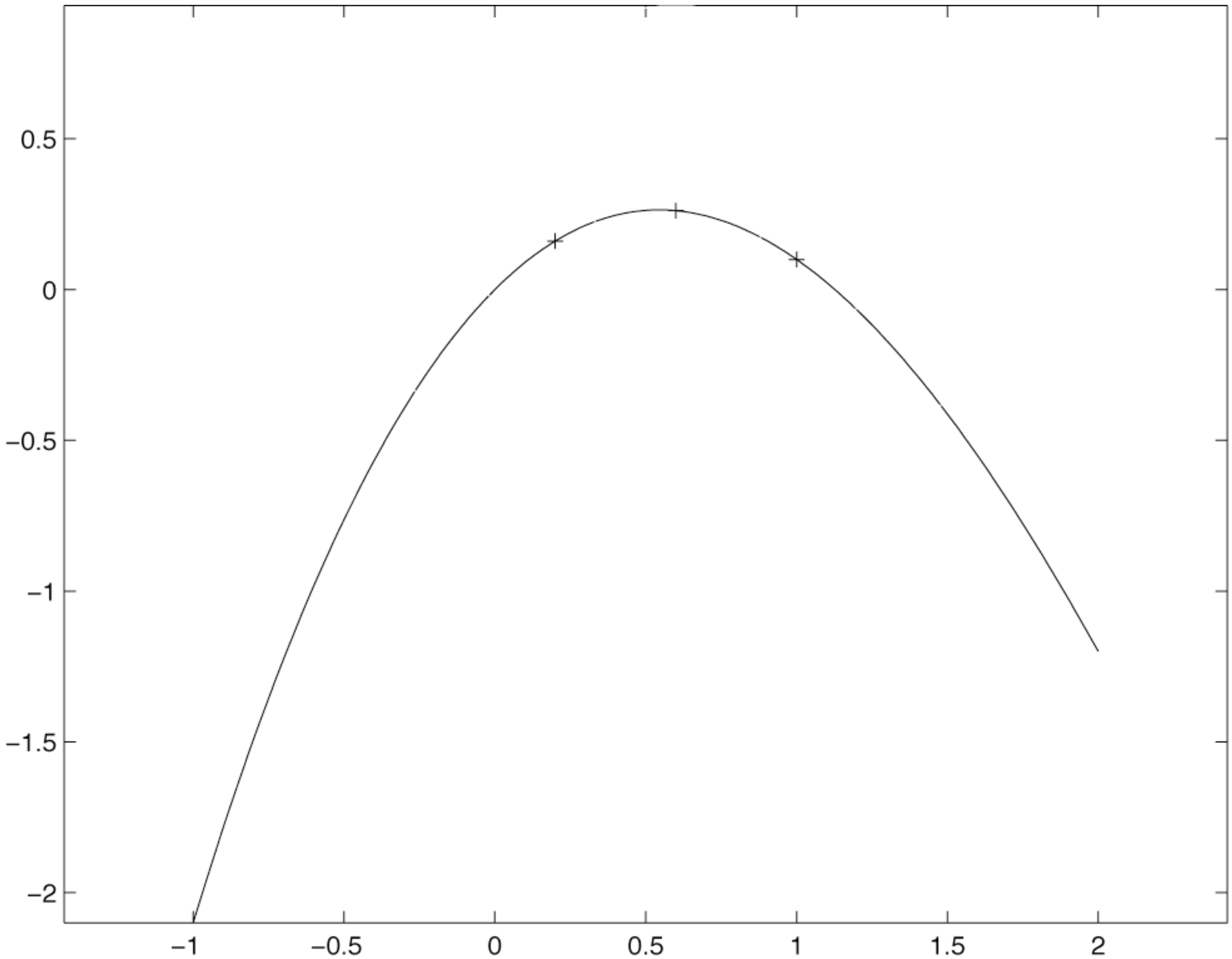
B Interlimb angle (see figure 28.4)

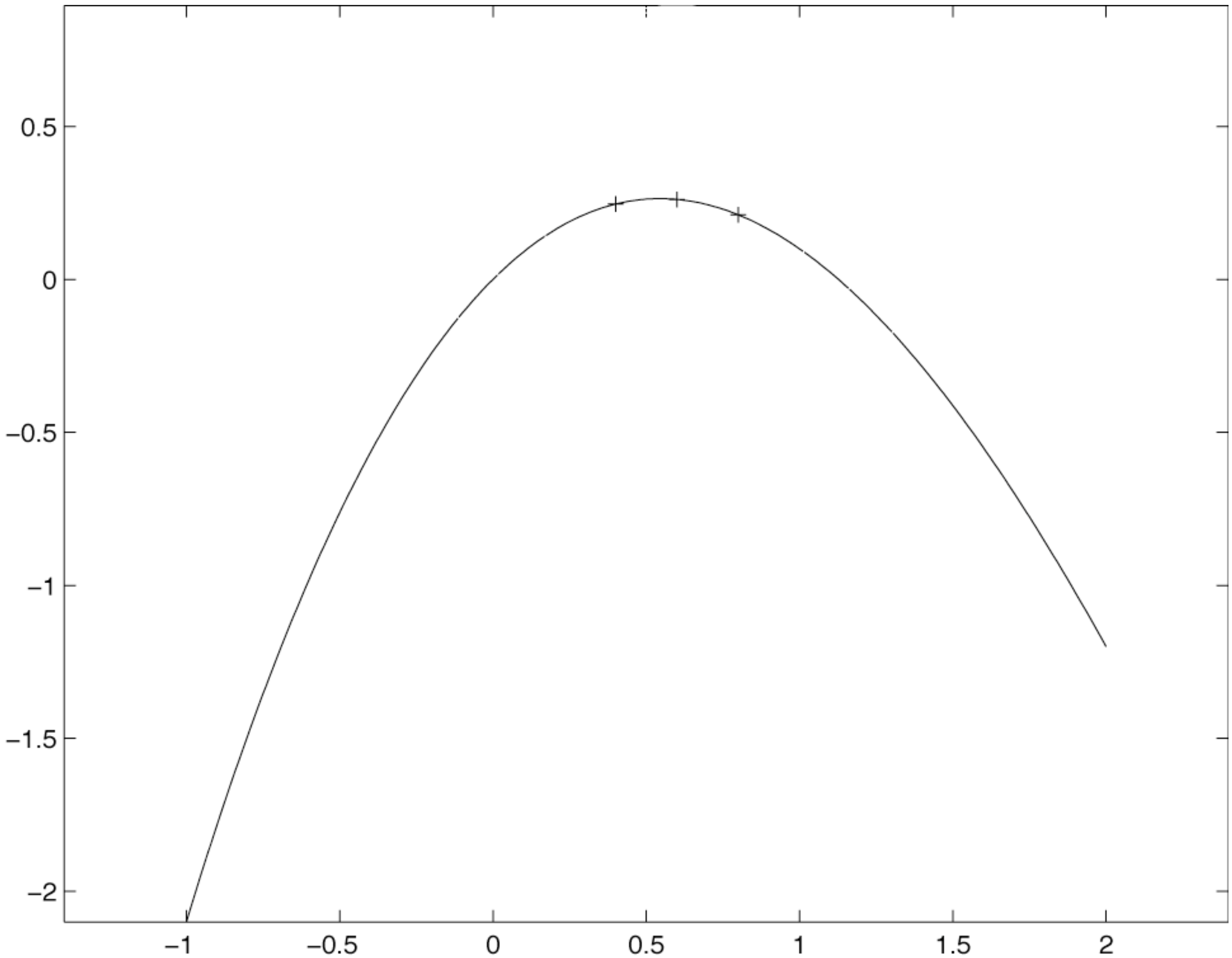
1 Limb: portion of fold where curvature is low

2 Hinge: portion of a fold where curvature is greatest

Exercise 1: Graphical solution for curvature (**12 points total**)

Find the curvature graphically at the indicated points for the two curves on the two following pages. Give the curvature to 3 significant figures; use the scale on the figure, and give the curvature in terms of inverse distance units (e.g., if the radius is 2 units, the curvature would be 0.5 units^{-1}. For each curve: 4 pts for graphical construction, 2 points for curvature value.


0.5
0
−0.5
−1
−1.5
−2
−1
−0.5
0
0.5
1
1.5
2


0.5
0
−0.5
−1
−1.5
−2
−1
−0.5
0
0.5
1
1.5
2

Exercise 2: Analytical solution for curvature (**42 points total**)

Calculate the curvature of the following curves:

a $y = x^{1/3}$ (an inverse cubic function);

b $y = \sin(x)$ (sine wave);

c $y = \text{atan}(x)$ (arctangent, a function resembling a monocline)

d $y = x^4 - 2x^2 + 1$ (function that yields the shape of a beam with a constant overpressure on one side, the shape is like that of a laccolith);

Use the formula $K = |y''|/[(1+\{y'\}^2)^{3/2}]$ in the following procedure:

A Derive the solutions for the first derivative of y with respect to x (y') and second derivative with respect to x (y") for each curve neatly on a separate page. (**2 points for each derivative; 16 points total**)

B Download my Matlab script curvature.m (see my web page), and modify it by inserting your solutions for y' and y" for each of the four functions on the lines marked by asterisks (yp = *********; ypp = *********;). I have provided a complete example in the Matlab script for the solution for a parabolic curve. The script runs by typing "curvature". Include hard copies of the plots produced. (**1 point for each curve; 4 points total**).

C Locate and clearly label the hinge points <u>on the top and bottom of each of the four curved layers</u> where highest strains of extension and the highest strains of contraction occur. Label the points of highest extension (there can be more than one) with a plus sign (+) and the points of highest contraction (there can be more than one) with a minus sign (-). (**1 point per location and label; 18 points total**)

D Which curve would be the most reasonable to fit to the fault data from the Big Island field trip? Explain your reasoning. (**4 points total)**

Exercise 3: Fold classification (**32 points total**)

For the following cases find the orientation of the fold axes using an equal angle projection (stereonet). For each fold plot the orientation of the limbs, the orientation of the axial surface on the equal angle projection. Find the orientation of the fold axis and the angles between the limbs. Using Fleuty's classification scheme of Fig. 28.5, classify the folds according to the orientation of the fold axis and the axial surface. Also classify the folds using the classification scheme of Fig. 28.4 based on the interlimb angle. **Plot fold A and fold B on separate pages!**

Limb A1 **(2 pts)**	Strike: 20	Dip: 30SE
Limb A2 **(2 pts)**	Strike: 250	Dip: 30NW
Axial surface **(2 pts)**	Strike: 315	Dip: 14
Fold axis **(2 pts)**	Trend:	Plunge:
Fold classification from Fig. 28.5	**(2 pts)**	xxxxxxxxxxx
Interlimb angle	**(2 pts)**	xxxxxxxxxxx
Fold classification from Fig. 28.4	**(4 pts)**	xxxxxxxxxxx
Limb B1 **(2 pts)**	Strike: 330	Dip: 10E
Limb B2 **(2 pts)**	Strike: 150	Dip: 70W
Axial surface **(2 pts)**	Strike: 330	Dip: 60E
Fold axis **(2 pts)**	Trend:	Plunge:
Fold classification from Fig. 28.5	**(2 pts)**	xxxxxxxxxxx
Interlimb angle	**(2 pts)**	xxxxxxxxxxx
Fold classification from Fig. 28.4	**(4 pts)**	xxxxxxxxxxx

For the interlimb angle, full credit for angles within two degrees of the correct value, half credit for angles within four degrees of the correct value.

Exercise 4: Analytical solution for curvature (12 pts)

The Matlab functions "gg303_2006_profile_data" and "gg303_profile" prepare a best fit function that passes through the points we surveyed along the Ohale fault. It also calculates the curvature profile using a procedure like the graphical procedure in Exercise 1. Run the script, and discuss the curvature of the Ohale fault profile and relate it to the features we saw in the field (fissures and buckles):

A Locate and clearly label the points along the profile where the highest fiber strains for contraction and extension would be expected and you would predict fissures and buckles to occur. (2 pts)

B How do these locations correspond to the approximate locations of buckles and fissure we observed along (or very near) the profile? (2 pts)

C How do they correspond to the exact locations of buckles and the fissures? (2 pts)

D Where does the profile match the observations the best? The worst? (2 pts)

E Discuss any shortcomings you see to describing the profile now with a continuous arc tangent curve as a basis for your predictions. (4 pts)