Lab 2: Structure contour mapping (20 pts.):

KEY 9-2

- know the definition of a structure contour.
- be able to hand contour data.
- be able to calculate surface traits (e.g. local strike and dip) from structure contours.
- construct map pattern of a contact from structure and topographic contours.
- be able to use Surfer (or equivalent software) to contour data.
- be able to interpret the structure contours geologically.

Structure contour maps are basically the same as topographic maps, where the surface being mapped is some geologic surface. Geologic surfaces commonly mapped in this way are:

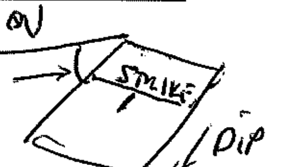
- a stratigraphic horizon.
- a fault surface.
- top of the groundwater table.
- a seismic reflection surface.

There are some differences with standard topographic maps. Your surface does not have to be continuous everywhere, but can be truncated. For example the surface created by the top of a sill can be truncated by a fault.

You can also contour and 'map' other features than a physical surface. In this case the z axis instead of being elevation can be any physical/chemical parameter. For example, you can contour geophysical parameters such as the acceleration of gravity, or the strength of a magnetic field. When working with contaminant plumes the z parameter is the concentration of some contaminant. Isopach maps are where you are contouring the thickness of some unit.

When contouring you are assuming that for some x,y area the z values form a smooth continous surface.

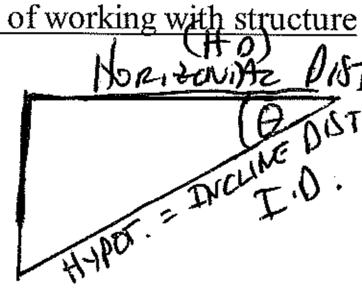
Structure contours of a plane: STRIKE = COMPASS DIRECTION RELATIVE TO NORTH



- straight lines with a trend parallel to the strike of the plane.
- lines evenly spaced with spacing distance that is a function of the dip.
- from strike and dip can construct the structure contours if you know the x,y,z position of one point, or can calculate strike and dip if giving the structure contours.
- Powerpoint presentation that goes through the mechanics of working with structure contours on a plane.

DIP = ANGLE OF INCLINATION FROM HORIZONTAL

Trig functions for a right triangle:



- **tan (angle) = opposite / adjacent.** = VD/HD (VD) VERTICAL DIST.
- **sin (angle) = opposite / hypotenuse.** = VD/ID
- **cos (angle = adjacent / hypotenuse.** = HD/ID.
- These are amazingly useful - commit them to memory!
- distance between contour strike lines = contour interval / tan of the dip angle.

$\tan\theta = \frac{VD}{HD}$ INV($\tan^{-1}$) = θ

INV($\tan^{-1}$) $\frac{VD}{HD}$ = θ ANGLE

Exercise 1: Use one of the two structure contour maps provided below to answer the following questions (you will be instructed which one you should use). The assumption here is that there is no significant topography.

a) The contours shown are on a fault surface and the numbers are meters above sea level. What is the strike of the fault (you will need a protractor to answer this)? N. 59°W = 301°

b) What direction does the fault dip in? SOUTH WEST

c) What is the dip angle? You will need to measure the spacing between the strike lines and then use the appropriate trig function above to compute the dip amount. Remember to measure the distance between the strike lines in a direction perpendicular to the strike lines. DIP = 67.5°

NA

~~d) The center of the star marks a point on the top of a stratigraphic formation. In the top map the planar surface is oriented N20E - 40SE, and in the lower map it is oriented 150- 30 SW. Draw and label a strike line so that the strike line truncates against the 300 m strucctur contour for the fault.~~

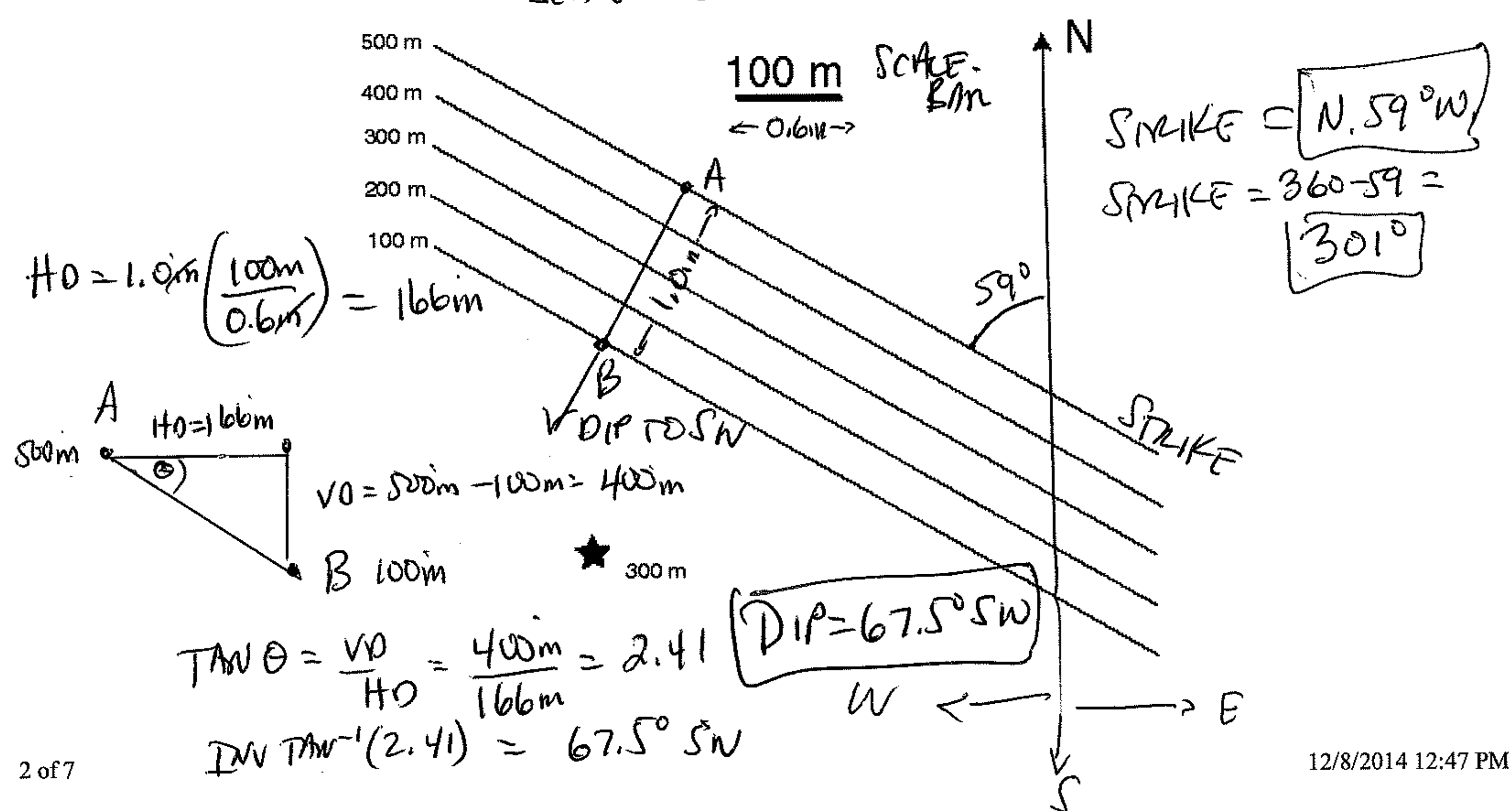
~~e) Compute the map distance between strike lines with a 100 m contour interval for the stratigraphic formation top using the appropriate trig function above.~~

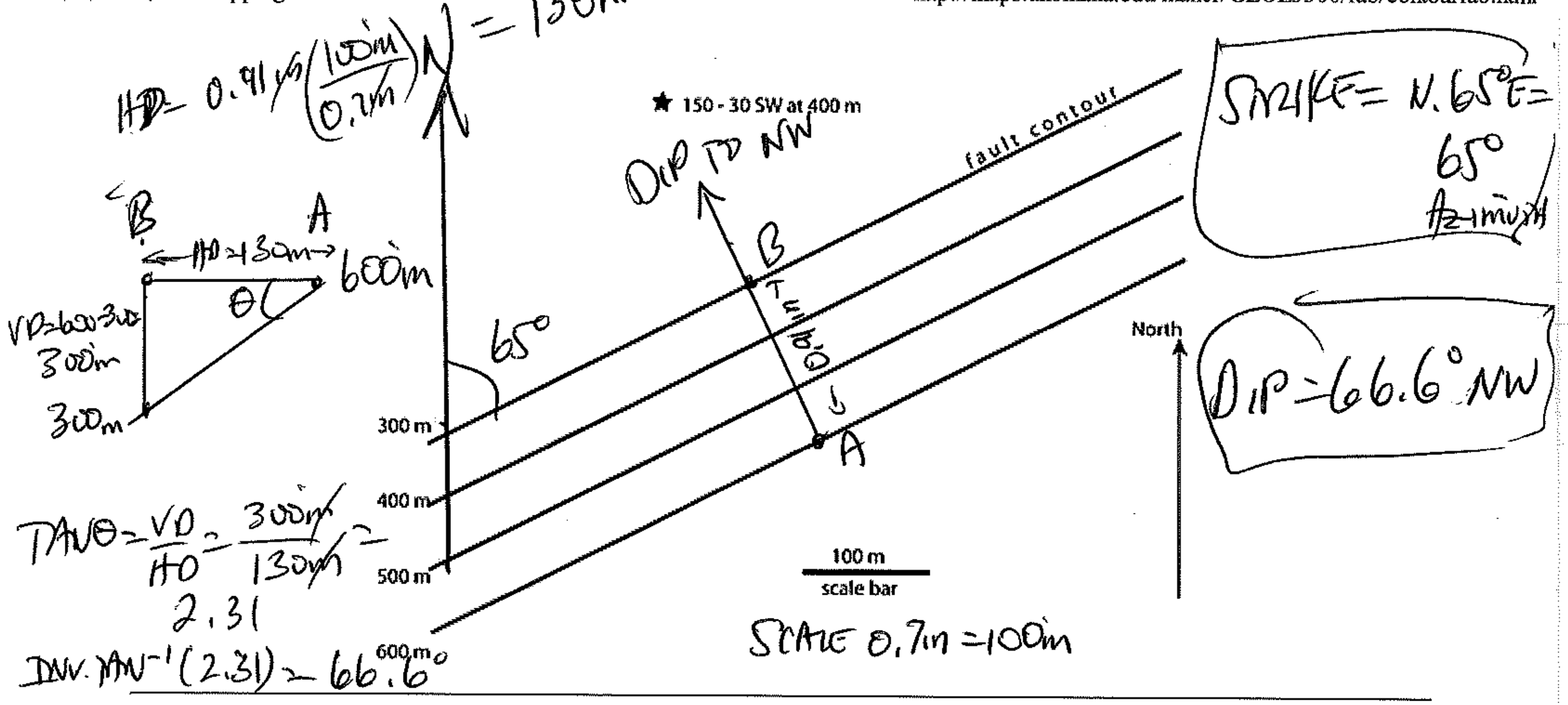
~~f) Draw the structure contour for the stratigraphic formation top that match the fault structure contour values, truncating eacg if them against the equivalent fault structure contour.~~

~~g) Draw and label the cut-off line, the line formed by the truncation of the stratigraphic formation top surface against the fault surface.~~

~~h) Use the protractor to measure the trend, the angle from N of the cut-off line, using the quadrant the line descends towards.~~

SCALE 0.6in = 100m





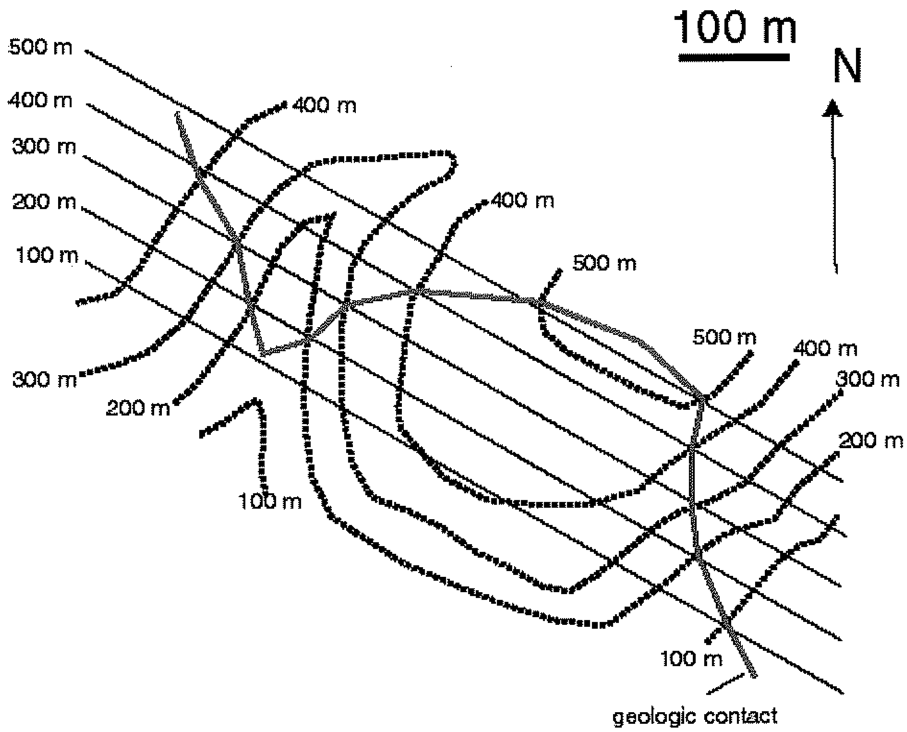
Relationships between structure contours for a planar surface, a topographic surface and the map expression on the map of the planar surface.

You saw in the above exercise how one can map the line created by the intersection of two surfaces. You basically connect the points created by the intersection of the contours of equal elevation of the two respective surfaces to create what the map pattern should be. You of course can do the opposite, connect the points where the line representing the map expression crosses the same contour to estimate the structure contour line at the elevation of the contour.

Exercise 2: Use the map diagram below to complete the following. The thicker dotted line represents topographic contour lines, the thinner continuous line represent the same fault surface as depicted above, and the red (grey in b&w) represents the map expression of the fault surface.

a) A second fault surface exists exactly 100 meters elevation above the one depicted below. Draw its map expression.

b) A horizontal bed is cut by these faults. In the footwall of the lowest fault it is at an elevation of 190 m. In the footwall of the higher fault it is at an elevation of 290 m, and in the hanging wall of the higher fault it is at 410 m elevation. Draw in the map expression of the horizontal bed as it is cut by these two faults. You will need to interpolate between the given contour lines. Remember that the footwall is the block beneath a dipping fault, and the hanging wall is that above.



Hand contouring point x,y,z data.

While computer programs conduct this type of analysis readily, it is useful to hand contour data also. In some cases it can be argued that an experienced geologist might produce a better contour map of a surface than the computer does because they can use their expert knowledge of how that type of geologic surface behaves.

When contouring you will first need to pick a likely contour interval. You want the smallest contour interval possible without overinterpreting the data (producing false accuracy). A general rule of thumb is that if you commonly have several contours passing between two known control points then your interval is too small. You could think of some calculations on the data set that can suggest a good interval (e.g. histogram of neighbor differences). Too large of a contour interval will lead to an oversimplified interpretation.

Use your geologic knowledge to guide your contour construction.

Produce the simplest interpretation (in this case the simplest surface possible). Don't over interpret so that surface features are indicated which could exist, but that the data doesn't constrain to exist.

The contour map product is an interpretation since interpolation and significant discretion of exactly where you draw the lines can exist. What are some *rules of interpolation* between two constraining control points? A simple approach is to position the contour proportionally. If the control points are at 60 and 30 units, then the 50 unit contour interval should be 2/3rds the way along a line as your travel from the 30 to the 60 point. Other better rules of extrapolation exist.

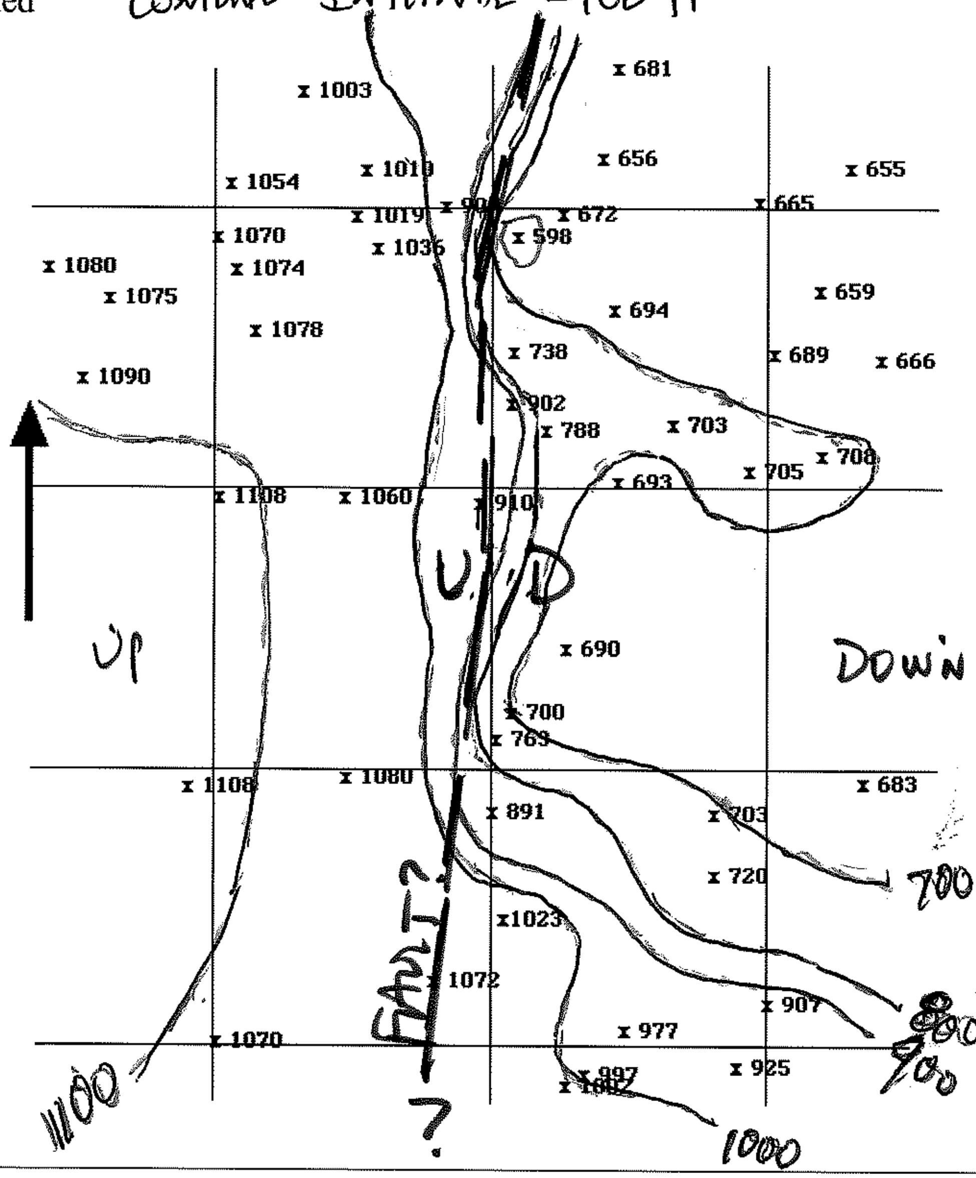
Where should you start contouring? Where you start can make a difference, since you tend to use the existing contours as a guide to help you draw the contours under construction. One suggestion is to start where the surface is best constrained, where you have the maximum density of points, and then to work to areas where the surface is less constrained. This usually means starting in the middle of the map and in the middle range of the contour elevations being constructed.

Exercise 3: Below is a map of drill hole data, showing the elevation in feet above sea level of the Tarkio limestone. This is in the area of the Humboldt fault zone, SE Nebraska. ~~Hand contour~~ the data, also interpreting where you think the faults may lie. There will be a lot of interpretation/discretion involved in how this map looks. Make sure your contours and any faults are well labeled

CONTOUR INTERVAL = 100 ft

ABOVE SEA LEVEL

MAX = 1080
MIN = 598
1100
1000
900
800
700
600



Computer contouring:

Computer contouring and visualization of the surfaces created is a marvelous tool. However, don't let it be a black box, magical sort of endeavor. You should understand at some level how the computer is generating that surface. There are different ways and the results can be quite