LAB #1 – Orientation of Structures in Space

Make sure that you are familiar with the following terms. Draw the feature listed with relevant details, e.g. footwall, hanging wall, and motion arrows. Also ***always include at least 3 horizontal layers and an up arrow in cross section and a north arrow in map view.***

Stress vs. Strain
- compression
- tension
- contraction/shortening
- extension

Brittle Deformation
- joint
- fault
  - earthquake
  - thrust/reverse fault
  - normal fault
  - footwall
  - hanging wall
  - strike-slip fault
    - right lateral or dextral
    - left lateral or sinistral
  - dip-slip
  - oblique-slip

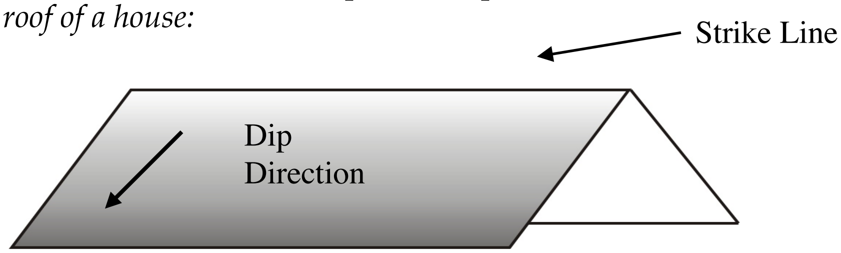
Ductile Deformation
- fold
  - anticline
  - syncline

Map View
- longitude
- latitude
- geographic vs. magnetic north
- topography
- scale
- profile

Feature	**Cross Section**	**Map View**
Horst and Graben (Label hanging /foot wall and slip direction)		
Thrust Fault (Label hanging /foot wall and slip direction)		
Anticline (Label hinge axis, force direction, contact topo lines in map view)		
Normal Fault (Label hanging /foot wall and slip direction)		
Syncline (Label hinge axis, force direction, contact topo lines in map view)		
Strike-Slip fault (Label hanging /foot wall and slip direction)		

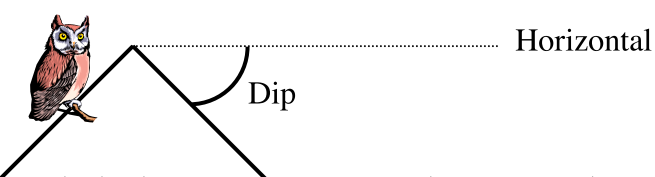
Strike & Dip

Strike and dip describe the orientation of a plane in space.
Example: the peaked roof of a house:



Strike is the orientation of the intersection line of the plane in question (*roof of a house*) with the horizontal plane. If you were to look down on the house from directly above, it would look like this:

The angle between the strike line and north is used to describe the strike. In this example the strike is, in essence, the direction the house is facing. If you look at the front of the house, it looks like this:



The angle that the roof makes with the horizontal is called the dip. In this example the dip is, in essence, the steepness of the roof.

<u>Water Analogy</u>
If you submerge a plane, the strike line will be the water-line.
The dip direction is the direction that a drop of water will flow down the plane.

Trend & Plunge

In structural geology, the orientations of linear features are also important. The orientation of lines in space can be described using two distinct angles referred to as the trend and plunge.

To measure the trend and plunge of a linear feature, look at it end on:

A horizontal line will look like a point. This line has a plunge of 0 degrees:

But a line that is not horizontal will look like this when viewed end on:

To measure the trend of this line, you simply record the direction that you are facing when the linear feature is viewed dead on. From above, this will look like:

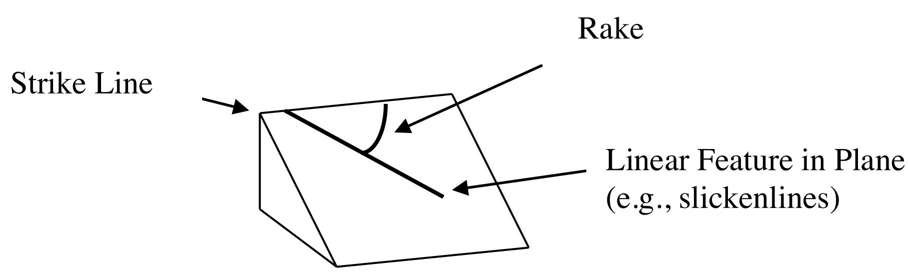
From the side, that same line may look like:

Look familiar?

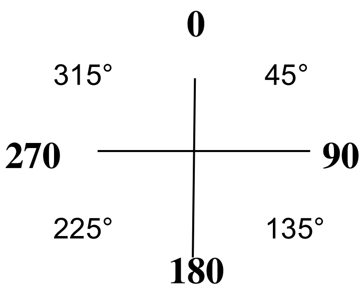
It is. To measure strike, you took the trend of a horizontal line that you called the strike-line. To measure the dip, you envisioned a linear feature on the plane -- its dip direction line -- and you measured the plunge of that line

Rake

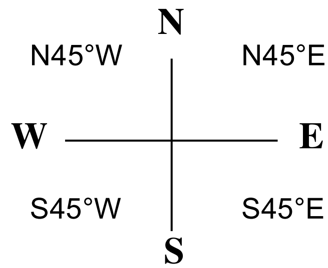
Rake is a single angle measurement that, along with the strike and dip of a plane, will give the orientation of linear features in a plane. You can measure rake by laying a protractor against the plane and measuring the angle between the strike line and the linear features. You can always use trend and plunge to describe the orientation of linear features but rake only describes linear features that exist in a plane.



Ways of Recording Strikes and Trends



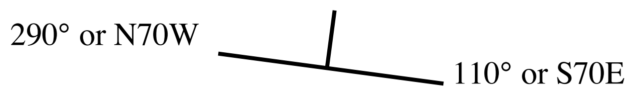
Azimuth Method



Quadrant Method

Right Hand (Rule) Convention

Planes are non-directional; every plane can be properly described by two different strikes. Example:



For the sake of brevity, we report only one of those numbers. The right hand convention is one way to establish a consistent recording system.

When looking along the strike direction that you report, the plane should dip off to your right. Point the fingers of your right hand down-dip of the plane you are measuring with your palm down. The direction your thumb is pointing is the orientation of the strike you should record. The photos below illustrate strike measurements (white dashed lines) on both a hanging wall (right) and a foot wall (left) exposure.

Measuring Strike & Dip -- Tips

Since strike is measured in the horizontal plane, your Brunton transit/compass should always be horizontal. Use the bull's-eye level to maintain horizontality during measurement.

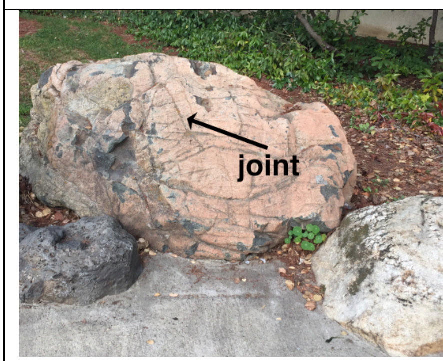
When measuring dips, be sure to measure the TRUE dip. The true dip is the steepest angle that you can measure on a plane. Try rotating your Brunton a bit while making your dip measurements to ensure that you are recording the maximum dip.

Here is an example of a geologic structure whose orientation you might want to measure some day:

LAB Exercise #1

Some problems adapted from Marshak & Mitra (pp. 17, 37, 42)

1. Fill out cartoons on page 1. (10 pts)
2. Campus scavenger hunt. (20 pts)

<table>
<tr>
<td>
</td>
<td>a. Rock 1 – Outside McCone
What is the strike and dip of the face that we're looking at now? (3 pts)
155˚ 62˚
What is the trend and plunge of the lineation in amphiboles? (3 pts)
250˚ 55˚
What is this rock? (BONUS 2 pt)</td>
</tr>
<tr>
<td>
</td>
<td>b. Rock 2 – Outside McCone
What is the strike and dip of the face? (2 pts)
115˚ 35˚

What is the trend and plunge of the linear feature on this face? (2 pts)
170˚ 40˚

What is this rock? (BONUS 1 pt)</td>
</tr>
<tr>
<td>
</td>
<td>c. Stairwell 1 – Outside East Asian Library
What is the strike and dip of the lower staircase handrail? (2 pts)
000˚ ~20˚ it's beveled so results will vary</td>
</tr>
<tr>
<td>
</td>
<td>d. Stairwell 2 – Near Doe Library
What is the strike and dip of the lower staircase handrail? (2 pts)
227˚ 23˚

What is the strike and dip of the upper staircase handrail? (2 pts)
80˚ 25˚

What is the difference between these two dips (i.e. how much would you have to rotate the first handrail by so that it would look like the second?) (1 pt)
~180˚</td>
</tr>
</table>

3. Translate from the quadrant form to the azimuthal form, or vice-versa, while using the *right-hand rule*. (8 pts)

   a) N30°W, 34°E *330°, 34°*
   b) S78°W, 18°S *78°, 18°*
   c) S12°E, 56°SW *168°, 56°*
   d) N48°E, 56°SE *48°, 56°*
   e) 067°, 74° *N67°E, 74°SE*
   f) 234°, 43° *S54°W, 43°NW*
   g) 078°, 76° *N78°E, 76°SE*
   h) 117°, 21° *S63°E, 21°SW*

4. Imagine that you discover a previously unreported fault on the Berkeley campus. During field mapping, you recorded the trend and plunge of 4 different and overprinted sets of slickenlines. When you sit down to write the paper that will make you famous, you find something wrong. Here is the information from your field notes:

   Fault Surface Strike/Dip: N39°W, 47°E
   Slickenline lineation 1 Plunge/Trend: 47°, N51°E
   Slickenline lineation 2 68°, due N
   not in plane because can't be more than true dip
   Slickenline lineation 3 47°, N51W
   not in plane because can't be same as true dip with different trend
   Slickenline lineation 4 34°, due N

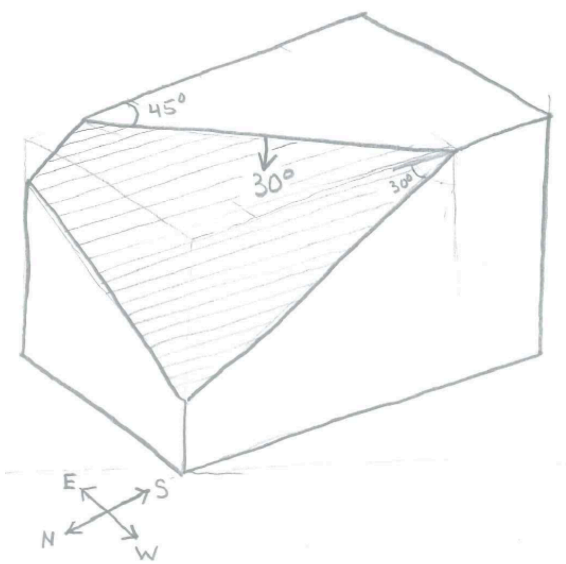
a) Assuming that you recorded the planar attitude of the fault surface correctly, determine which lineation measurements are impossible. In other words, which lineation(s) cannot possibly lie in the specified plane? (Explain why for each) (8 pts)

b) Assuming the measurement of lineation 1 is correct, what is its rake? (4 pts)
90°

c) Assuming the measurement of lineation 1 is correct, is the fault a strike-slip fault or a dip slip fault? How do you know?(4 pts)
dip-slip because direction of slip is perpendicular to strike and therefore in the dip direction

5. Draw an isometric bloc diagram of a cube. Within the volume of this cube, draw a plane whose attitude is 225˚, 30˚NW. Indicate the orientation of the three dimensional coordinate system that defines your reference frame. Make sure to use a ruler to keep the line straight. (10 pts)

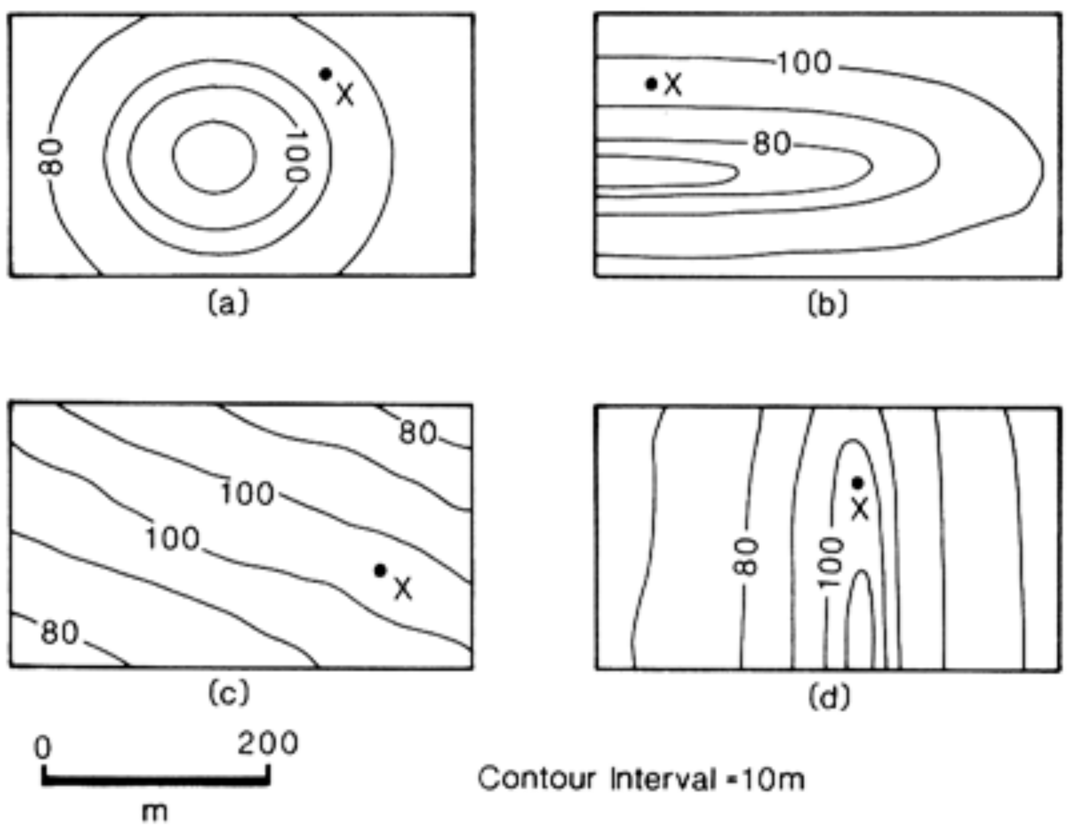
Something like this. As long as the angles are correct.



6. Why do we learn strike and dip? Why is it important to describe the orientation of planes and lines in the field? (20 pts – 5 -10 sentences)

We learn strike and dip because many geologic features can be represented as planes, such as: faults, beds, joints, veins, cleavages, foliation, dikes, contacts, and unconformities. The attitude of the plane can be described by strike, dip, and general direction of dip (or dip and dip direction). Many geologic features can be pictured as lines, such as: scratches on a fault surface, elongate minerals, and fold hinges. It's important to be both quantitative and qualitative in your field notes in order to avoid mistakes (such as problem 5).

7. Sometimes, the orientation of geologic structures is recorded by someone else and reported in graphical format. The maps below show contours of the depth of a lithologic contact ***below*** sea-level. Estimate the attitude of the contact at point X for each of the structural contour maps and describe the structure using a simple phrase (i.e., "anticline") and explain your reasoning. (16 pts)



a) basin 135°, 10°
b) anticline 270°, 10°
c) syncline 300°, 0°
d) syncline 90°, 5°