GEOLOGY 365: STRUCTURAL GEOLOGY
Lines and Planes in Structural Geology

DEFINITIONS

Terms for lines: Two pieces of information, a *trend* and a *plunge,* are necessary to describe the orientation of a line in space.

Trend - the direction of a line on a horizontal plane. We use the *azimuth* of a line to define its trend.

Azimuth - a horizontal angle (between 0 and 360°) measured clockwise from true north, which has an azimuth of 000. As a couple of examples, E has an azimuth of 090 while SW has an azimuth of 235.

Plunge (inclination) - the vertical angle, measured downward, between the horizontal and a line.

Terms for planes: We define the attitude of a plane by the azimuth of its strike, its dip, and its dip direction.

Strike - the one horizontal line on an inclined plane. This line can be imagined as the intersection of an inclined plane with a horizontal plane.

Dip - the vertical angle, measured downward, between the horizontal and the line of greatest slope in an inclined plane.

Apparent dip - the inclination of any line on an inclined plane that is oblique to the plane's dip direction. The apparent dip is always less than the true dip of the plane (which is the inclination of the line of greatest slope).

Pitch - the angle, measured on an inclined plane, between the strike and any other line that lies in the plane. The line of greatest slope in any plane must have a pitch of 90°

INTRODUCTION AND BACKGROUND:

Geologists usually describe the orientation of physical features in rocks as lines and planes. These three-dimensional features are commonly represented on a two-dimensional projection called a stereonet. The idea is similar in its goal to representing the three-dimensional surface of the Earth in two dimensions on a topographic map.

Stereonets are commonly reported to be the least-intuitive part of structural geology. The big problem with stereonets is that they *require* you to think and visualize in three dimensions. For some of you, this will be easy; for most, it will take some thinking; for others, it may extremely difficult.

Note: The problem with teaching this subject is that most structural geologists are capable of doing origami in their heads, and thus do not relate easily to people who cannot. So, if you are one of the people who have problems with three-dimensional thinking or visualization, I'll make you a deal: If you promise to try not to get frustrated, I promise to try to explain it different ways. Also, you may have to put in more time than your classmates. Take the time and do it, because it is guaranteed to pay off. For the record, probably the most important skill students learn in structural geology is to think in three dimensions or four dimensions (progressive time development of a three-dimensional body). Spatial reasoning is what a lot of field geology is all about.

GEOLOGICAL PLANES AND LINES

Lots of geological features can be idealized and described as planes. A few of these features are bedding, fault planes (locally, anyway), cleavage, foliation, joints, limbs of folds (sometimes), and axial planes of fold. Similarly, many geological features can be described as lines. A few of these are stretched conglomerate pebbles, flute casts, slickenlines (note however that these are usually on a fault *plane*), mineral stretching lineations, and fold hinges. There are plenty more examples of both planar and linear features in rocks.

LINES

Lines are commonly represented by their *trend* and their *plunge*. We will use the convention that the trend of lines is given with three digits from 000 to 360. So, 000 is N, 090 is E, 180 is S, 270 is W, 360 is again N. The plunge is given with two digits from 00 to 90°. A trend and a plunge give the orientation of any line in space. Since lines are either horizontal, vertical, or somewhere in between, the bearing points toward the plunge – it is the plunge direction.

These are generally written as *plunge -> trend*. You can remember how to write a plunge & trend measurement down by recalling that a line plunges in the direction of the trend – hence we write the measurement with an arrow pointing from the plunge value toward the trend value.

Examples of line orientations:

<u>plunge -> trend</u>
00 -> 000 (N-oriented, horizontal)
00 -> 084 (horizontal, in direction 084, which is almost due E)
90 -> 000 (vertical)
90 -> 084 (vertical, same as the line above)
42 -> 084 (the trend is the same as line above, but the line plunges only 42°)

PLANES

Planes are more complicated than lines because they are two-dimensional rather than one-dimensional. Planes are commonly represented by their *strike* (azimuth in the horizontal plane) and their *dip* (angle between the horizontal and the line considered, or between the horizontal and the normal to the plane considered).

We will use the convention that the strikes of a plane is given with three digits, from 000 to 360 (the azimuth). Again, 000 is N, 090 is E, 180 is S, 270 is W, 360 is again N. The dip is given with two digits from 00 to 90°, and is followed by the general direction the plane is dipping, N, S, E, or W. Remember, the dip direction is always 90° away from the strike. So, if you have a NS-striking plane, the dip direction must be to the E or W.

Examples of plane orientations: these are recorded as Strike / Dip, Dip Direction

Plane orientations with N-S and E-W strikes:

<u>Strike, Dip</u>
000 / 90 E or W (NS oriented, vertical)
084 / 90 N or S (almost EW plane, vertical)
084 / 42 S (almost EW plane, dips 42° to the south)
000 / 0 E or W (horizontal, no dip)
084 / 0 N or S (horizontal, no dip—same as previous example)

Other Examples:

045 / 90 SE or NW (Northeast oriented plane, vertical)
045 / 12 SE (Northeast striking plane, dipping to the SE at 12°)
342 / 12 W
163 / 78 E

Generally, if a plane strikes within 30° of N or S, the dip is to the E or W. If a plane strikes within 30° of E or W, the dip is to the N or S. So, the typical breakdown of dips is:

Strike	Dip
330-030	E or W
030-060	NW or SE
060-120	N or S
120-150	NE or SW
150-210	E or W
210-240	NW or SE
240-300	N or S
300-330	NE or SW

Right-hand rule: Some people use a convention called the “right hand rule” for strikes and dips. This means that the dip direction is always 90° clockwise from the strike direction. This convention has the advantage that you don’t necessarily need to record the dip direction (For instance: 045 / 65 implies 045 / 65 SE), however it is a good habit to *always* record the dip direction, even if you're using the right hand rule. We will not require that you use right-hand rule convention, but you are free to do so. It doesn't take any more time to follow the right hand rule than to ignore it, and it might come in handy someday. Looking back on their field notes in the laboratory, everybody realizes that they forgot to write down the occasional plane's dip direction. If you follow the right hand rule you can be pretty sure of your measurement. If you don't, that measurement will be worthless.

LINES ON A PLANE

In some cases, you might be interested in the orientation of a line on a plane. An example of this is a slickenline on a fault surface. One can characterize the orientation of this line in two ways: (1) Measure the strike and a dip of the plane, then measure the trend and plunge of the line; or (2) Measure the strike and dip of the plane and the *pitch* of the line.

The advantage of a pitch is that you only need one additional measurement after the strike and dip of your plane. The pitch is just the angle between the line and the strike of the plane (figure below). The pitch has a measurement from 0 to 90° (0 = horizontal; 90 = vertical) and is generally measured with a protractor. It also has a direction, which corresponds to the direction of the strike that you started to measure from. Consequently, both the pitch and the dip must have directions and their inclination directions must be 90° apart.

Examples:

Strike	Dip	Pitch
000	90 E	0 N (A NS-oriented vertical plane with a horizontal lineation)
000	45 E	0 N (A NS-oriented plane dipping 45° E, with a horizontal lineation)
090	60 N	90 W (An EW-oriented plane, dipping 60° N, with down dip lineation)
038	29 SE	56 SW
076	77 S	61 E