Chapter 4
Using a Compass and Clinometer

In this chapter you will learn about:

- *Parts of a compass*
- *Tips on getting accurate compass readings*
- *Adjusting a compass for magnetic declination*
- *Orienting a compass*
- *Taking bearings (direct and back)*
- *Following bearings*
- *Estimating slope with a clinometer*

A compass is an instrument that is used for navigation and mapping because it measures the geographic direction between two points. It is a fairly simple instrument that uses a magnet, mounted on a pivot that turns in response to the earth's magnetic field, to determine direction (but not position). The magnetic needle points to the magnetic North Pole, which is different from geographic North Pole. A compass bearing, which is typically expressed as an angle (degrees), refers to the horizontal direction to or from any point. In this publication, the term "bearing" is used interchangeably with the term "azimuth."

A compass is used for several different purposes including:

- Determine direction to a destination or landmark.
- Stay on a straight course to a destination or landmark, even if you lose sight of it.
- Avoid obstacles in the path to the destination or landmark.
- Return to your starting point.
- Pinpoint locations on a map and in the field.
- Identify what you are looking at in the field or on a map.
- Orient a map.
- Plot points on a map.
- Plot route of travel on a map.

There are a variety of different types and models of compasses, such as baseplate, sighting, prismatic, and electronic. This chapter focuses on using a baseplate compass because it is a common, inexpensive, and easy to use compass that does not require batteries.

This chapter starts with discussing the parts of a compass and tips on getting accurate readings. Then it describes adjusting a compass for magnetic declination. Finally it provides step by step instructions on orienting a compass, taking bearings (direct and back bearings), following bearings, and estimating slope with a clinometer.

Refer to Chapter 6, Navigation and Field Mapping, for information on using a compass with a map. Chapter 6 also discusses how to use the compass as a protractor to take a bearing from a map.

Parts of a Compass

The basic parts of a base-plate compass are described below and illustrated in Figure 4-1.

- **Magnetic needle.** The magnetic needle typically has a red end that points to magnetic north, as long as the compass is being used properly and there is no local magnetic attraction.

- **Housing with cardinal points and degrees.** The housing includes a revolving dial that shows the cardinal points (at least north, east, south, and west) and degrees (0 – 360) (Figure 4-2). The housing is rotated to line up the compass needle with the orienting arrow when taking a bearing.

- **Orienting arrow.** The north-south orienting arrow (red or black outline of an arrow) is used to align the magnetic needle when taking a bearing. It is also what is adjusted to set the compass for magnetic declination.

- **Orienting lines.** The north-south orienting lines parallel the orienting arrow and can be used to line up the compass dial with grid lines on a map. When the declination is set on a compass with an adjustment screw, the orienting lines no longer parallel the orienting arrow.

- **Index line.** Marked on the front sight of the compass base plate, the index line is where you read the indicated bearing.

- **Direction of travel arrow.** The direction of travel arrow or sighting line is used for sighting and following bearings. The arrow should be pointed in the direction of the destination or landmark.

- **Base plate.** The transparent plate (everything is attached to the baseplate) can be used as a ruler to measure map distances. The direction of travel arrow is also located on the baseplate. Some compasses will have a protractor on the baseplate that can be used to determine bearings from a map.

- **Magnifying lens.** Useful for reading tiny map symbols and features.

- **Declination adjustment screw.** Some compasses have a screw that can be turned to set compass for proper declination. Some compasses have an internal adjustment that automatically corrects for declination.

- **Clinometer.** Some compasses have a clinometer that can be used to estimate slope.

- **Sighting mirror.** Some compasses have a flip up mirror that can improve accuracy when reading bearings. Read the bearing in the dial's reflection where the mirror line crosses it. It can also be used for signaling.

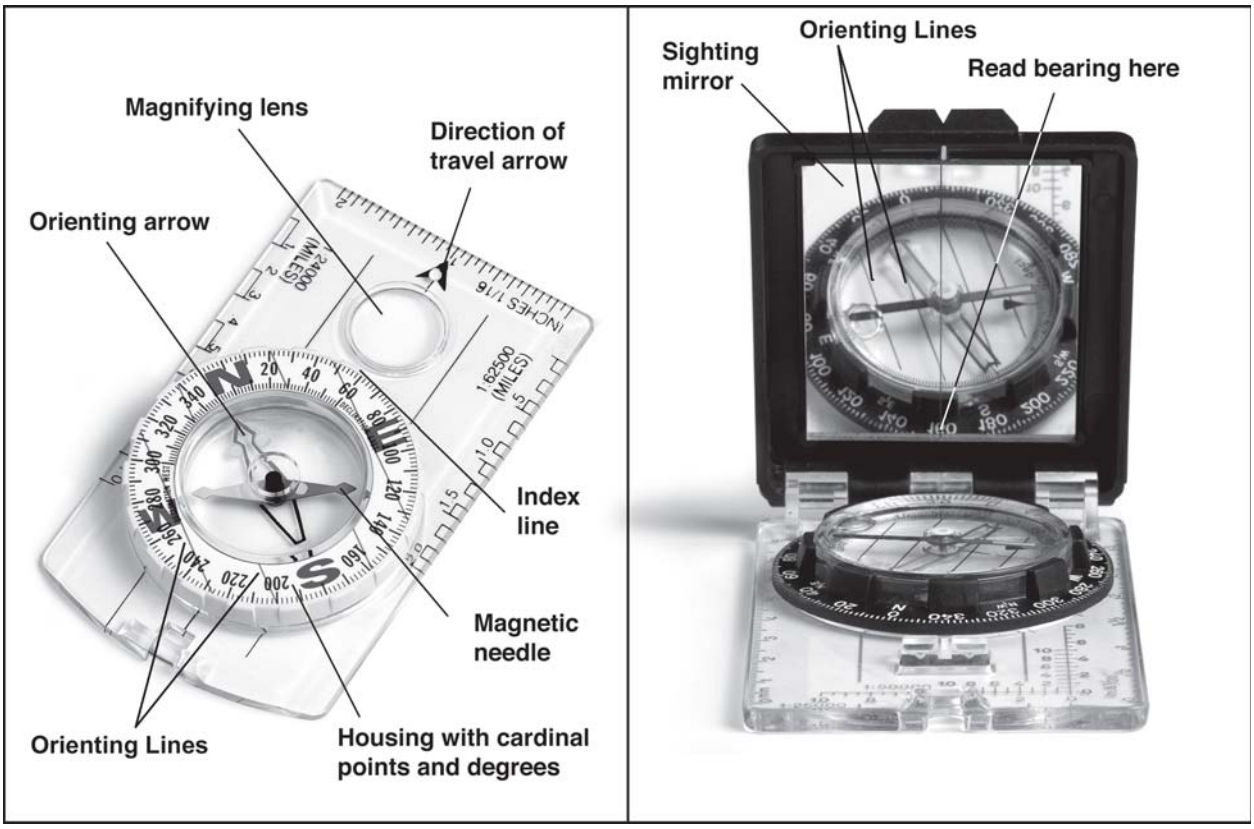


Figure 4-1. Parts of a compass.

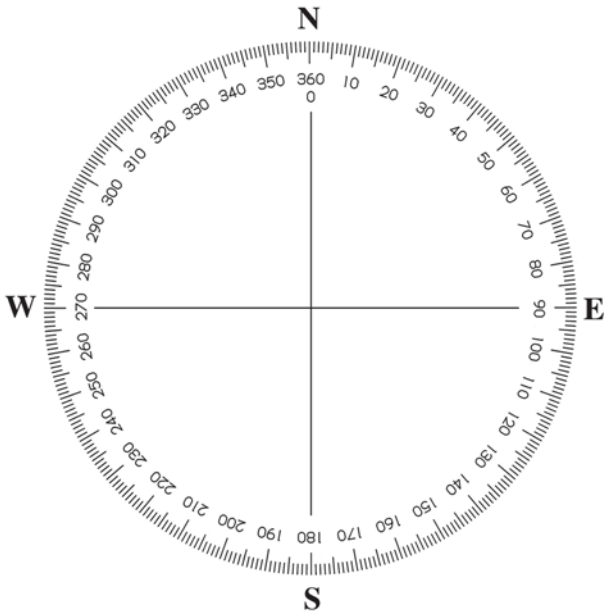


Figure 4-2. Cardinal points and degrees.

Tips on Getting Accurate Compass Readings

A small error when using a compass can result in a significant error in measurement on the ground. To obtain accurate readings when using a compass:

- Hold the compass level and steady so the needle swings freely.
- Hold the compass about waist high in front of the body, except when using a compass with a sighting mirror or a sighting type compass.
- Raise and lower eyes when taking a bearing, do not move your head. Always use the same eye when taking bearings.
- Directly face object that is being measured.
- Magnetic fields will give incorrect compass readings. Avoid taking readings near magnetic fields such as steel, iron (ferrous metals), vehicles, rebar, and clipboards. Even belt buckles, glasses, and rings can interfere with the compass reading.
- Take bearing twice.
- Adjust for magnetic declination as appropriate.
- Follow the direction of travel arrow, not the compass needle, when walking a bearing. Always follow the line indicated by the compass rather than relying on judgment as to the direction.
- Use back bearings to ensure you are on track when navigating.

Adjusting a Compass for Magnetic Declination

The compass needle always points toward magnetic north; however, topographic maps are drawn in reference to true north (North Pole). The difference between magnetic north and true north is called the angle of magnetic declination, or simply, the declination. Therefore, when using a map and compass together, an adjustment has to be made for declination.

Magnetic declination not only changes with geographic location, but also changes slightly over time. In the contiguous U.S., the magnetic declination generally varies between zero and twenty degrees (Figure 4-3). Only along the zero declination line are true north and magnetic north the same, and therefore, no adjustment has to be made for declination (this is the dark, heavy line labeled as 0° in Figure 4-3).

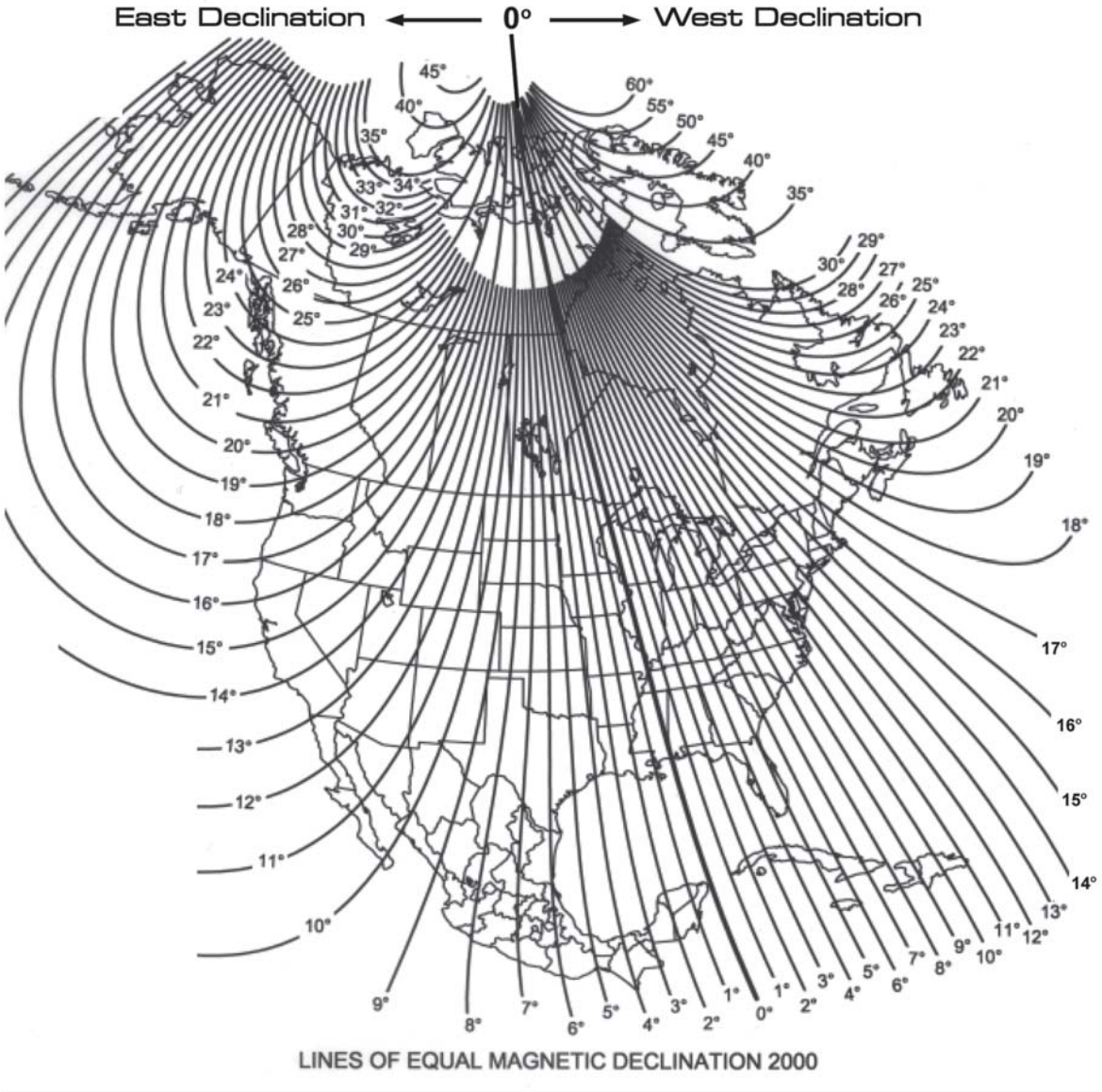


Figure 4-3. Declination chart of United States.

When someone is using their compass in a location that is east of the zero declination line (for example Maine), the needle will point in a direction that is west of true north – this is referred to as westerly declination. When someone is using a compass in a location that is west of the zero declination line (for example Nevada), the needle will point in a direction that is east of true north – this is referred to as easterly declination.

Magnetic Declination on Topographic Maps

Magnetic declination is printed in the lower left hand corner on USGS topographic maps in the arrow diagram or in the information block. Since declination does slightly change over time, topographic maps of the same area can have different declinations if the maps were published on different dates. There are web sites that will provide declination when a zip code is entered.

Adjusting a Compass

Making an adjustment for declination is essential when using a map and compass together. Either the map or the compass needs to be adjusted for declination. It is generally easier to adjust the compass for declination, rather than the map. When the compass is adjusted then geographic north is the reference point for both the compass and the map.

The process for adjusting declination on a compass depends upon the type of compass; therefore, refer to the owner's manual for specific instructions. Some compasses have a declination screw that can be turned which rotates the orienting arrow. Others require the rotation of the center of the case so the orienting arrow is offset by declination. Some compasses are automatically adjusted. It is important to be accurate when setting declination because 1 degree off can result in 920 feet off course in 10 miles.

Orienting a Compass

There are two different ways to orient a compass – to magnetic north or geographic north. The purpose of orienting a compass is so you know your location in relation to north. Orienting a compass to north is also called "boxing the needle" because it refers to aligning the north seeking end of the magnetic needle over the orienting arrow.

Orient to Magnetic North

One method for orienting the compass to magnetic north is described in Table 4-1 and illustrated in Figure 4-4.

Table 4-1. Steps to orient a compass.

Steps	Directions
1	Set 360° or 0° on the compass dial in line with the index line.
2	Hold the base plate and turn your body until the north seeking end of the magnetic needle lines up with the orienting arrow. The direction you are facing is magnetic north.

Figure 4-4. Orient a compass.

Orient to Geographic North

If you are going to use your compass with a map, then orient the compass to geographic north. Adjust the compass for magnetic declination and then follow the steps in Table 4-1.

Taking Bearings (Direct and Back)

Taking a bearing refers to measuring the direction from one point to another, either in the field or on a map. A bearing is the measurement of direction between two points and it is typically expressed as an angle, for example 30 degrees. Bearings taken with a compass that has **not** been adjusted for magnetic declination are called "magnetic bearings." Whereas bearings taken with a compass that has been adjusted for magnet declination are called "true bearings." This section focuses on taking a direct and back bearing in the field and Chapter 6, Navigation and Field Mapping, addresses how to take a bearing on a map.

Taking a Direct Bearing

A direct bearing is measured from your position towards an object. It tells you the direction from you to the object, destination or landmark. One method for taking a direct bearing is described in Table 4-2 and illustrated in Figure 4-5.

Table 4-2. How to take a direct bearing.

Steps	Directions
1	Adjust compass for declination if using the bearing with a map.
2	Face object and align the direction-of-travel arrow with the object whose bearing you want to measure.
3	Turn the compass housing until the north end of the magnetic needle is aligned with the orienting arrow.
4	Read the bearing where the direction of travel arrow or index line meets the dial. This is the direction to the object, expressed as an angle.

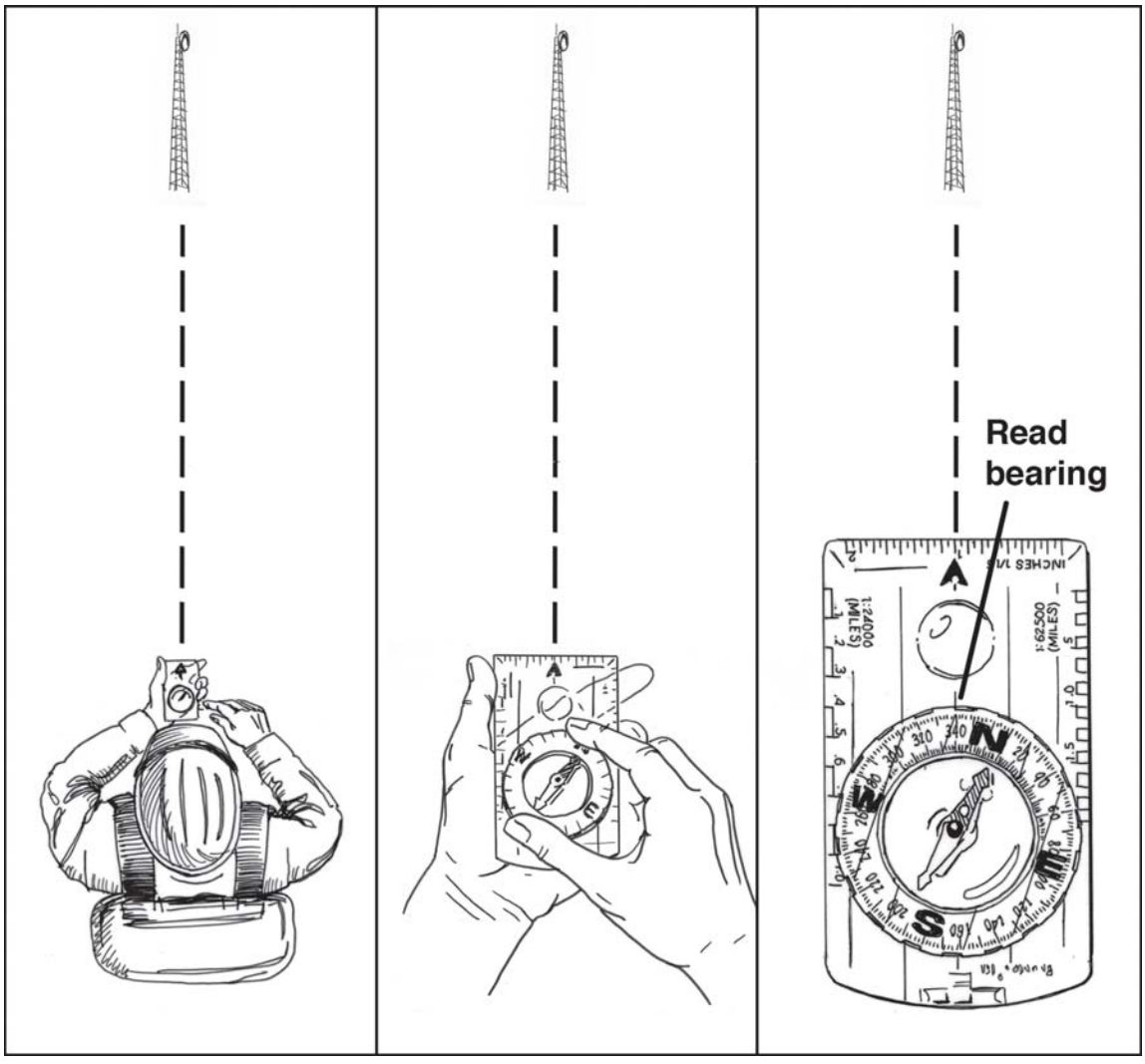


Figure 4-5. Taking a direct bearing.

Taking a Back Bearing

A back bearing, which is sometimes called backsighting, is the exact opposite of a bearing – it is measured from the object to your position. The back bearing differs by 180° or the opposite direction from the direct bearing (Figure 4-6).

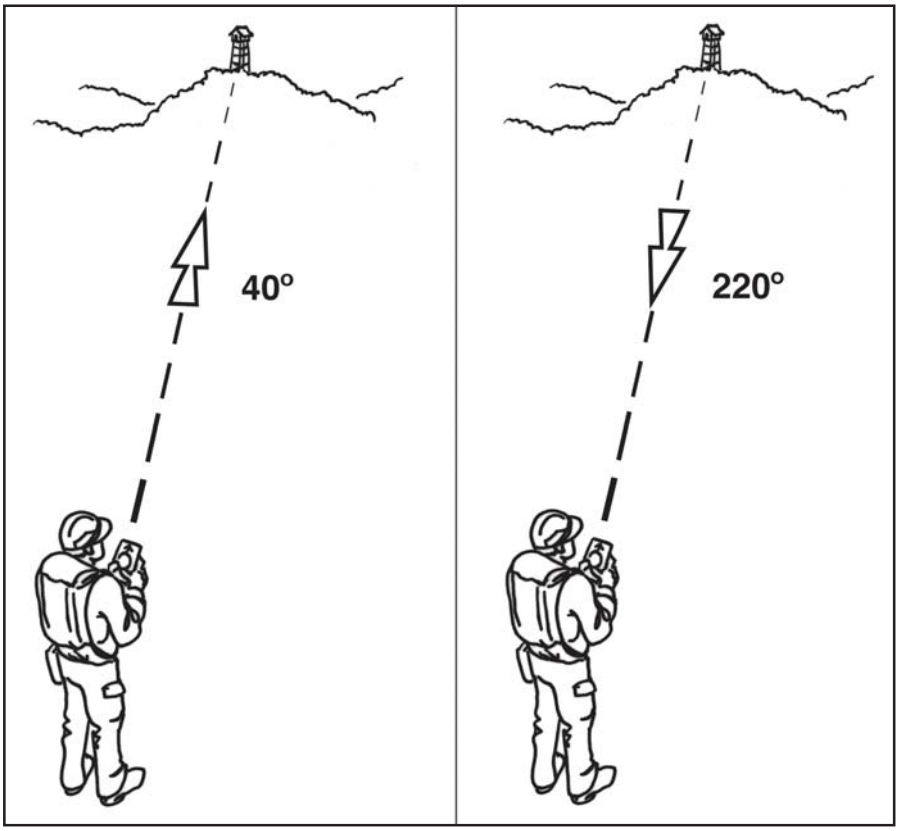


Figure 4-6. Direct and back bearing.

Two common methods for determining a back bearing include:

- Using a compass – similar process to taking a direct bearing, but instead take a back bearing by aligning the south end of the needle with the orienting arrow.
- Using addition and subtraction.
  - If the direct bearing is between zero and 180° **add** 180° to find the back bearing. For example, if the direct bearing is 60° the back bearing is 240°.
  - If the direct bearing is between 180° and 360° **subtract** 180° to find the back bearing.

Back bearings are important because they can be used to communicate your position to someone else, for example, "I am located 145° from the cell tower." They are also used when navigating to help ensure you are on course.

Following Bearings

One of the main reasons for using a compass is to help you follow a straight course to a destination. A bearing can help you stay on course even if you lose sight of your destination due to terrain, vegetation, fog, smoke or other conditions.

Following a bearing refers to setting a bearing on the compass and then following that bearing along a line to the destination. If the final destination is a long distance from starting point or if it is visually obstructed (due to vegetation, terrain, weather, or other condition) look for an intermediate destination (boulder, landmark, identifiable tree) that is on that same bearing. If there are no visible intermediate destinations, another person can serve as the intermediate destination.

One method for following bearings is described in Table 4-3 and illustrated in Figure 4-7.

Table 4-3. How to follow a bearing.

Steps	Directions
1	Adjust compass for declination if using the bearing with a map.
2	Take a bearing of the destination or landmark. If the destination or landmark is a long way away, choose an intermediary object that is visible and located along the line of the direction-of-travel arrow. Don't turn the compass housing after you have taken the bearing.
3	Walk to the intermediary or goal destination by the easiest route, it doesn't have to be straight route. Don't look at your compass while you are walking, just walk towards the destination.
4	Check to make sure you are still aligned with the original bearing. – Stop walking. Hold the compass but don't turn the housing. Turn your body left or right until the north-seeking end of the needle end matches the pointed end of the orienting arrow. The direction-of-travel arrow should now be pointing towards the object. – Take a back bearing to the intermediary or starting point. It should be 180° from the direct bearing that was taken from that point. If it isn't – walk to one side or the other until it is. Then turn around and sight ahead on the original bearing. A mistake of a few degrees can result in a significant mistake in distance from your final destination.
5	Repeat steps above until goal object is reached.

Figure 4-7. Following a bearing.

Estimating Slope with a Clinometer

A clinometer is an instrument that measures the angle of a slope. It can also be used to measure elevation or height. There are different types of clinometers and they have different scales. Table 4-4 outlines one method to estimate slope using a clinometer, which is illustrated in Figure 4-8.

Table 4-4. Steps to estimate slope using a clinometer.

Steps	Directions
1	Stand so you are facing directly up or down the slope.
2	Hold clinometer vertically. Keep both eyes open. Use one eye to read the scale inside the hole and the other eye to sight on an object that is about the same height above the ground as your eye level height. Align the horizontal band with this object.
3	Read the appropriate scale in percent or degrees as indicated by the horizontal band.

Figure 4-8. Estimating slope with a clinometer.

Some compasses have a built-in clinometer; however, when using the clinometer on a compass, the slope is reported in degrees, not percent. Figure 4-9 illustrates a general relationship between percent slope and degree slope. Refer to the compass owner's manual for instructions on estimating slope using the built-in clinometer and conversion information.

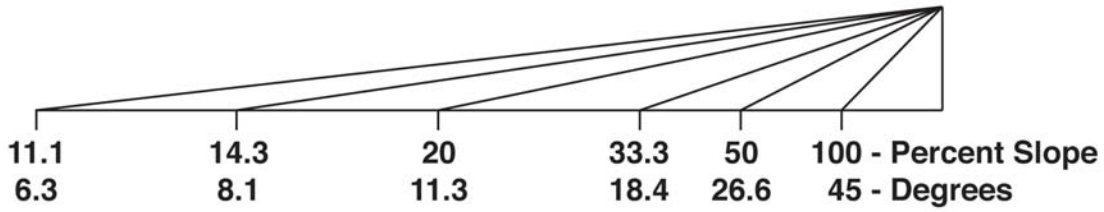


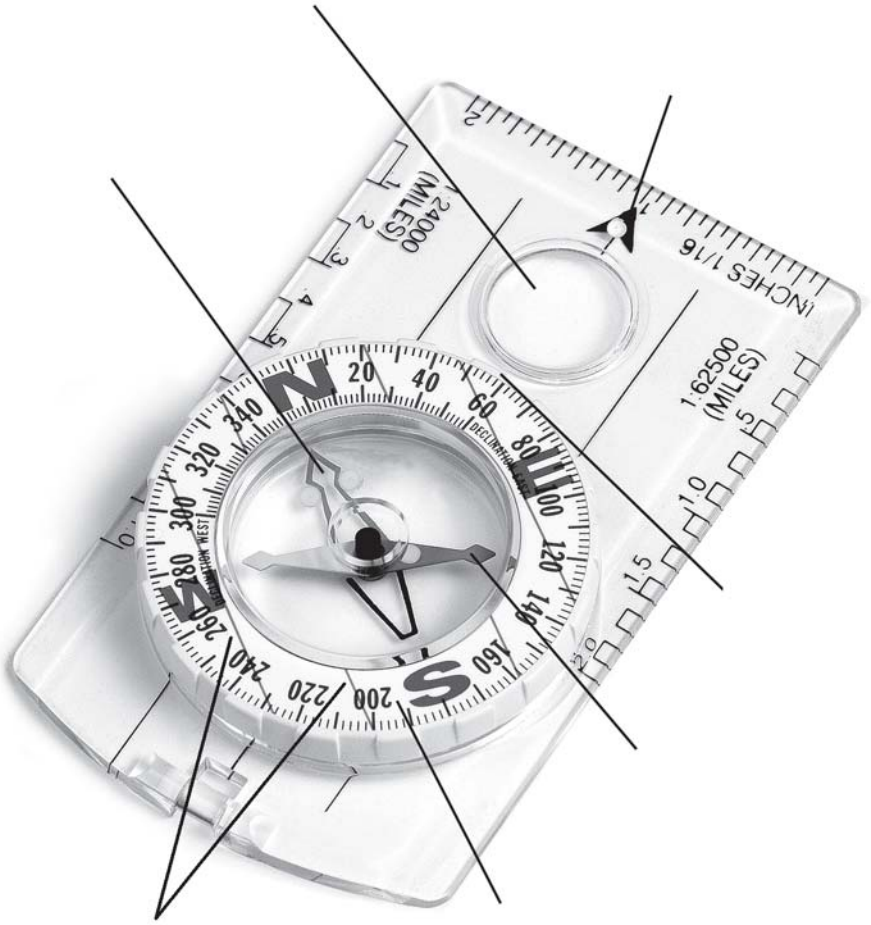
Figure 4-9. General relationship between percent slope and degree slope.

Checking Your Understanding

Answers to "Checking Your Understanding" can be found in Appendix B.

1. List three examples of how you may use a compass on an incident.

2. Label the seven parts of a compass.



3. List five tips on how to obtain accurate compass readings.

4. How do you adjust your compass for declination? How do you know what the declination is for the area where you are working?

5. What are the two different ways to orient a compass?

6. The following exercises will improve your performance.

   - Practice taking direct bearings and back bearings of various objects.

   - Take a compass bearing of a distant object. Mark your starting location, walk to your object. Now take a back bearing and follow that bearing. How far off were you from your starting point?

   - Practice estimating slope using a clinometer.