Chapter 1

Lesson 7
Determining Direction

Key Terms

azimuth
back azimuth
degree
grid azimuth
grid north
magnetic azimuth
magnetic north
true north

WHAT YOU WILL LEARN TO DO

- Calculate direction on topographic maps

LINKED CORE ABILITIES

- Communicate using verbal, non-verbal, visual, and written techniques
- Apply critical thinking techniques

SKILLS AND KNOWLEDGE YOU WILL GAIN ALONG THE WAY

- Define the three base directions
- Identify the symbols that represent direction on a topographic map
- Demonstrate how to determine and measure a magnetic azimuth
- Demonstrate how to determine, measure, and plot a grid azimuth
- Demonstrate how to determine a back azimuth
- Define key words contained in this lesson

Introduction

In the last lesson, you learned how to determine the distance between two points. After you have determined this distance, you have part of the information you need to get where you are going. To reach your destination, however, you still need to know what direction to travel.

Directions play an important role in everyday life. People oftentimes express them as right, left, straight ahead, and so forth; but then the question arises, "to the right of what?" To answer that question, this section first defines different types of azimuths and three different types of north. It then explains how to determine grid and magnetic azimuths using a protractor and compass.

Key Note Term

degree – a unit of latitude or longitude, equal to 1/360 of the globe

true north – a line from any position on the earth's surface to the geographic north pole; symbolized by a line with a star at the apex

magnetic north – the direction to the north magnetic pole, as indicated by the north-seeking needle of a magnetic instrument

grid north – the direction of north that is established by using the vertical grid lines on a map

Expressing Directions

Direction is typically expressed as a unit of angular measure. The most common unit of measure is the **degree**. There are 360 degrees in a circle. Each degree is subdivided into 60 minutes and each minute into 60 seconds.

To express direction as a unit of angular measure, there must be a starting point (or zero measurement) and a point of reference. These two points designate the base direction or reference line. There are three base directions—**true north**, **magnetic north**, and **grid north**—but you will only be using magnetic and grid north in this lesson.

- **True north is a line from any point on the earth's surface to the north pole. All lines of longitude are true north lines. Mapmakers normally represent true north in the marginal information with a star, as shown in Figure 1.7.1.**
- **Magnetic north is the direction to the north magnetic pole, as shown by the north-seeking needle of a compass or other magnetic instrument. Mapmakers usually illustrate magnetic north in the marginal information by a line ending with a half arrow-head, as shown in Figure 1.7.1.**
- **Grid north is the north that mapmakers establish with the vertical grid lines on a map. They usually illustrate it by placing the letters "GN" on a vertical line in the marginal information, as shown in Figure 1.7.1.**

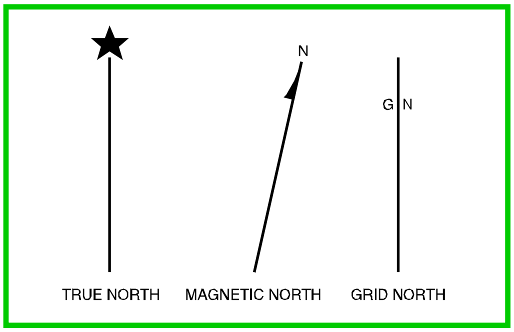

Figure 1.7.1: The three norths.

Courtesy of CACI and the US Army.

Azimuths

An **azimuth** is defined as a horizontal angle measured clockwise from a base direction. The azimuth is the most common military method to express direction. When using an azimuth, the point from which the azimuth originates is the center of an imaginary circle (see Figure 1.7.2).

Key Note Term

azimuth – a horizontal angle usually measured clockwise in degrees from a north base line (direction)

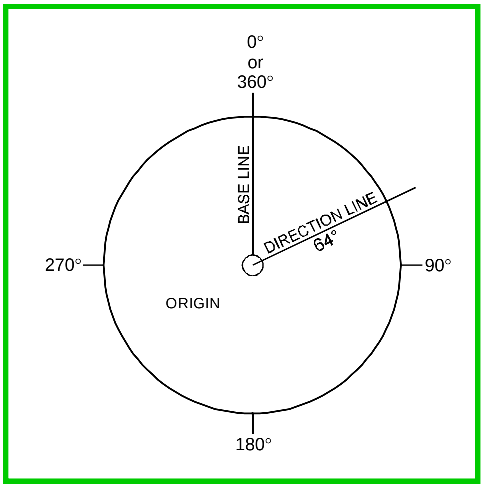

Figure 1.7.2: The circle used to determine an azimuth.

Courtesy of CACI and the US Army.

Key Note Term

back azimuth – the opposite direction of an azimuth obtained by adding 180 degrees to or subtracting 180 degrees from an azimuth

magnetic azimuth – a direction that is expressed as the angular difference between magnetic north and a line of direction

grid azimuth – the angle measured between grid north and a straight line plotted between two points on a map

There are three distinct ways to express an azimuth: **back azimuth**, **magnetic azimuth**, and **grid azimuth**. Following the definition of these azimuths, the remainder of this lesson explains how to measure magnetic and grid azimuths.

A back azimuth is the opposite direction of an azimuth. It is just like doing an "about face." To obtain a back azimuth from an azimuth, *add* 180 degrees if the azimuth is 180 degrees or less; or *subtract* 180 degrees if the azimuth is 180 degrees or more (see Figure 1.7.3). The back azimuth of 180 degrees may be stated as 0 degrees or as 360 degrees.

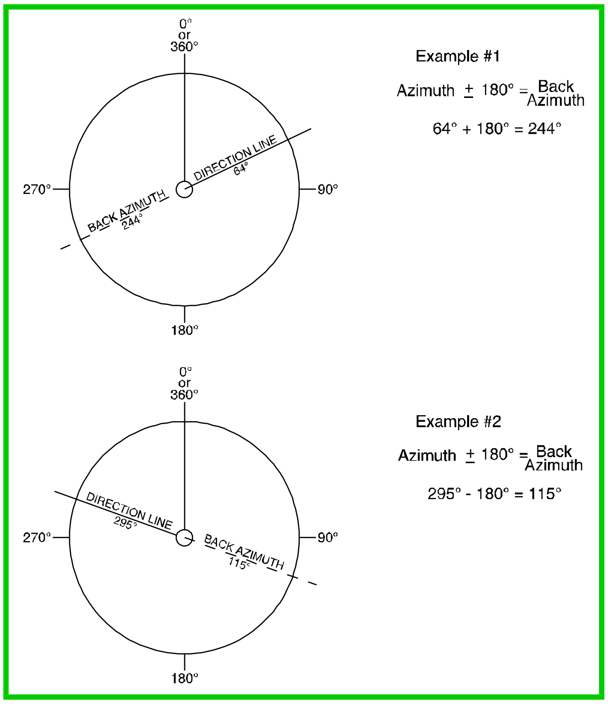

Figure 1.7.3: Calculating a back azimuth.

Courtesy of CACI and the US Army.

A magnetic azimuth is a direction expressed as the angular difference between magnetic north and the direction line (see Figure 1.7.4). You can determine a magnetic azimuth using a compass or other magnetic instrument (such as surveying equipment).

A grid azimuth is the angle measured between grid north and a straight line plotted between two points on a map (see points "a" and "b" in Figure 1.7.4). You would use a protractor to measure this angle.

Types of Compasses

You determine a magnetic azimuth with the use of a compass. Two of the most common types of compasses are the magnetic lensatic compass and the silva compass.

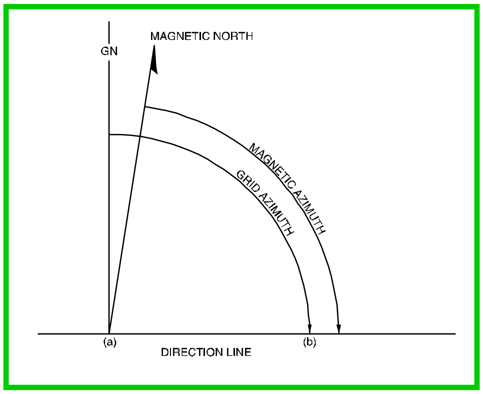

Figure 1.7.4: Magnetic and grid azimuths.

Courtesy of CACI and the US Army.

The Magnetic Lensatic Compass

The magnetic lensatic compass (see Figure 1.7.5), used by the military, is the most common and simplest instrument for measuring direction. It has three major parts: cover, base, and lens.

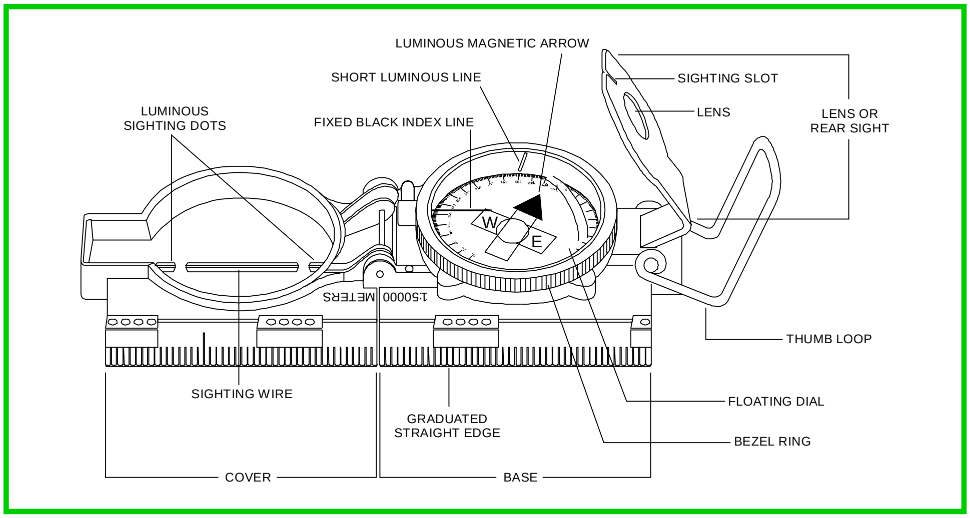

Figure 1.7.5: The magnetic lensatic compass.

Courtesy of CACI and the US Army.

The cover protects the floating dial. It contains the sighting wire (front sight) and two luminous sighting slots or dots used for night navigation. The base contains several movable parts, including the floating dial, the bezel ring, and the thumb loop.

The floating dial is mounted on a pivot so it can rotate freely when you hold the compass level. Printed on the dial in luminous figures are an arrow and the letters E and W or E, W, and S. The arrow always points to magnetic north and the letters fall at East (90 degrees), South (180 degrees), and/or West (270 degrees). There are two scales. The outer denotes mils and the inner scale (normally in red) denotes degrees. Encasing the floating dial is a glass containing a fixed black index line.

The bezel ring is a ratchet device that clicks when turned. It contains 120 clicks when rotated fully. Each click is equal to 3 degrees. A short luminous line used in conjunction with the north-seeking arrow is contained in the glass face of the bezel ring.

The base also contains the thumb loop.

You use the lens to read the dial. The rear sight also serves as a lock and clamps the dial when closed. You must open the rear sight more than 45 degrees to allow the dial to float freely. There is also a rear-sight slot used for sighting on objects. Use this with the front sight sighting wire.

The Silva Compass

The Silva Polaris (Type 7) precision compass (see Figure 1.7.6) is also one of the most accurate compasses on the market today. Some high schools prefer it over the military issued, magnetic lensatic compass due to its cost and availability. The Silva compass is easy to use, especially with its hand-contoured base plate. It is typically available at certain discount department stores for just under $10. Figure 1.7.6 shows the Silva Polaris (Type 7) compass along with its eight features.

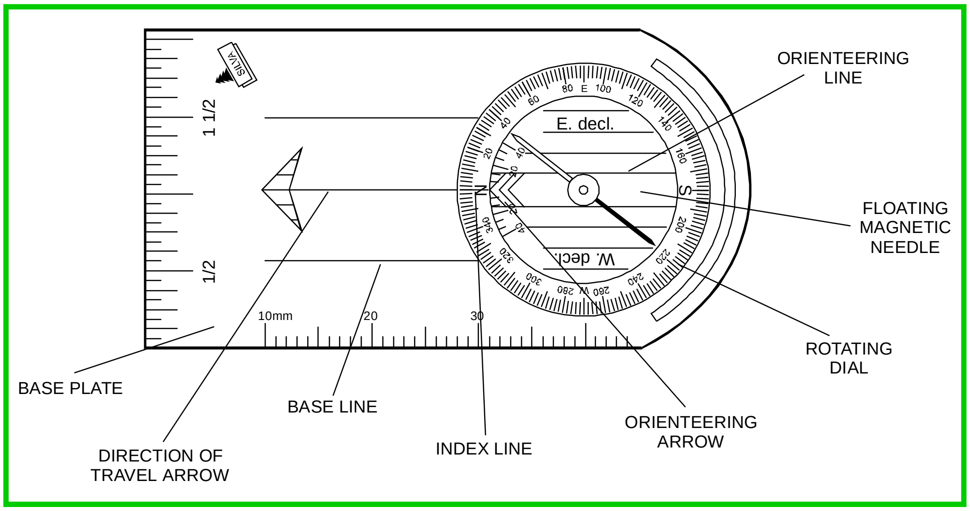

Figure 1.7.6: The Silva compass.

Courtesy of CACI and the US Army.

The floating needle is mounted on a pivot so that it can rotate freely when you hold the compass level. It settles within four seconds, always pointing to magnetic north. Printed distinctly on the rotating dial are the letters N and S, to represent 0/360 degrees and 180 degrees, respectively. The dial is graduated at two degree intervals, marked at 20 degree intervals, and contains the letters E (at 90 degrees) and W (at 270 degrees).

The base plate contains two rulers (one measured in inches and the other in millimeters). It also has a 40-degree east and west declination scale inside the area of the floating dial.

Measuring a Magnetic Azimuth

The following steps explain how to determine a magnetic azimuth using the centerhold technique (see Figure 1.7.7). This method is the fastest and easiest way to measure a magnetic azimuth. There is also a compass-to-cheek technique as well as ways for presetting a compass; however, those procedures will not be covered in this unit.

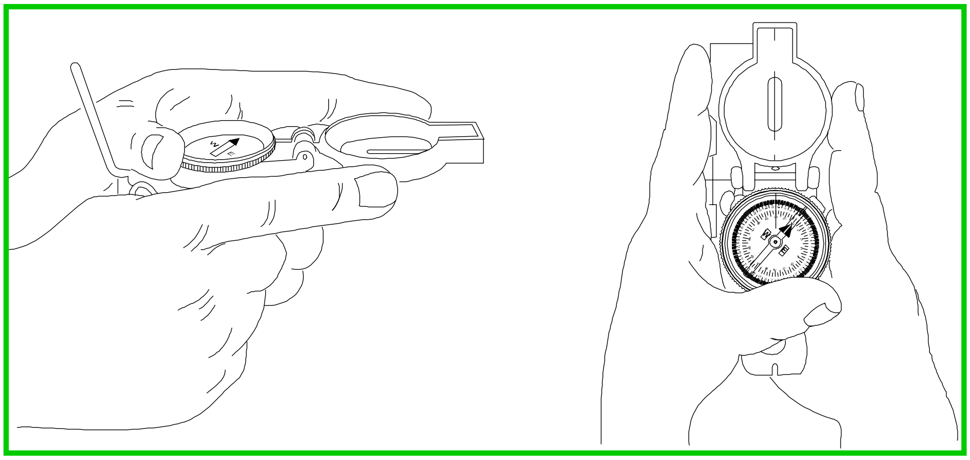

Figure 1.7.7: The centerhold technique is used to determine a magnetic azimth.

Courtesy of CACI and the US Army.

These six steps are for the magnetic lensatic compass.

1. **Open the compass to its fullest so that the cover forms a straightedge with the base.**
2. **Move the lens (rear sight) to the rearmost position, allowing the dial to float freely.**
3. **Place your thumb through the thumb loop, form a steady base with your third and fourth fingers, and extend your index finger along the side of the compass. Place the thumb of the other hand between the lens (rear sight) and the bezel ring. Extend the index finger along the remaining side of the compass, and the remaining fingers around the fingers of the other hand.**
4. **Pull your elbows firmly into your sides. This action places the compass between your chin and waist.**
5. **To measure an azimuth, simply turn your entire body toward the object, pointing the compass cover (zero or index mark) directly at the object.**
6. **After you are pointing at the object, look down and read the azimuth from beneath the fixed black index line. Figure 1.7.8 shows a magnetic azimuth of 320 degrees.**

For the Silva compass, modify step 3 to hold it either completely in one hand (with the curved end toward the back of the palm) or with both hands (as shown in Figure 1.7.7, but disregarding the information on thumb loop and rear sight).

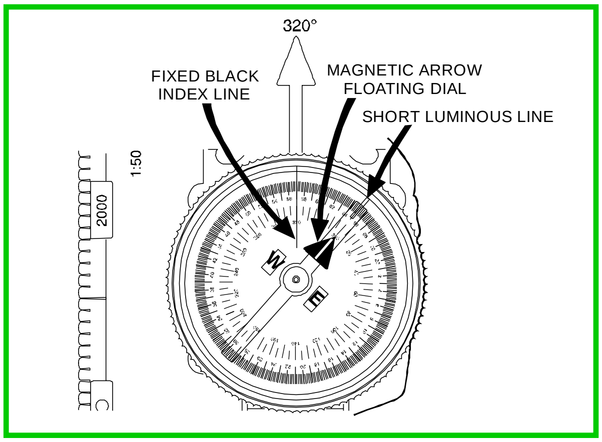

Figure 1.7.8: Using the centerhold technique to determine a magnetic azimuth of 320 degrees.

Courtesy of CACI and the US Army.

Note

Ensure that you are away from power lines, vehicles, or other metal objects when using a compass because these objects will affect its accuracy.

Some compasses may have a 1:25,000 scale; you can still use this scale with a 1:50,000 scale map, but you must halve the values read.

Using Protractors

You determine a grid azimuth with the use of a protractor. There are several types of protractors: full circle, half circle, square, or rectangular. All of them divide the circle into units of angular measure, and each has a scale around the outer edge and an index mark. The index is the center of the protractor circle from which you measure all directions.

On the military protractor, you read the inner of two scales because it is graduated into degrees—from 0 to 360 degrees. Each tick mark on the degree scale represents one degree. The base line of this protractor is a line from 0 degrees to 180 degrees. Where the base line intersects the horizontal line, between 90 degrees and 270 degrees, is the index or center of the protractor.

When using the protractor, the base line is always oriented parallel to a north-south grid line. The 0- or 360-degree mark is toward the top or north on the map, and the 90-degree mark is to the right. Steps for determining and plotting grid azimuths are explained in the following section.

Measuring a Grid Azimuth

The following steps explain how to measure a grid azimuth using a map and protractor (see Figure 1.7.9).

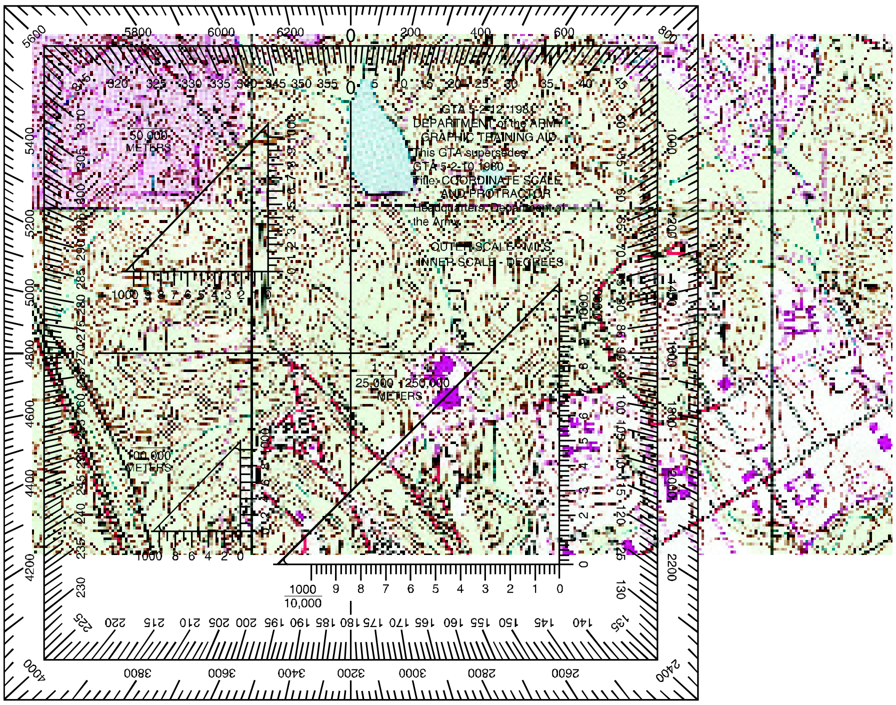

Figure 1.7.9: Using a protractor to measure a grid azimuth.

Courtesy of the United States Geological Survey, modified by Pearson Custom Publishing.

1. **Draw a line connecting the two points (A and B on Figure 1.7.9).**
2. **Place the index of the protractor at the point where the drawn line crosses a vertical (north-south) grid line.**
3. **Keep the index at that point and align the 0–180 degree line of the protractor on the vertical grid line.**
4. **Read the value of the angle from the scale. This value is the grid azimuth from point A to point B, or 68 degrees in our example.**

Plotting a Grid Azimuth

Use the following steps to plot an azimuth from a known point on a map (see Figure 1.7.10). For this example, you will *not* have to convert the azimuth from magnetic to grid.

1. **Place the protractor on the map with the index mark at the center of mass of the known point and the 0–180 degree base line parallel to a north-south grid line. (Use BM 145 on State Route 103.)**
2. **Make a mark on the map at the desired azimuth. (Use an azimuth of 210 degrees.)**
3. **Remove the protractor and draw a line connecting the known point and the mark on the map. This is the grid direction line or grid azimuth.**

> ### *Note*
> Distance has no effect on azimuths.

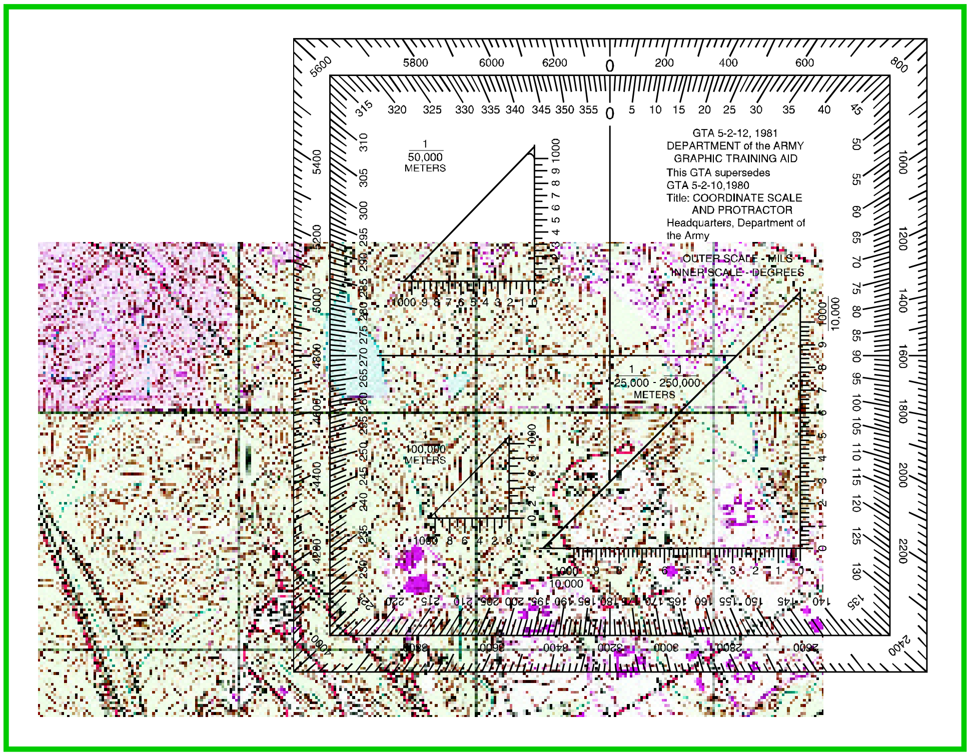

Figure 1.7.10: Using a protractor to plot a grid azimuth.

Courtesy of the United States Geological Survey, modified by Pearson Custom Publishing.

Proceed with Caution!

When measuring azimuths on a map, remember that you are measuring from a starting point to an ending point. If you make a mistake and you take the reading from the ending point, the grid azimuth will be opposite, thus causing you to go in the wrong direction.

Chapter 1 Lesson Review

Conclusion

Regardless of where you live, you need a way of expressing direction that is accurate and has a common unit of measure. Simply expressing, "to the right of that_._._._," may not be sufficient. The use of azimuths, compasses, protractors, and maps will improve the accuracy of your directions.

Lesson Review

1. **Define and describe the three base directions.**
2. **Describe how to determine and measure a magnetic azimuth.**
3. **Describe how to determine, measure, and plot a grid azimuth.**
4. **Explain how to calculate a back azimuth.**