Unit VI – Geography and Survival Skills

Chapter 1 - Geography, Map Skills, and Environmental Awareness

Section 4 – Distance and Direction

What You Will Learn to Do

Understand the principles and tools of map reading and land navigation

Objectives

1. Measure distance using maps
2. Calculate direction on topographic maps

Key Terms

CPS Key Term
Questions 1 - 7

Key Terms

Representative Fraction (RF) -	The relationship of distance measured on a map to the corresponding distance on the ground; usually written as a fraction
Center of Mass -	The point closest to the middle of an object
Azimuth -	A horizontal angle usually measured clockwise in degrees from a north base line(direction)

Key Terms

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

Key Terms

Grid Azimuth - The angle measured between grid north and a straight line plotted between two points on a map

Mil - A unit of angular measurement equal to $^{1}/_{6400}$ of a complete revolution

Opening Question

How might terrain variations affect your ability to judge distance and direction?

1.

2.

3.

(Use CPS "Pick a Student" for this question.)

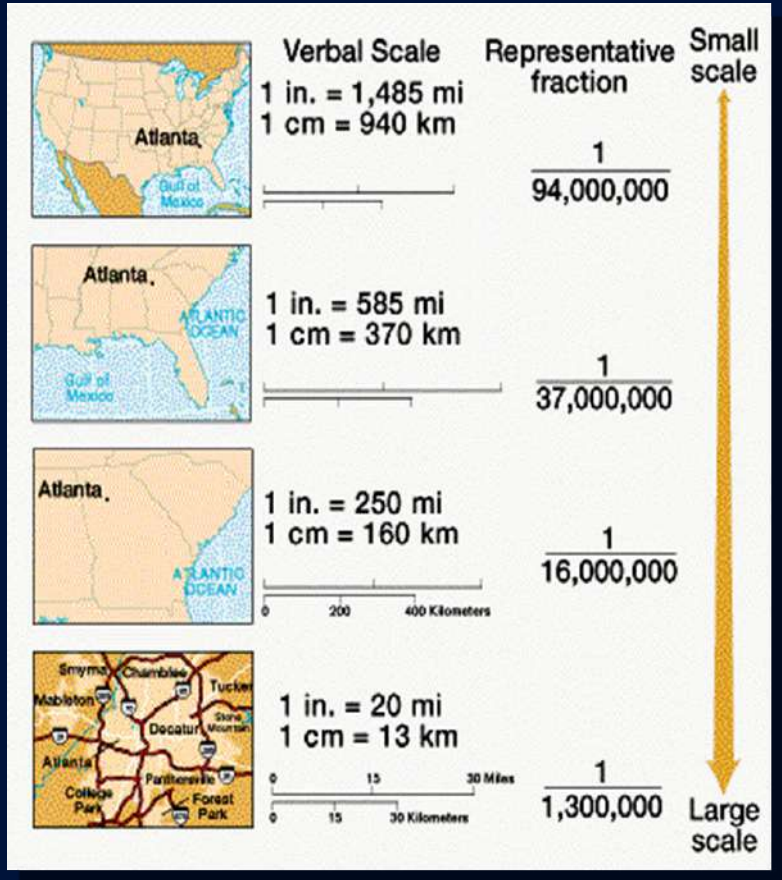
Warm Up Questions

CPS Lesson
Questions 1 - 2

Determining Distance

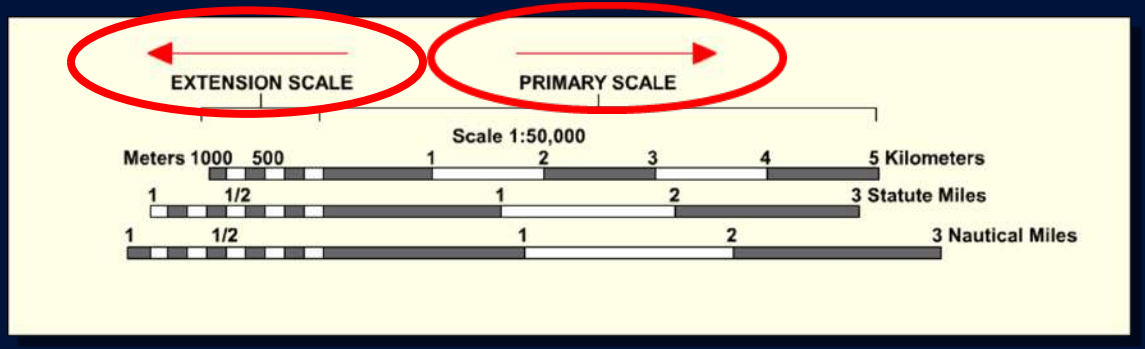
Navigating from one point to another with the use of a map and compass involves the ability to apply simple map-reading skills.

Mapmakers express a map scale as a representative fraction, which gives the ratio of map distance to ground distance.



Determining Distance

Mapmakers divide the graphic scale into two parts: extension and primary scales.



Use the extension scale, located to the left of the zero, to measure tenths of a unit.

Read the extension scale right to left from the zero and the primary scale left to right from the zero.

Use the primary scale, located to the right of the zero, to measure full units.

Determining Distance

Most road maps indicate distance in miles along primary roads between towns, road junctions, or dots.

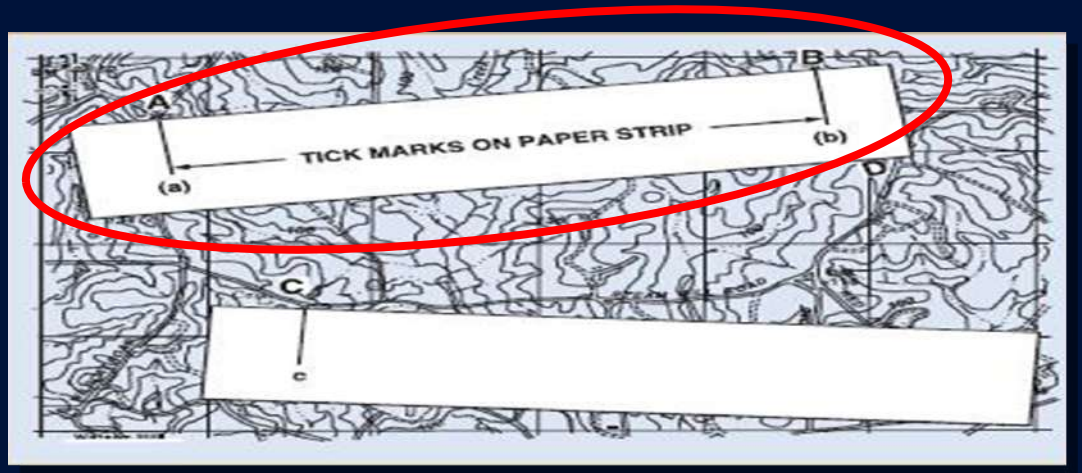
But distance isn't given on a topographic map, so you must determine the distance between two points.

To do this, you must first measure the map distance, then convert that measurement to actual ground distance.

Using the bar scale is the best way to do this.

Measuring Straight-Line Dista

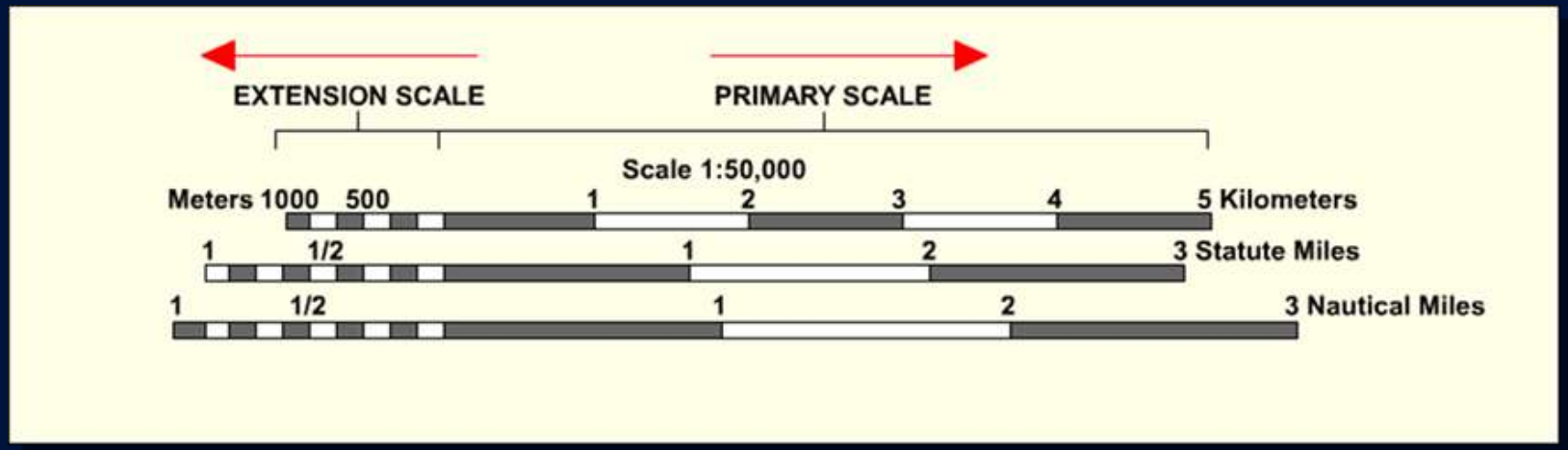
Lay a straight-edged piece of paper on the map so that the edge of the paper touches both points and extends past them.



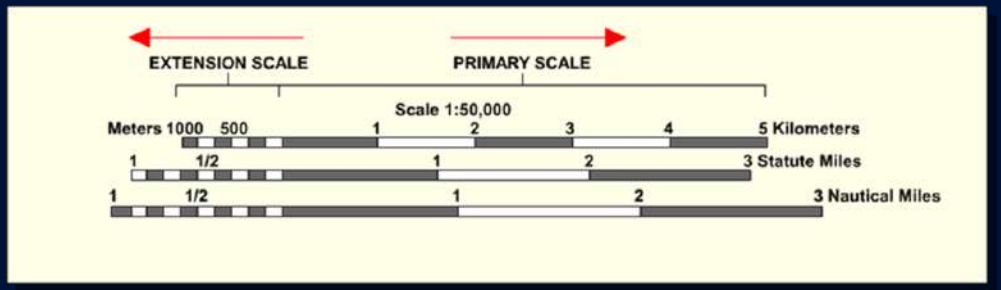
Make a tick mark on the edge of the paper at the center of mass for each point, (a) and (b).

Measuring Straight-Line Distance

To convert the map distance to ground distance, move the paper down to the graphic bar scale, and align the right mark (b) with a printed number on the primary scale so that the left mark (a) is in the extension scale.



Measuring Straight-Line Distance



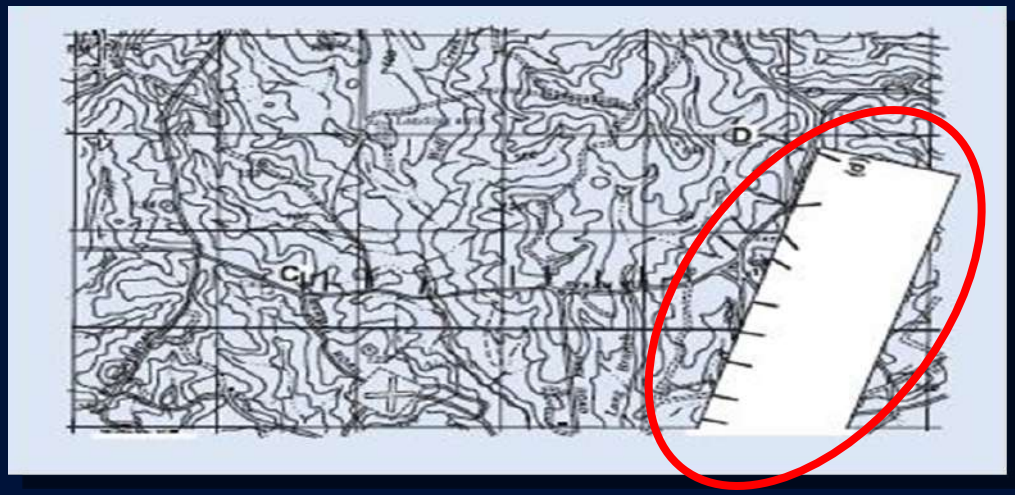
To determine the distance from the zero to mark (a):

- Count the number of whole shaded and clear 100 meter rectangles
- Mentally divide the distance inside the rectangle containing mark (a) into tenths (or 10-meter intervals)
- Now add the distance of 3,000 meters (determined using the primary scale) to the 950 meters (determined using the extension scale)

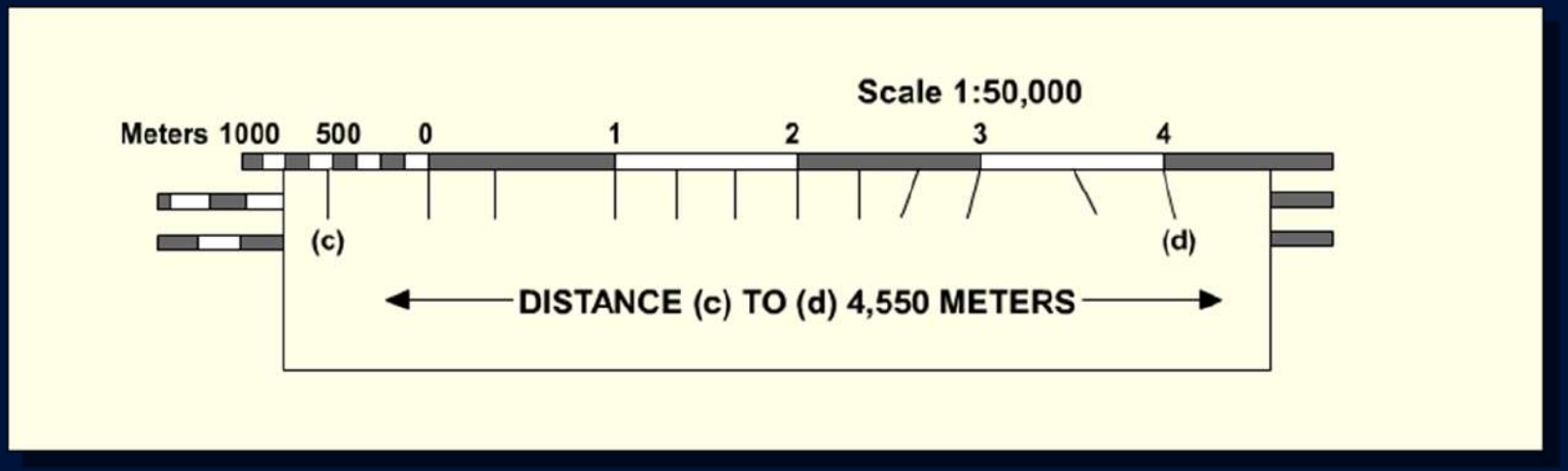
Measuring Curved Lines

Start by making a mark on the paper at the beginning point's center of mass. Move the paper along the curve making marks at short straight distances.

Continue in this manner until you reach the center of mass at the ending point.



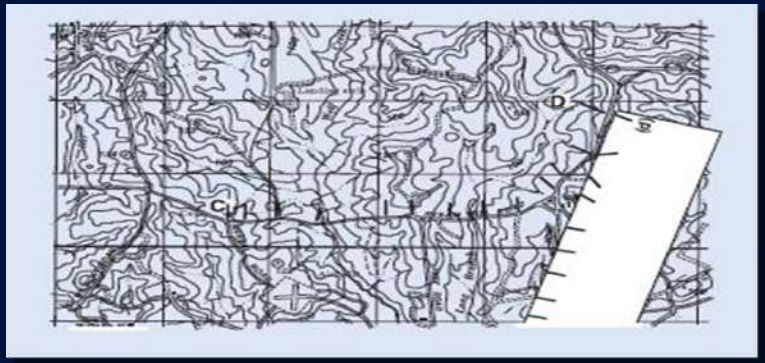
Measuring Curved Lines



Now place the paper on the desired bar scale and read the distance between the beginning and ending marks.

Measuring Curved Lines

Measure the road distance between two points (c) and (d) this way:

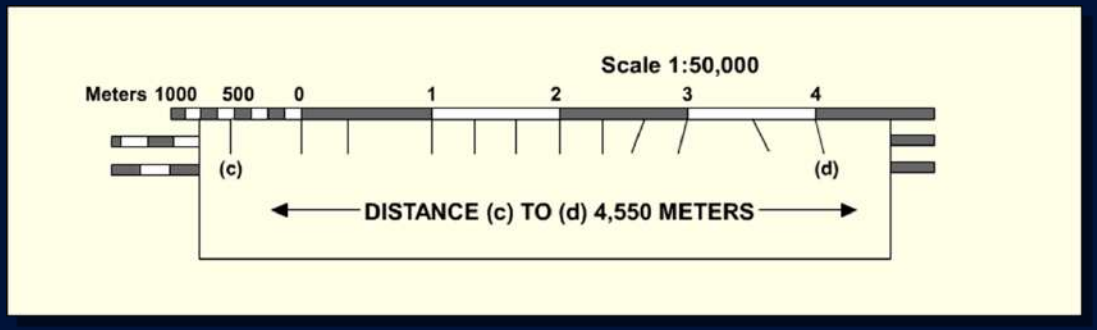


1. Mark the beginning point (c) on straight-edged paper
2. Place marks on both the straight edge piece of paper and the map for each straight portion of road between points (c) and (d).
3. Pivot the straight-edged paper as you make the marks on the paper and map until you reach point (d)

Measuring Curved Lines

Final steps to measure the road distance between two points (c) and (d)…

4. Place the straight-edged paper on the correct bar scale, using only the beginning and ending marks calculate the total distance.
5. You can now use the same method with the bar scale as in the previous example.



Check On Learning Questions

CPS Lesson

Questions 3 - 4

Calculating Distance to a Point off the Map

Follow these steps:

1. Measure the distance (straight-line or curved-line) from the start point to the edge of the map.
2. Check to see if the marginal information gives the road distance from the edge of the map to the point you want; often this is included.
3. When measuring distance in statute or nautical miles, round it off to the nearest one-tenth of a mile.

Calculating Distance to a Point off the Map

Additional Note:

- Distance measured on a map does not take into consideration the rise and fall of the land. All distances measured by using the map and graphic scales are flat distances.
- Therefore, the distance measured on a map will increase when actually measured on the ground. You must take this into consideration when navigating cross-country.

Other Methods of Determining Distance

When navigating, you may encounter circumstances where you are unable to determine distance using your map, or perhaps you may find yourself without a map.

So it's essential to learn alternative methods by which you can accurately pace out or estimate distances on the ground.

Pace Count

Your pace can be used to measure distance in the field.

A pace is equal to one natural step, about 30 inches long. To accurately use a pace count, you must know how many paces it takes to walk 100 meters.

To determine your pace, walk an accurately measured course and count the number of paces (steps) it takes.

The pace course should be on terrain similar to that over which you will be walking.

Pace Count

Adjustment of your pace count occurs due to the following conditions:

- Slopes - Your pace will lengthen on a down-slope and shorten for upgrade.
- Winds - A headwind shortens the pace; a tailwind increases it.
- Surfaces - Sand, gravel, mud, snow, and similar surfaces tend to shorten your pace.
- Elements - Snow, rain, or ice may cause you to reduce the length of your pace.
- Clothing - Excess clothing or shoes with poor traction can affect the pace length.
- Visibility - Poor visibility, such as fog, rain, or darkness can shorten your pace.

Pace Count

Several methods can be used to keep track of your pace count, for example:

- Put a pebble in your pocket every time you have walked 100 meters according to your pace count.
- Tie knots in a string (one for every 100 meters).
- Put marks in a notebook (one for every 100 meters).

Never rely on just your memory for counting!

Estimation

To use this method, you must be able to see a distance of 100 meters on the ground.

For distances up to 500 meters, determine the number of 100 meters increments between 2 objects.

Beyond 500 meters, select a point halfway to the objects and determine the number of 100 meter increments to the halfway point; then double it to find the distance to the objects.

Determining Direction

After you have determined distance, you have part of the information you need to get where you are going.

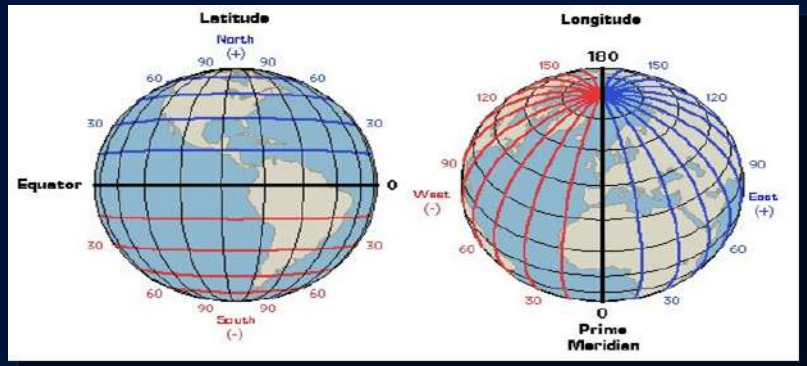
But to reach your destination, you still need to know what direction to travel.

Directions play a key role in everyday life. People often express them as right, left, and straight ahead.

Determining Direction

Direction is expressed as a unit of angular measure. The 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.

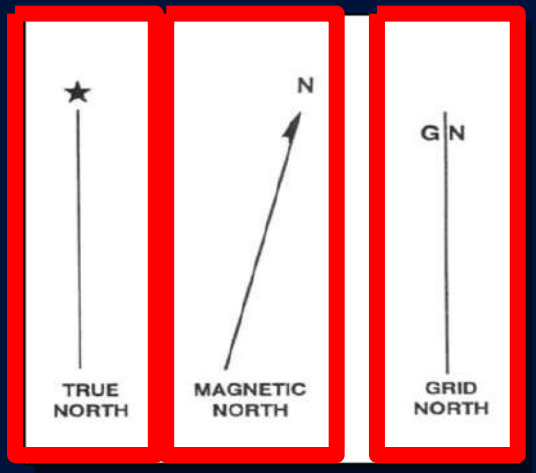


To express direction as a unit of angular measure, there must be a starting point and a point of reference. These two points designate the direction or reference line.

Determining Direction

There are three base directions:

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, and true north is represented with a star.



Magnetic north is the direction to the north magnetic pole as shown by the north-seeking needle of a compass. It's shown on a map by a line ending with a half arrowhead.

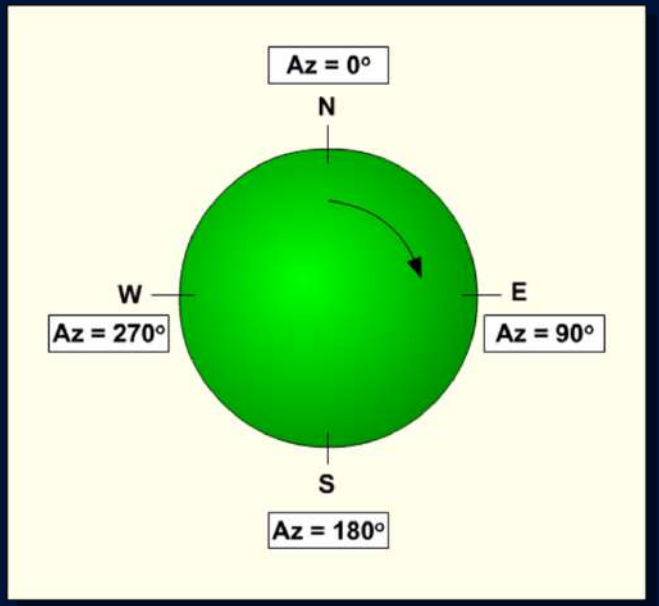
Grid north is the north that mapmakers establish with the vertical grid lines on a map, and it's illustrated by placing the letters "GN" on a vertical line.

Azimuth

Azimuth is the horizontal angle measured clockwise in degrees from a north baseline (direction).

The azimuth is the most common military method to express direction.

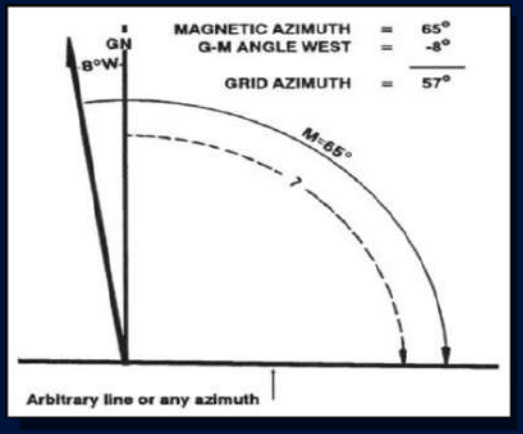
When using an azimuth, the point from which the azimuth originates is the center of an imaginary circle.



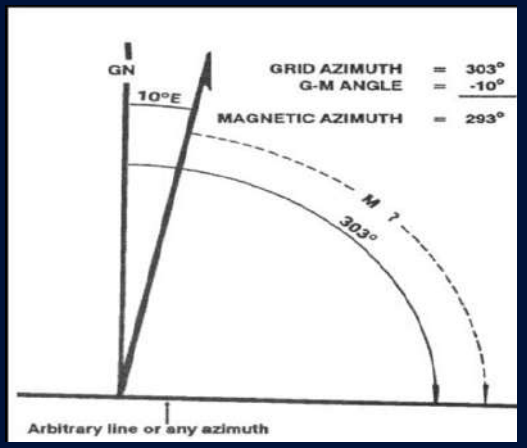
Azimuth

There are three distinct ways to express azimuth:

1. Grid azimuth is the angle measured between grid north and a straight line plotted between two points on a map. A protractor is needed to find grid azimuth.



2. Magnetic azimuth is a direction expressed as the angular difference between magnetic north and the direction line. You can determine a magnetic azimuth using a compass or magnetic instrument.



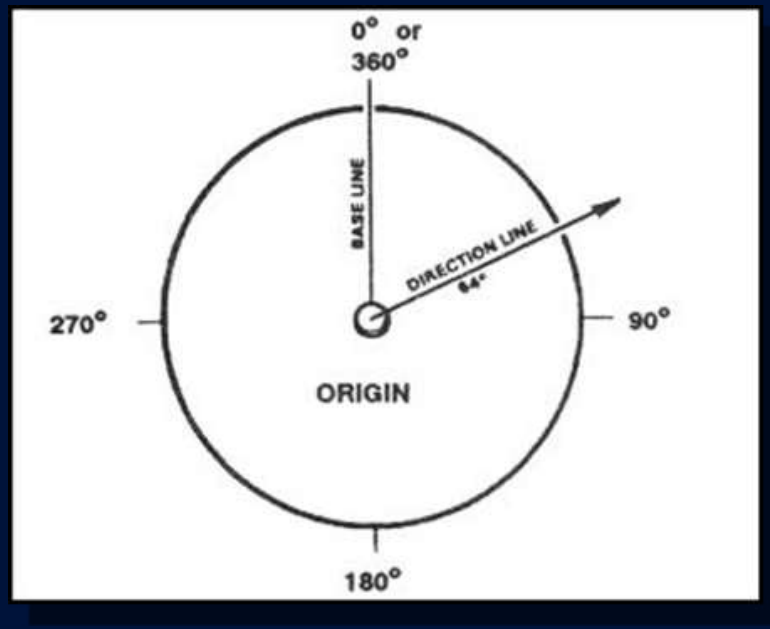
Azimuth

There are three distinct ways to express azimuth:

3. Back azimuth is the opposite direction of an azimuth.

To obtain a back azimuth, either…

- Add 180 degrees if the azimuth is 180 degrees or less, or
- Subtract 180 degrees if the azimuth is 180 degrees or more



Check On Learning Questions

CPS Lesson

Questions 5 - 6

Types of Compasses

A magnetic azimuth is determined with the use of a compass. Two of the most common types are the:

Magnetic Lensatic Compass

Silva Polaris Compass

Magnetic Lensatic Compass

The magnetic lensatic compass used by the military, is the most common and simplest instrument for measuring direction.

Its three major parts:

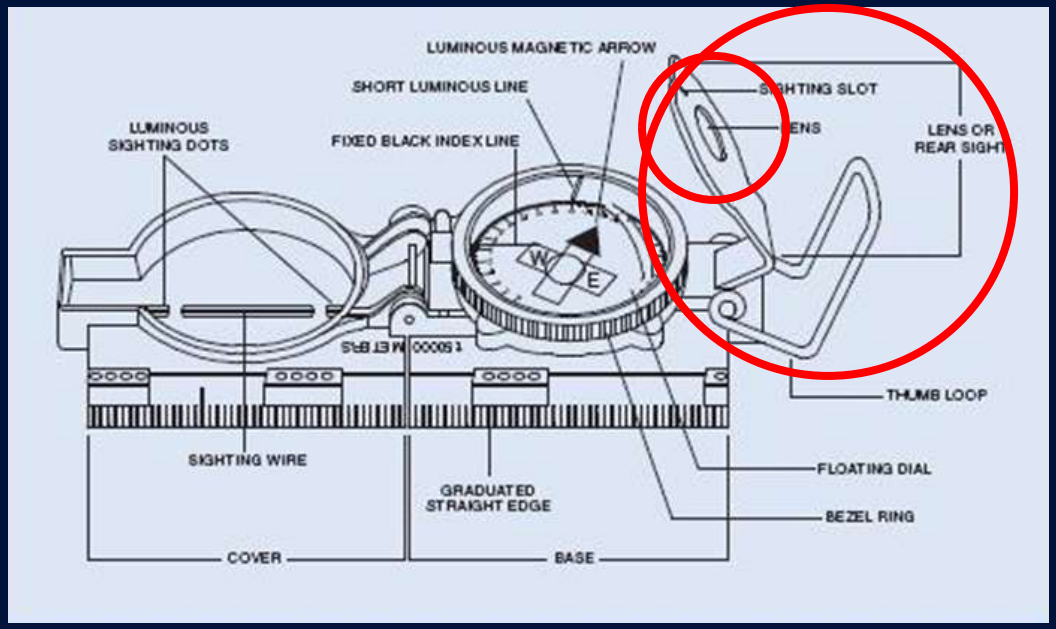
- Cover
- Base
- Lens

The cover protects the floating dial and contains the sighting wire (front sight) plus two luminous sighting slots or dots used for *night navigation*.

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.

Magnetic Lensatic Compass

The lens is used to read the dial



This compass has two scales:

1. Outer: denotes mils
2. Inner(red): denotes degrees

The rear sight:

- serves as a lock and clamps the dial when closed
- must be opened more than 45 degrees to allow the dial to float freely
- Includes rear sight slot used for sighting on objects, with the front sight sighting wire

Silva Compass

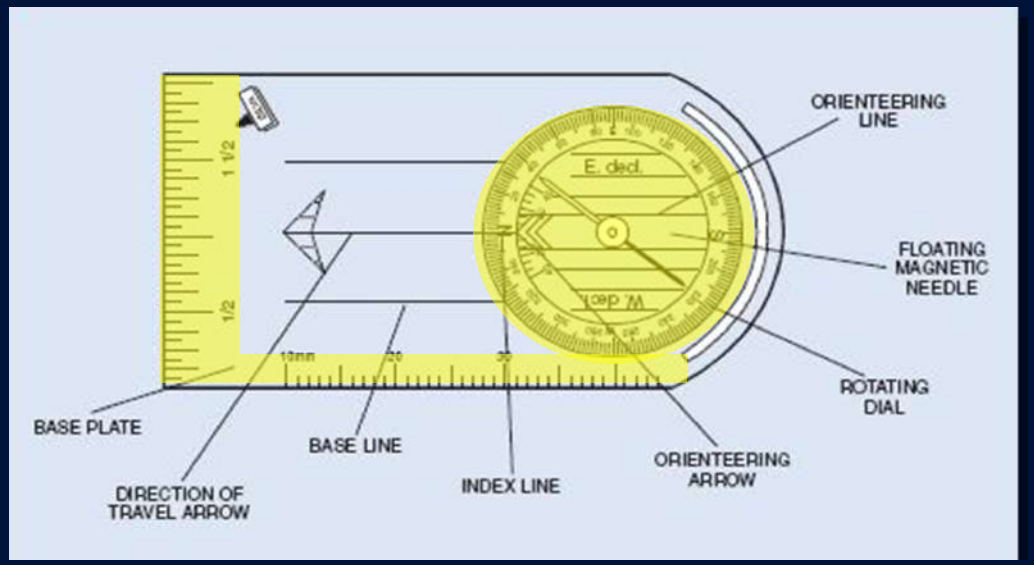
The Silva Polaris precision compass is also one of the most accurate compasses on the market today. The Silva compass is easy to use, especially with its hand-contoured base plate.

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.

Silva Compass

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 two rulers (one measured in inches and the other in millimeters).

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.

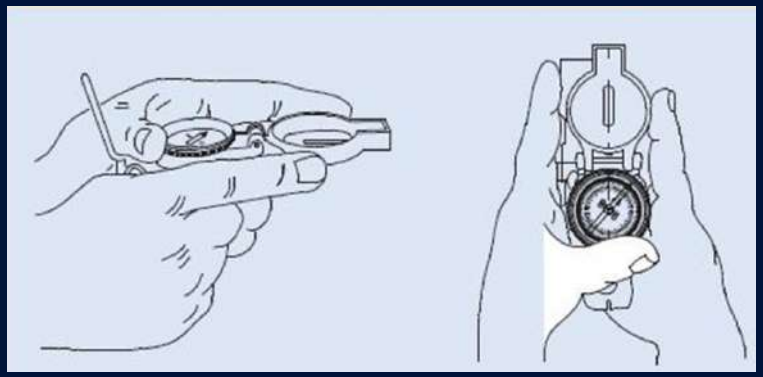
Measuring a Magnet Azimuth

This method is the fastest and easiest way to measure a magnetic azimuth, and will use the magnetic lensatic compass.

Before you start, be sure that you are away from power lines, vehicles or other metal objects when using a compass – they could affect its accuracy.

Measuring a Magnetic Azimuth

1. Open the compass to it's fullest so that the cover forms a straightedge with the base.
2. Move the lens 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.

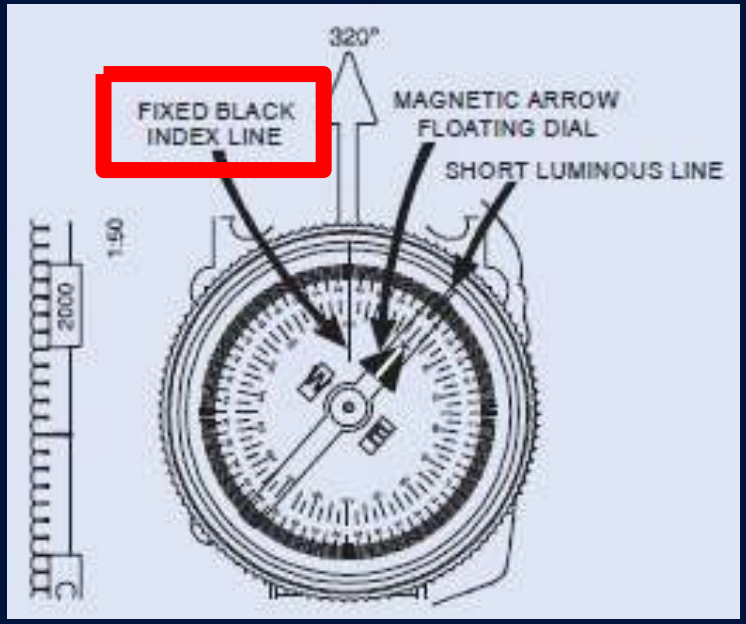


Measuring a Magnetic Azimuth

4. Pull your elbows in to your sides, which places the compass between your chin and waist.

5. Turn your entire body toward the object, pointing the compass cover (zero or index mark) directly at the object.

6. Now that you are pointing at the object, look down and read the azimuth from beneath the fixed black index line.



Measuring a Magnetic Azimuth

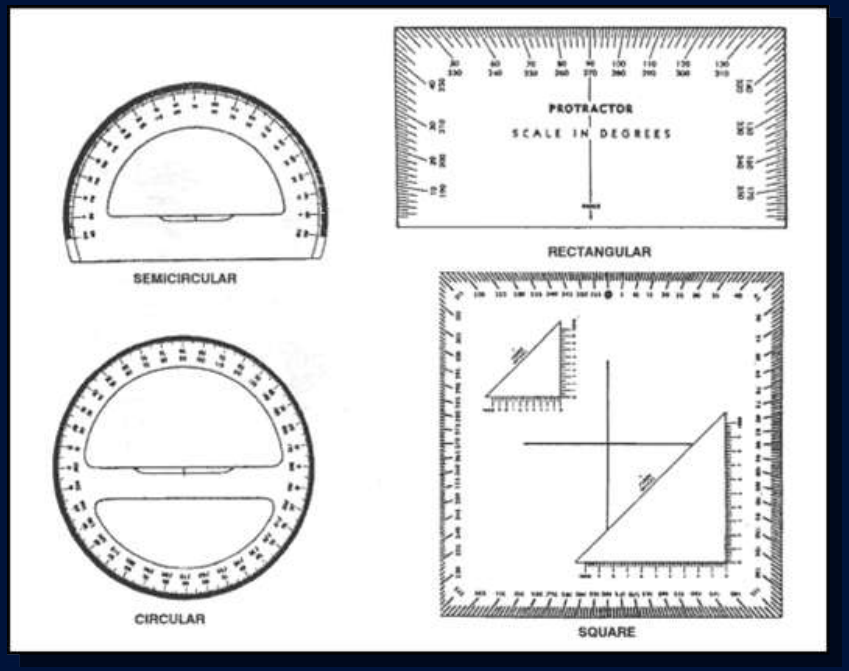
With a Silva compass, you'll need to modify step 3 to either hold the compass with one hand with the curved end toward the back of the palm or with both hands.

Protractors

There are several types of protractors: full circle, half circle, square, or rectangular. A grid azimuth is determined using one.

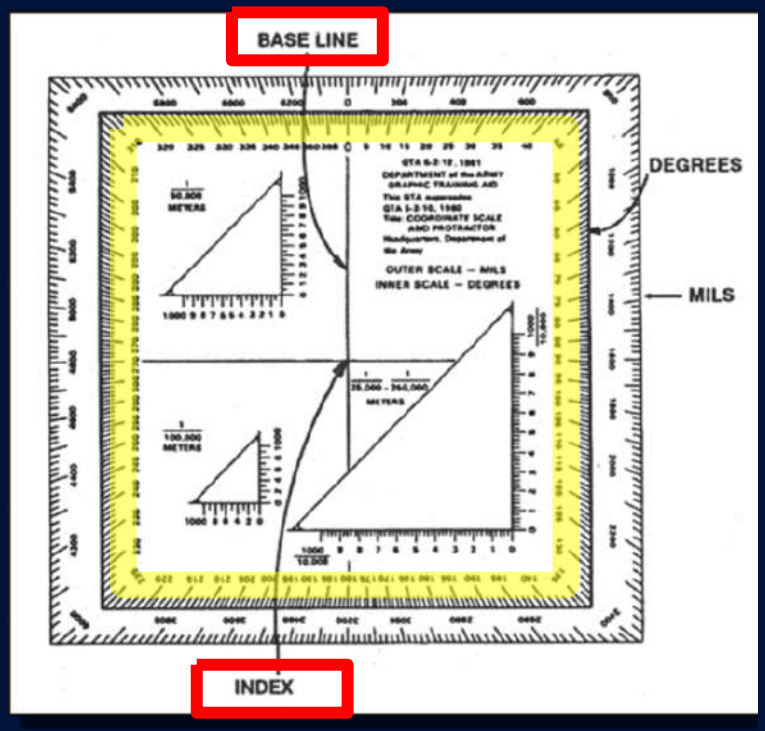
All of them divide the circle into units of angular measure.

Each has a scale around the outer edge, and an index mark, which is the center and the point from where measurements are made.



Protractors

On the military protractor below, note that the inner of the two scales is graduated into degrees from 0 to 360°, with each tick mark representing one degree.

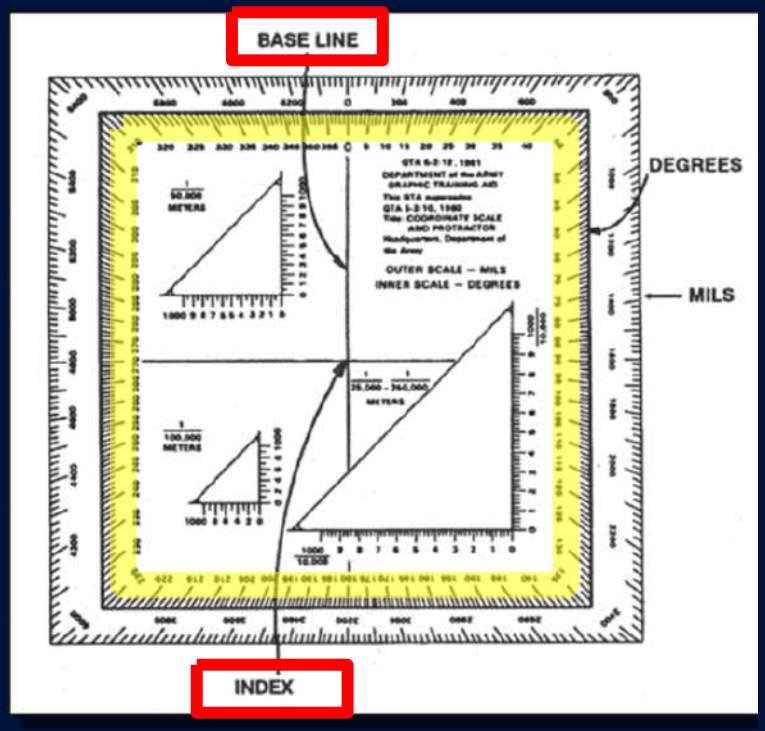


The base line of this protractor is a line from 0° to 180°.

Where the base line intersects the horizontal line, between 90° and 270°, is the index or center of the protractor.

Protractors

On the military protractor below, note that the inner of the two scales is graduated into degrees from 0 to 360°, with each tick mark representing one degree.

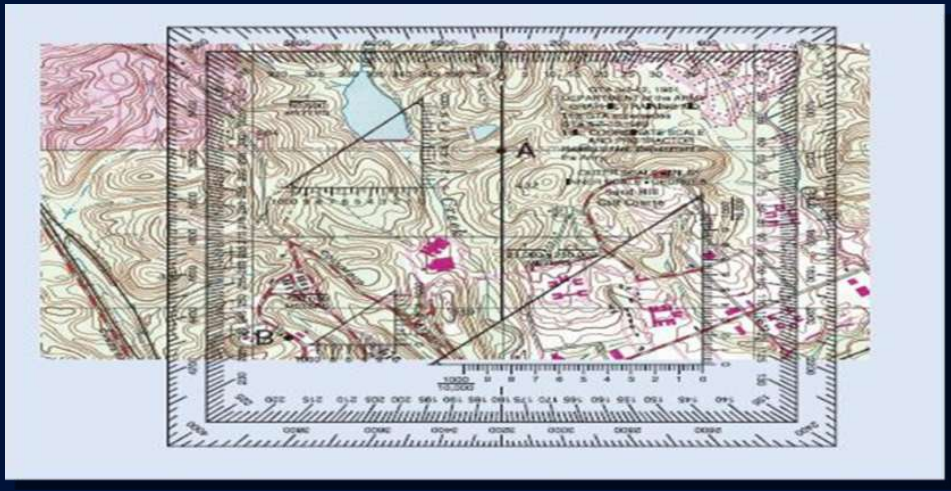


On a map, the base line is always oriented parallel to a north-south gridline, and the 0° mark toward the top or north. The 90° mark should always be to the right.

Measuring at Grid Azimuth

These steps explain how to measure a grid azimuth using a map and a protractor. Note: distance has no effect on azimuths.

1. Draw a line connecting the two points (start and endpoints).
2. Place the index of the protractor at the point where the drawn line crosses a vertical (north-south) grid line.

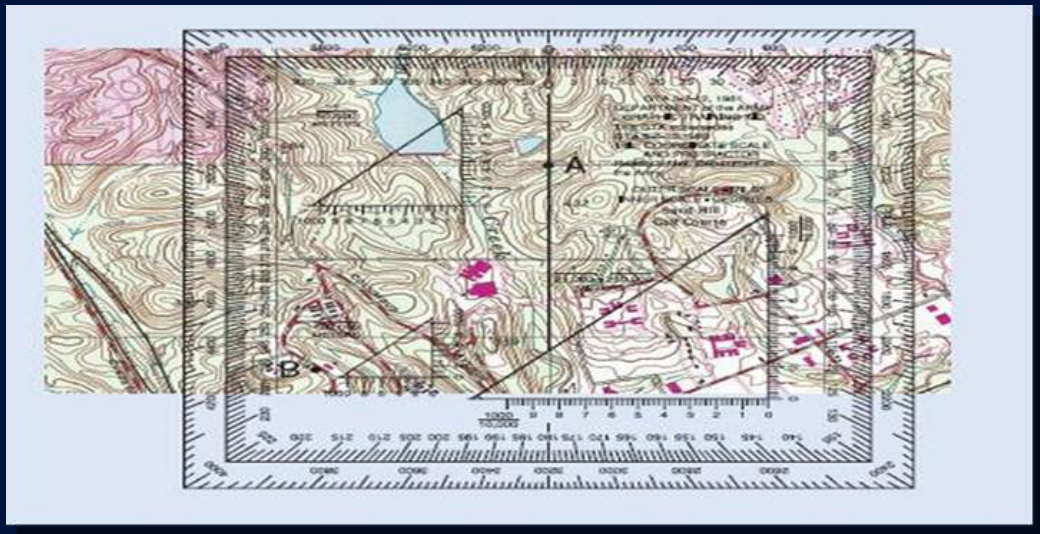


Measuring at Grid Azimuth

1. Draw a line connecting the two points (start and endpoints).

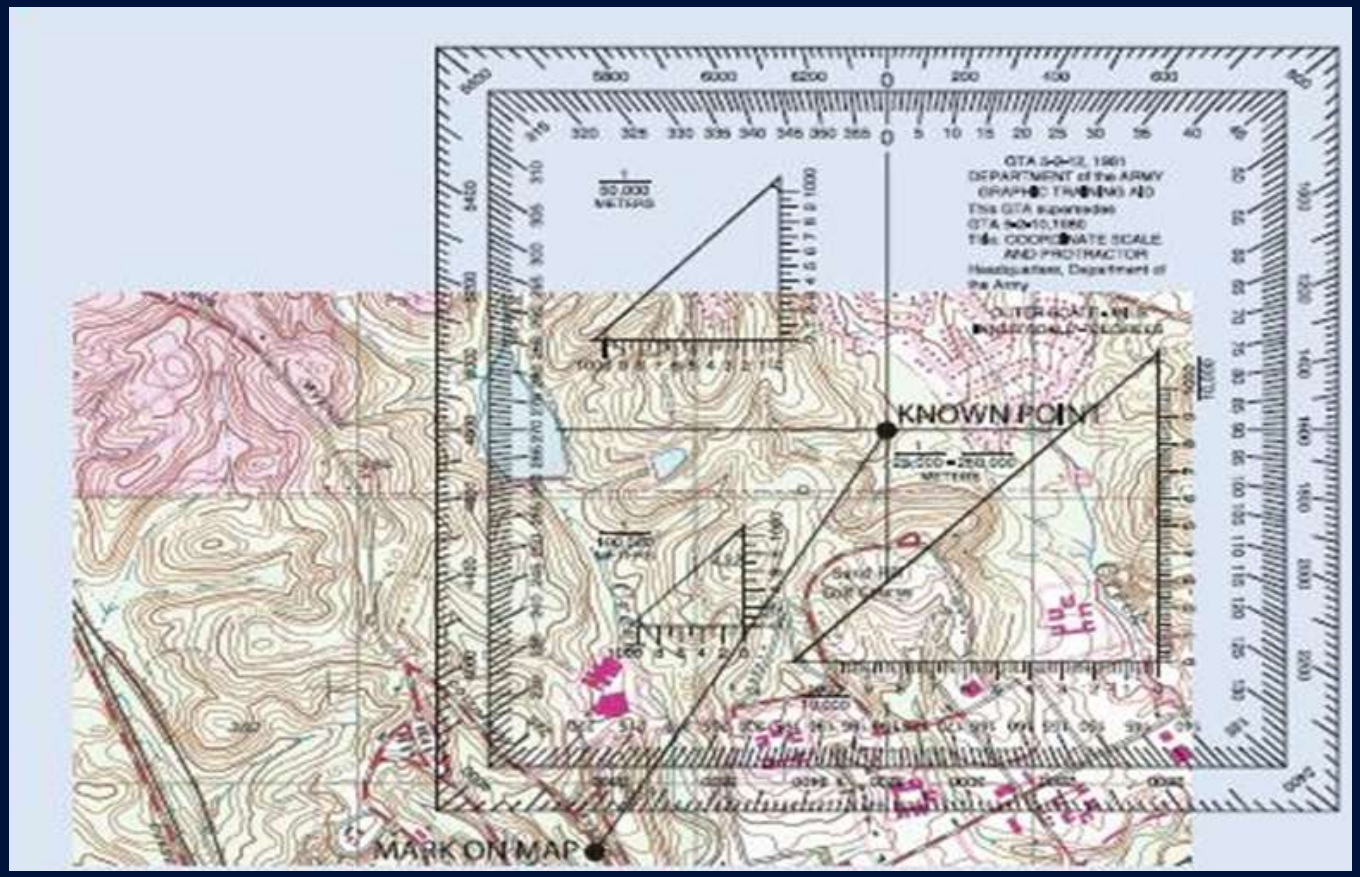
Measuring at Grid Azimuth

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 B, or 68 degrees in this example.



Measuring at Grid Azimuth

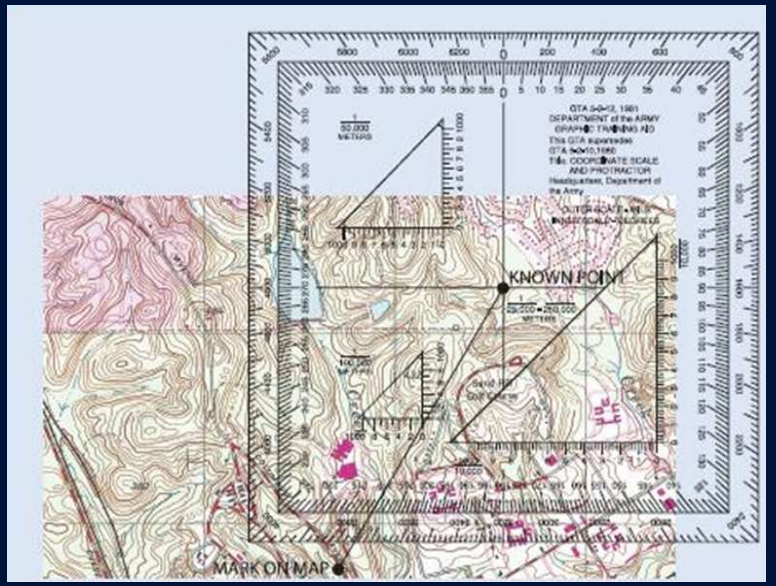
Practice here for Measuring a Grid Azimuth



Plotting a Grid Azimuth

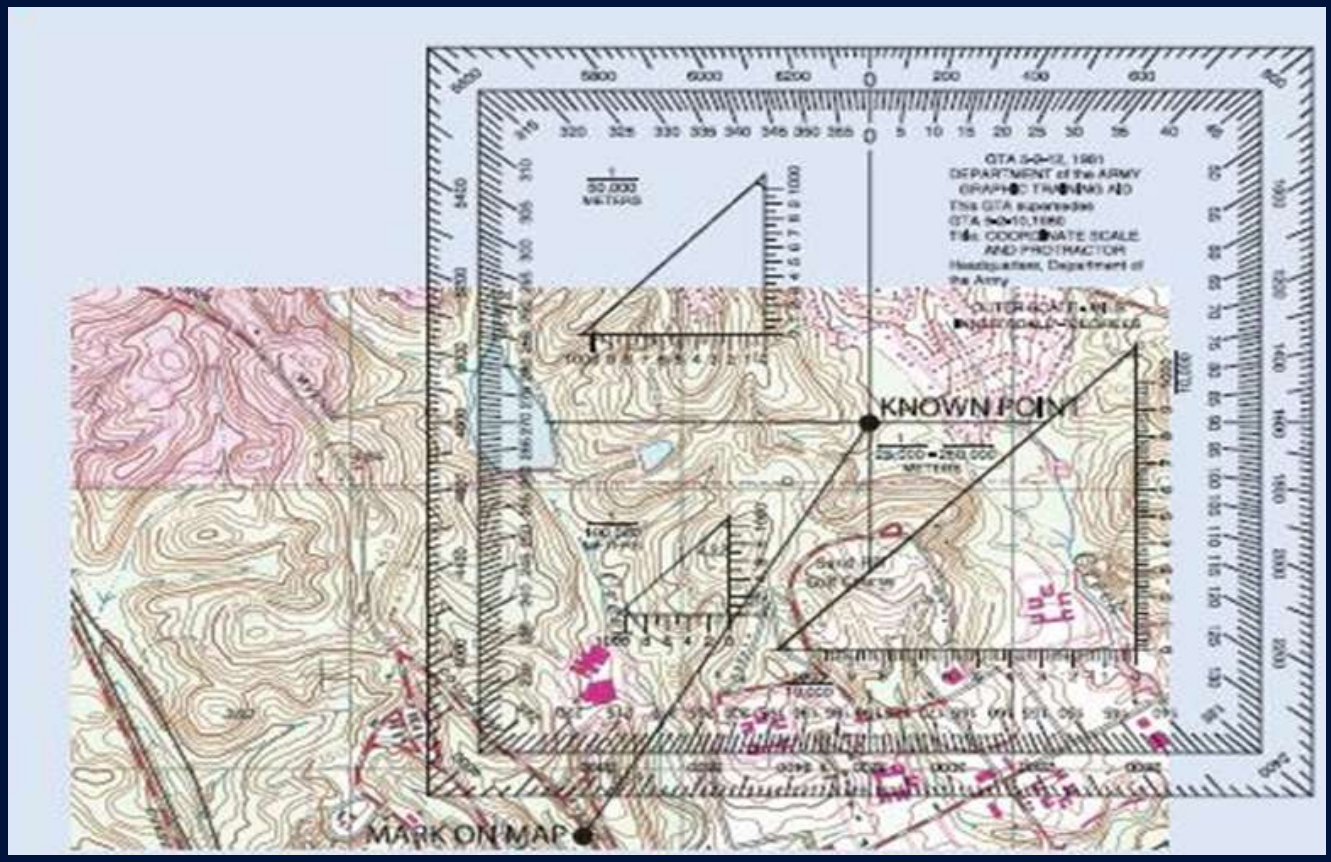
To plot an azimuth from a known point on a map:

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.
2. Make a mark at the desired azimuth.
3. Remove the protractor, and draw a line connecting the known point and the mark on the map.
4. This is the grid direction line or grid azimuth.



Plotting a Grid Azimuth

Practice here for Plotting a Grid Azimuth



Plotting a Grid Azimuth

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 take the reading from the ending point, the grid azimuth will be opposite, thus causing you to go in the wrong direction.

Closing Questions

CPS Lesson
Questions 7 - 8

Review Question

Discuss 2-3 ways you might determine distance in the field, if you didn't have any tools readily available.

1.

2.

3.

(Use CPS "Pick a Student" for this question.)

Questions?