California Cadet Corps

CURRICULUM ON MILITARY SUBJECTS

Strand M6: Maps and Navigation

Level 11

This Strand is composed of the following components:

A. Map Reading
B. Navigation Tools
C. Advanced Land Navigation

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A. Map Reading

Objectives

DESIRED OUTCOME (Self-Mastery)
Cadets will be able to read a topographic map, being able to identify the colors, symbols, and terrain features and what they symbolize. Cadets will be able to determine location, distance, direction, and will be able to convert back and forth between magnetic and grid azimuths, and understand why they need to.

A1. Describe the types of maps, what map projection is, how scale affects maps, and how latitude and longitude identify a specific location on the earth.

A2. Identify the meaning of colors and symbols used on a topographic map, and what the marginal information conveys.

A3. Define contour lines. Identify the five major and three minor terrain features from contour line patterns. Determine the elevation of a point using contour lines.

A4. Determine a 4-, 6-, or 8-digit grid coordinate for a point on a topographic map with a protractor.

A5. Measure distance on a topographical map using the map scale and a straight edge. Students should be able to measure distance of a straight line and of a curving road to within 50 meters.

A6. Name the three types of north on a topographic map. Determine a magnetic azimuth to a point using a compass. Plot a grid azimuth on a topographic map.

A7. Given a known point, a distance and direction, determine an unknown point on a topographic map.

A8. Use a Declination Diagram to convert a grid azimuth to a magnetic azimuth and vice versa.

A1. Introduction to Maps

Figure 1 Historical Map

A map is a graphic representation of a portion of the earth's surface drawn to scale, as seen from above; it uses colors, symbols, and labels to represent features found on the ground.

There are many types of maps, and they have evolved over a couple thousand years from maps that were more drawings to maps that scientifically convey information, and maps that portray what the ground looks like to maps that show information about a topic or area.

Map Types

Some types of maps are a Globe, City or State Road Maps, Geographic Maps/Atlases, and **Topographical** Maps.

A globe is an actual representation of the earth or other **celestial** body (such as a moon or planet). It is 3-dimensional, and shows the earth, at a very small scale, as it actually is. Globes don't have to deal with the problem of making a **spherical** world flat, so they show shapes and distance as they actually are. But you can't fold up a globe and put it in your glove compartment, and it's inconvenient to have a globe that's big enough to show the type of detail we want on maps, so globes aren't the best type of map to use most of the time.

Figure 2 Globe

Figure 3 Road Map

A **road map** or **route map** is a map that primarily displays roads and transport links rather than natural geographical information. It commonly includes political boundaries and labels, and points of interest, major features such as airports or **prominent** buildings, parks, hotels, etc. Road maps can be printed or they can be on your computer, phone, or display screen in your car.

When we're trying to convey information that relates to a specific or different areas, we often use **geographical maps**. Geographical maps convey information in ways related to both physical geography and culture or size. They may not be to scale, and may not truly represent the shape of the actual area depicted. They help us put what might otherwise be dry, uninteresting information into a type of picture that makes it more interesting.

Figure 4 Geographical Map

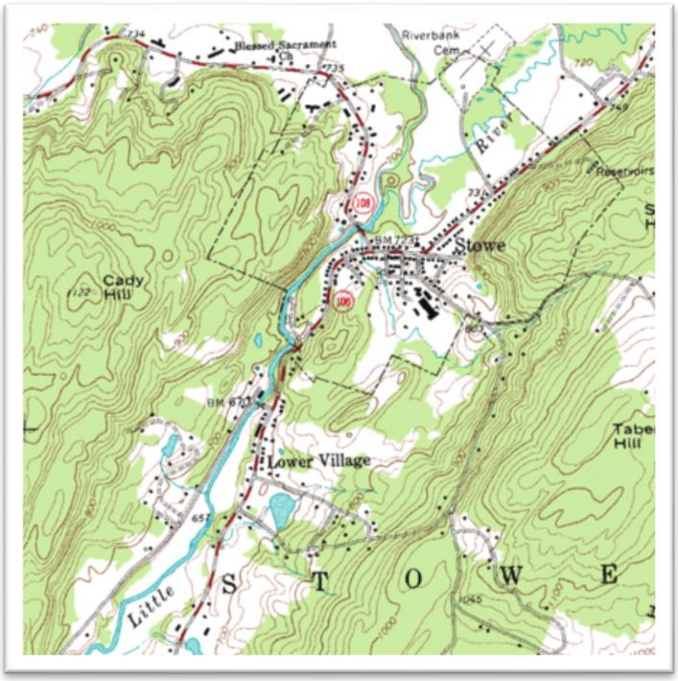


Figure 5 Topographic Map

In modern mapping, a **topographic map** (also called a "topo map") is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines, but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and man-made features.

Map Projections.

The Earth is more or less **spherical**, which makes it hard to recreate on a flat map. Any attempt to convey the earth's features on a flat map will have some distortion. Map Projections are different ways to portray the spherical earth on a plane (flat surface). Over the past few centuries, mapmakers have come up with different ways to deal with the distortions. Some have i**nnovative** ways of cutting out the parts of an area that don't have important information to show, and the pattern of the map helps keep the important areas together and more accurate. Others sacrifice accuracy in one area, like size and shape of a continent, for better accuracy in another, like **navigational** angles. You can select the type of map projection that best conveys what you need from the map, but it's best to know what type of information on your map isn't shown accurately.

Figure 6 Sample World Map Projection

Scale.

Map scale is the extent of reduction required to display a portion of the Earth's surface on a map Scale determines the informational content and size of the area being represented. The scale of a map is the ratio of a distance on the map to the **corresponding** distance on the ground. Map scales may be expressed in words (a **lexical** scale), as a ratio, or as a fraction. Examples are:

Table 1 Scale Examples

Lexical Scale	**Ratio**	**Fraction**
One centimeter to one hundred meters	1:10,000	1/10,000
One inch to one mile	1:63,360	1/63,360
One centimeter to one thousand kilometers	1:100,000,000 or 1:100M	1/100/000/000 or 1/100M

The smaller the number on the right, the **larger** the scale of the map.

Small Scale Maps have a scale of 1:1,000,000 and smaller. These maps are used for general planning and strategic studies. The standard small scale map is 1:1,000,000.

Medium Scale Maps are maps of scales that are larger than 1:1,000,000 but smaller than 1:75,000. In the military, these maps are used for operational planning. The standard medium scale map is 1:250,000.

Large Scale Maps are larger than 1:75,000. The standard large scale military map is 1:50,000, but 1:24,000 or 1:25,000 are popular as well.

Figure 7 shows the same location with different map scales:

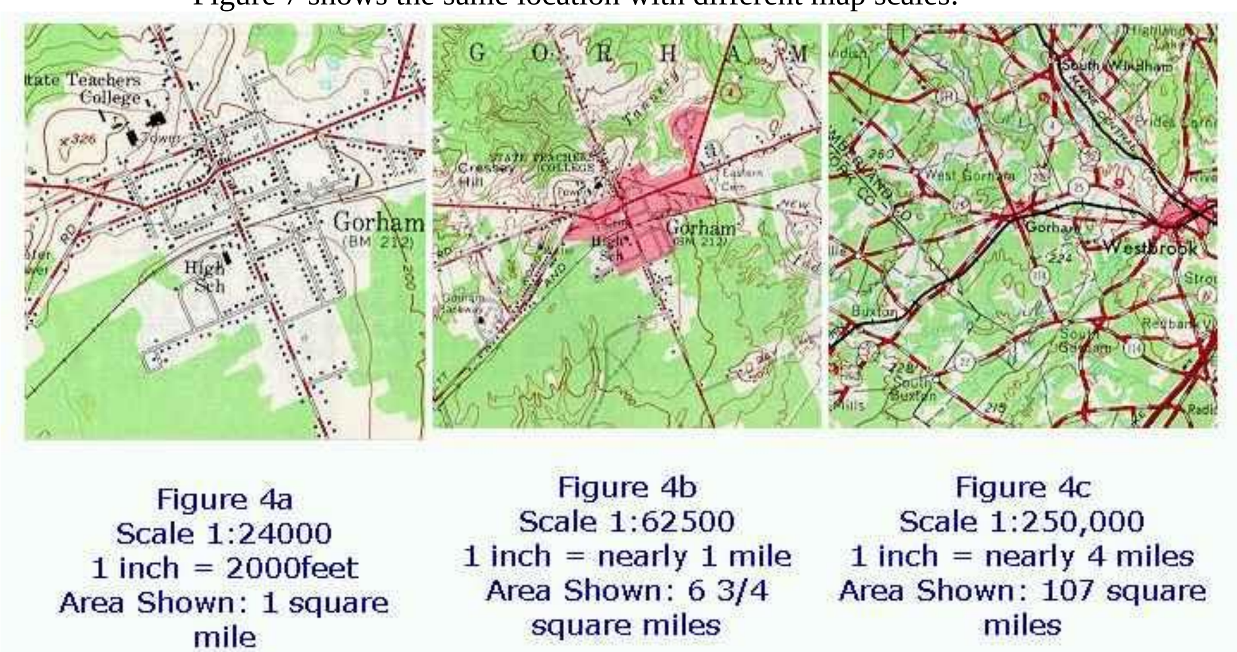


Figure 7 Various Scale Maps

Scale is also depicted graphically in the marginal information on a map. Map readers can measure a distance on the map and use the map scale to determine what it is.

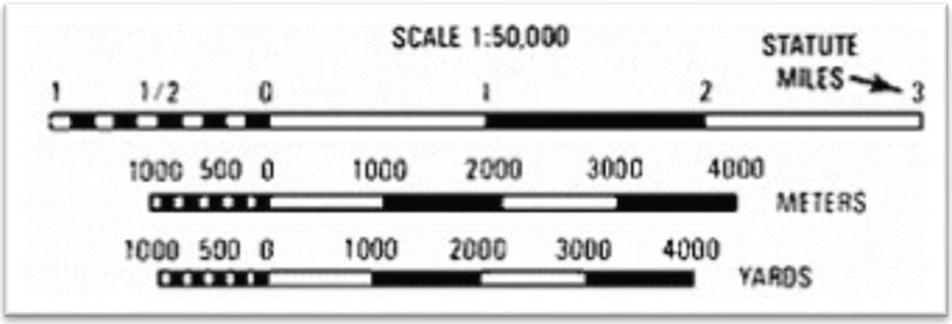


Figure 8 Map Scale

Latitude and Longitude.

Longitude lines (also called **meridians**) are **perpendicular** and **latitude** lines (also called parallels) are parallel to the equator. A geographic **coordinate** system is a **coordinate** system that enables every location on the Earth to be specified by a set of numbers or letters, or symbols.

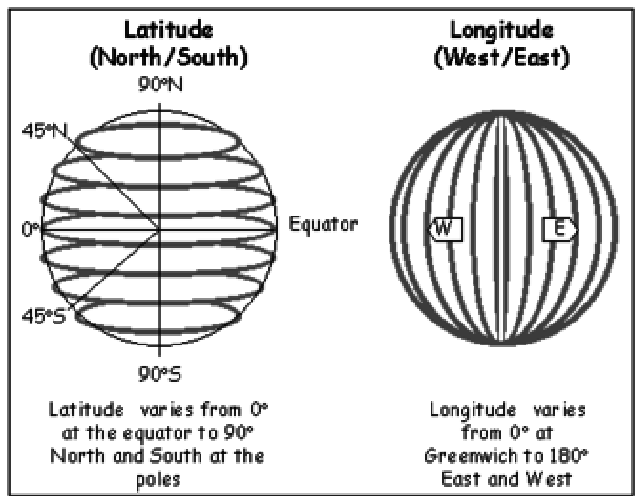


Figure 9 Latitude and Longitude Lines

Some of the significant lines of latitude or longitude have names:

The Arctic Circle is at Latitude 60° North.

The Tropic of Cancer is just over Latitude 23° North, the most northerly circle of latitude where the sun can be overhead (on the June solstice).

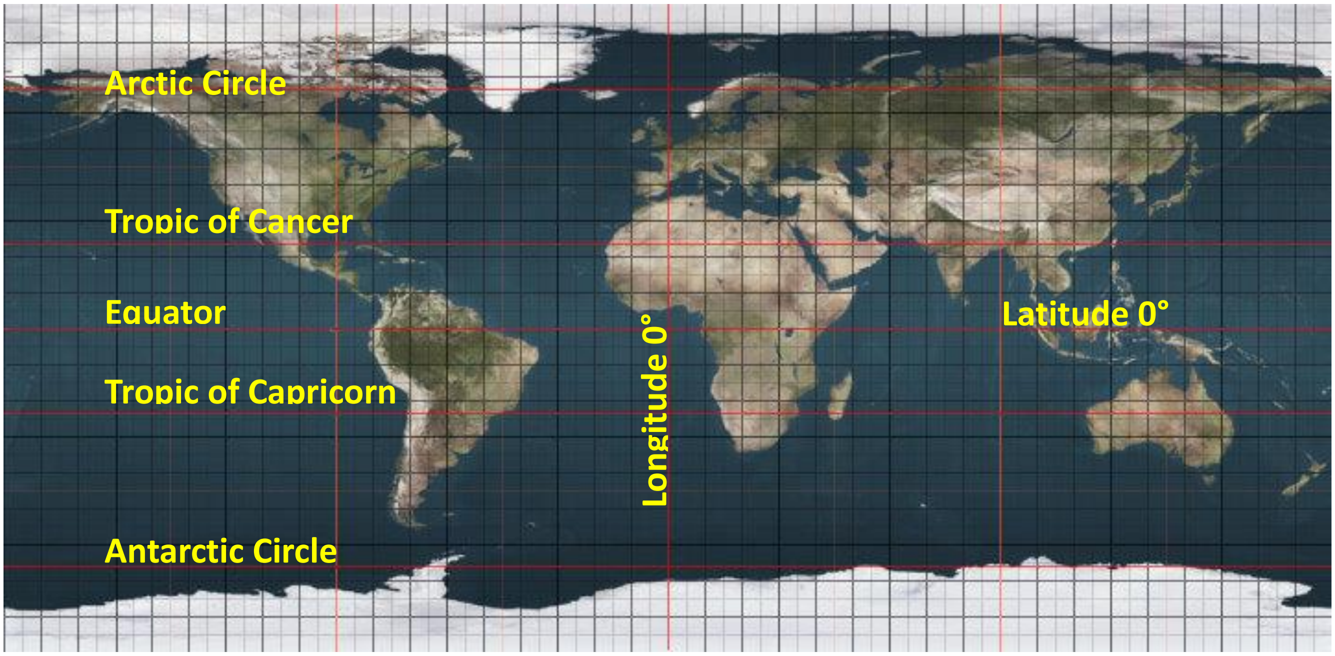
The Equator is at Latitude 0°.

The Tropic of Capricorn is just over Latitude 23° South, the most southerly circle of latitude where the sun can be overhead (on the December solstice).

The Antarctic Circle is at Latitude 60° South.

The North Pole is at Latitude 90° North, and the South Pole is at Latitude 90° South (not shown on this map projection).

The Prime Meridian is at Longitude 0° and passes though Greenwich, England



Latitudinal and Longitudinal coordinates can specify any point on earth. Latitude and longitude are expressed in degrees (°), minutes (‘) and seconds (“) (*For Example: N 34°- 17’ 52” W 115°- 27’ 24*”) but may also be described in degrees (°), minutes (‘) and decimals (*For Example: N 34°- 17.87’ W 115°- 27.43’*) . The two examples above are the same spot on earth, but the seconds are converted to decimals of minutes by dividing by 60. These are the two most common ways to display lat/long coordinates.

The length of one degree of latitude is 60 nautical miles, which equals 111 kilometers, or 69 **statute miles**. There are 60 minutes in a degree and 60 seconds in a minute.

Longitude is harder to measure, since longitudinal lines are not parallel to each other – they merge at the North and South Poles. At the Equator, a degree of longitude is the same length as a degree of latitude – about 111 km, or 69 miles. At 60°, a degree of longitude is 55.8 km, or 35 miles.
Some examples of geographical coordinates are:

Los Angeles, Ca	Lat/Long: N 34° 03.1338’ W 118° 14.6208’
Riverside, Ca	Lat/Long: N 33° 57.2009' W 117° 23.7694'
London, UK	Lat/Long: N 51° 30.0091' W 0° 07.5742'
Beijing, China	Lat/Long: N 39° 54.4500’ **E** 116° 23.8338’
Sydney, Australia	Lat/Long: **S** 33° 52.0710’ **E** 151° 12.4392’

Who Uses Latitude and Longitude?

In the US Military, aviation and naval forces typically use latitude and longitude. Ships, boats, and airplanes travel at speeds called knots. 1 knot = 1 nautical mile per hour. 60 nautical miles = 1 degree of latitude. This makes it very easy to chart boat and airplane positions on sea charts and aviation charts.

A2. Topographical Map Basics

The feature that most distinguishes topographic maps from maps of other types is the use of contour lines to portray the shape and elevation of the land. Topographic maps render the three-dimensional ups and downs of the terrain on a two-dimensional surface.

Topographic maps usually portray both natural and manmade features. They show and name works of nature including mountains, valleys, plains, lakes, rivers, and vegetation. They also identify the principal works of man, such as roads, boundaries, transmission lines, and major buildings.

Around the margins of a topographical (and most other types of) map, there is a lot of information that helps you read and interpret the symbols on the map. This is called, for obvious reasons, marginal information. Marginal information on a military map includes:

- **Sheet Name**. Like a title, in the center of the top margin. Also in the lower left margin.
- **Sheet Number**. Listed with the Sheet Name. Used as a reference number for the map sheet.
- **Adjoining Map Sheets Diagram (Figure 10)**. Shows the 8 map sheets **adjacent** to this sheet, with their sheet number (at the same map scale).
- **Special Notes.**
- **Declination Diagram.** Indicates the direction and relationship of True, Grid, and Magnetic North, the G-M Angle, and how to convert grid to magnetic and magnetic to grid.
- **Scales**. Gives the scale used on the map. Graphically depicts distance in miles, meters, and yards.
- **Contour Interval**. Tells you what the vertical distance between contour lines is on this map.
- **Unit Imprint**. Tells you who made the map.
- **Grid Reference Box.** Tells you the 2-digit Grid Zone Designators, and where the boundaries are between grid zones on the map.
- **Legend (Figure 11).** Gives the effective date of the map data and defines the symbols used on the map.

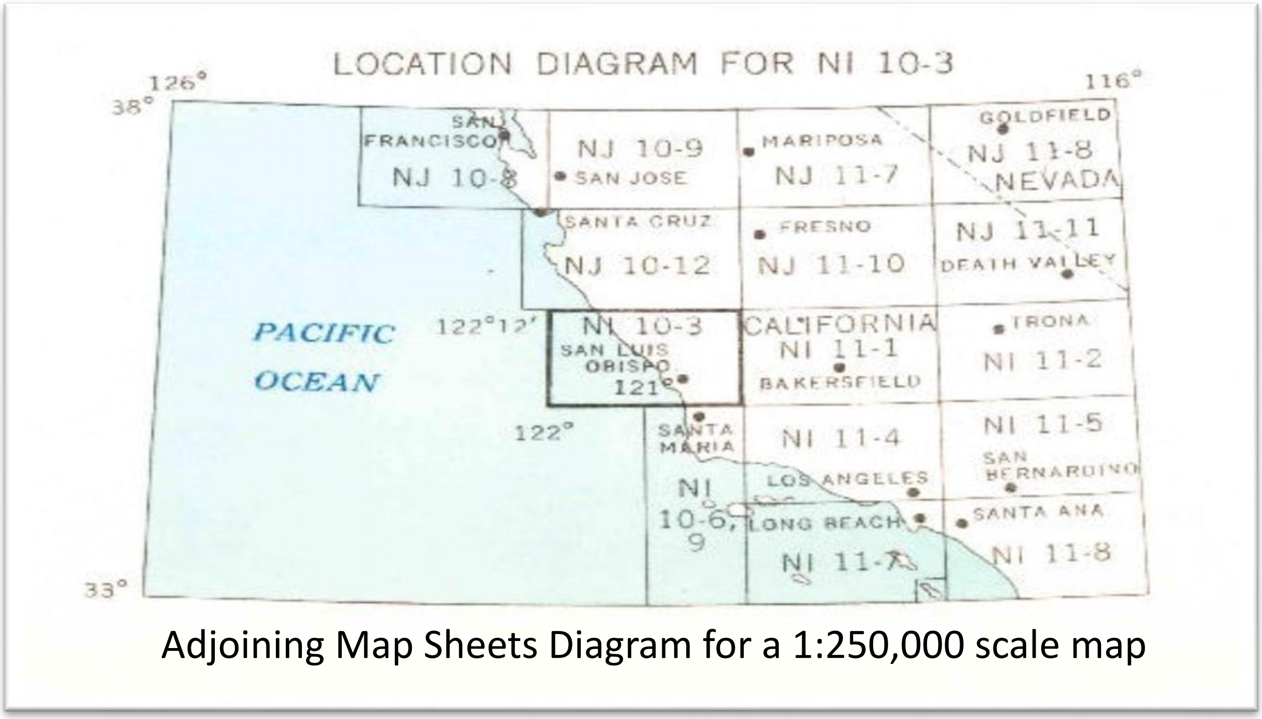


Figure 10 Adjoining Map Sheets Diagram

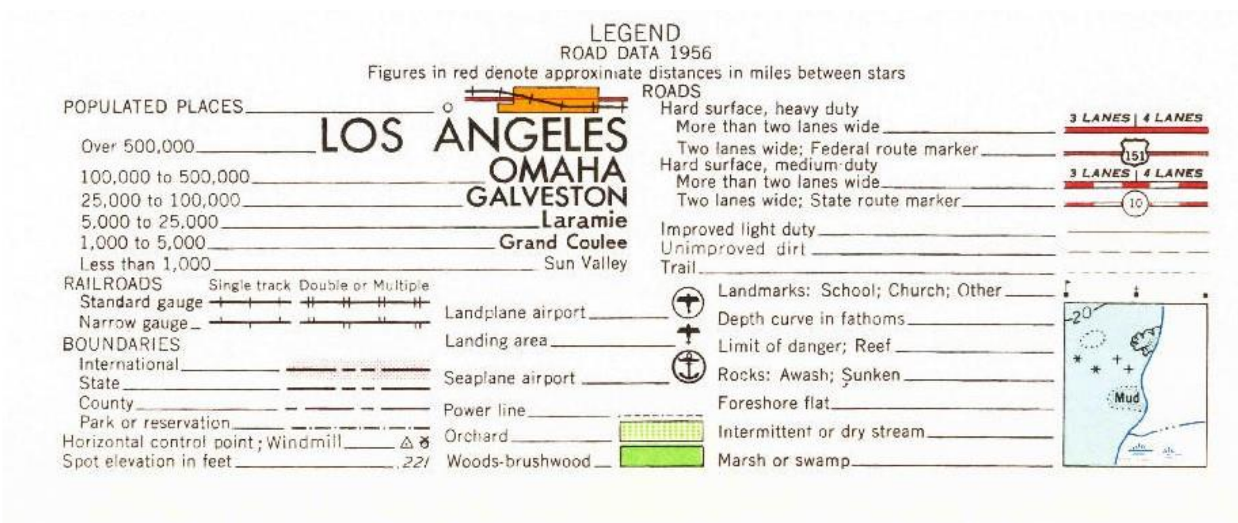


Figure 11 Legend

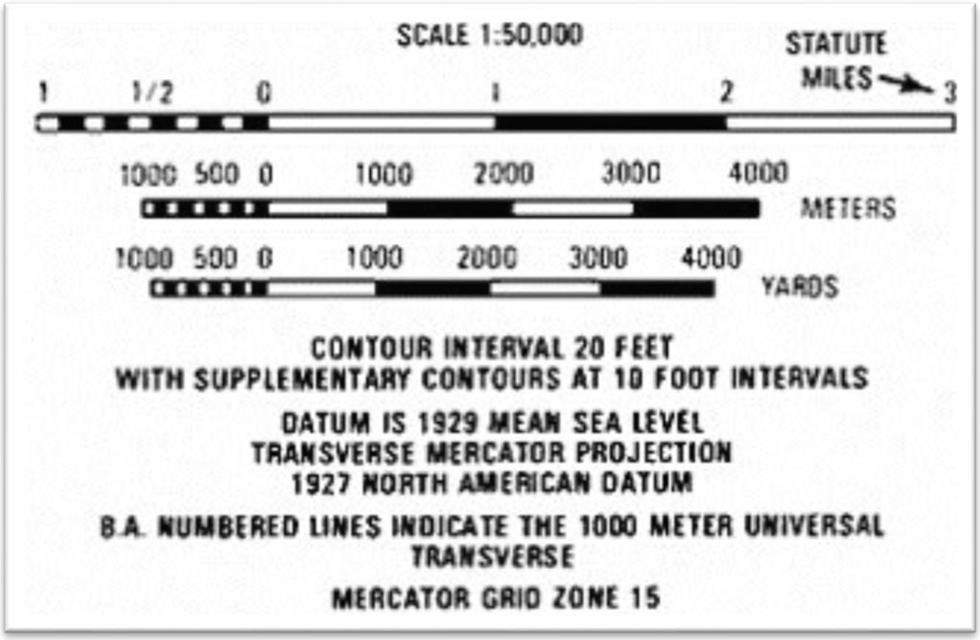


Figure 12 Scale and Contour Interval. Also gives map projection used.

Map Colors

A topographic map uses certain colors to help tell you what a graphic or symbol is. The colors on a topo map are:

Black - on a map is the work of humans: buildings, railroads, bridges, boundaries, names …

Blue - always means water: lakes, ponds, rivers, streams, water well, marshes …

Brown - symbols are used for relief features - contour lines and elevation …

Green - indicates forest, woodlands, orchards, and other areas of heavy vegetation.

Red - is used for larger, more important roads and surveying lines.

Purple - is for overprinting: Revisions added from aerial photographs but not yet field-checked, or

planned additions.

White - is mostly clear of trees: fields, meadows, rocky slopes, and other open country.

Map Symbols

The symbols used on a map are generally shown in the marginal information. These include roads, rivers, manmade objects like buildings or mines, and even sometimes the type of building, like a church or a school. Some sample symbols are shown here:

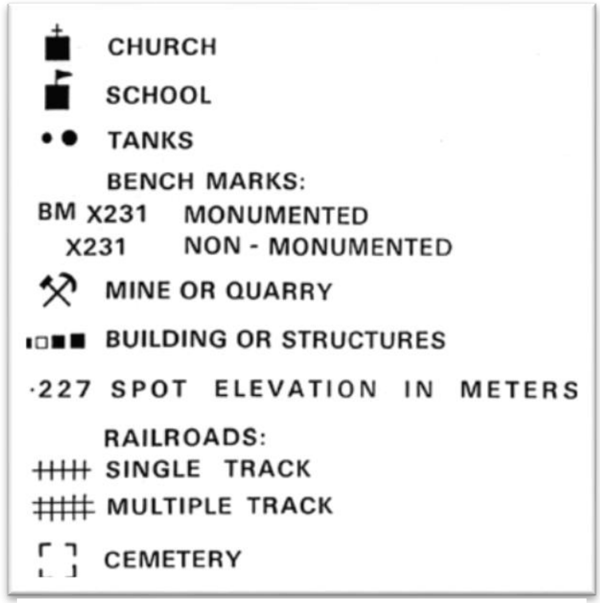


Figure 13 General Features

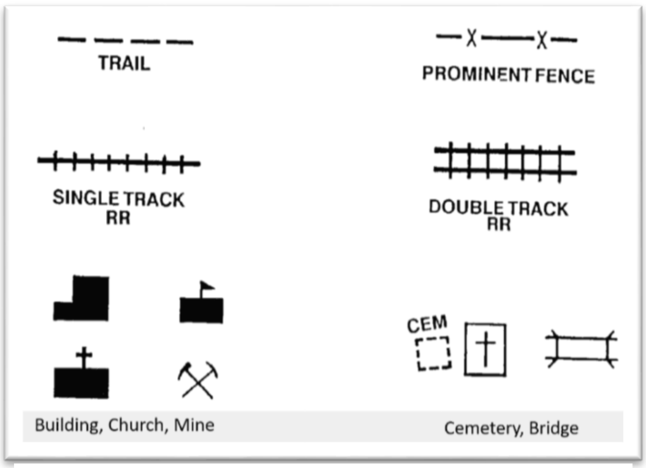


Figure 14 General Features

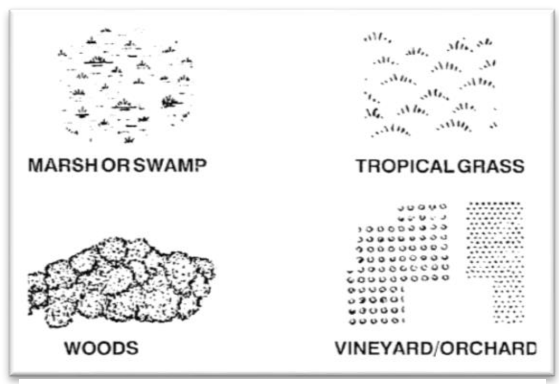


Figure 15 Land Type

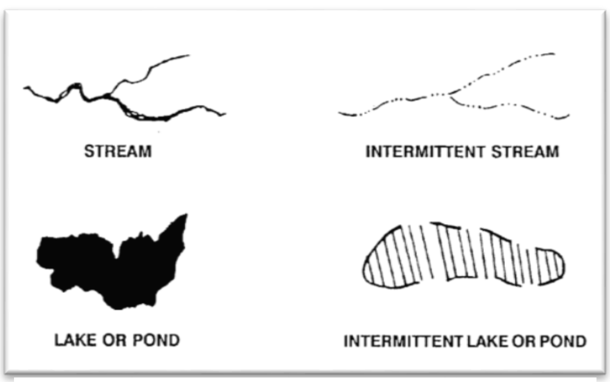


Figure 16 Water Features

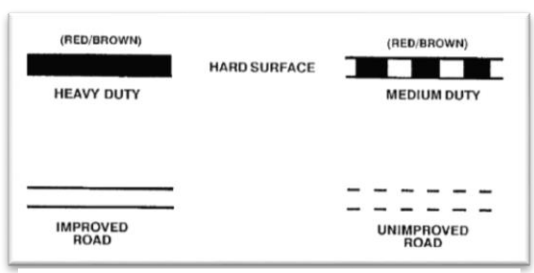


Figure 17 Road Types

A3. Elevation and Terrain Features

Contour Lines

Relief is the representation of the shapes of hills, valleys, streams and other features of the earth's surface. It can be represented by colors for different elevations (called layer **tinting**), form (dashed) lines to show the basic shape of land, and shading (where the darker the color, the steeper the land). Most often, relief is shown by CONTOUR LINES. **Contour** lines are what makes a map the equivalent of 3D. They are lines that connect points of equal elevation on the earth's surface, and are used to illustrate topography, or relief, on a map. On American maps, they are usually in feet. For example, numerous contour lines that are close together indicate hilly or mountainous terrain; when far apart, they represent a gentler slope.

There are three types of contour lines. **Index** lines are the HEAVY or DARK colored contours, generally every fifth contour line; they show an elevation number. Four **intermediate** contour lines fall between the index contours and do NOT show their elevation. **Supplementary** contour lines are generally DASHED lines that show one-half the contour interval. They are often used on maps where the contour interval is large, and the terrain somewhat featureless overall.

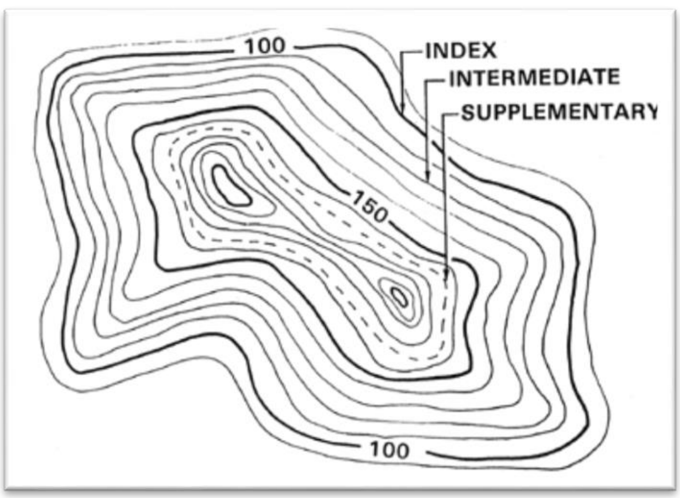


Figure 18 Contour Lines

Contour Interval

A contour interval is the vertical distance between two contour lines. The contour interval measurement, given in the map's marginal information, is the vertical distance between **adjacent** contour lines. The numbered Index contour lines, which are circled in red in *Figure 19*, give that particular line's elevation.

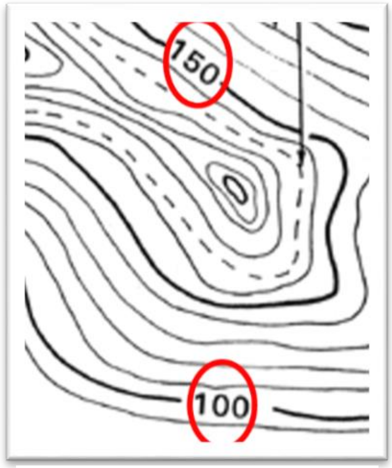


Figure 19 Contour Interval

If every contour line was numbered on a map, it might look like the example in *Figure 20*. Instead, you find an Index contour line to get a reference point for elevation, and then count up or down using the contour interval. Contour interval isn't the same on all maps. When there is a lot of change in elevation on a map, and the slopes are steep, the contour interval tends to be bigger – otherwise there would be too many lines, and they would blend together too much. So the mapmakers increase the contour interval, and instead of 10 feet, it might be 20 or 50 between each contour line.

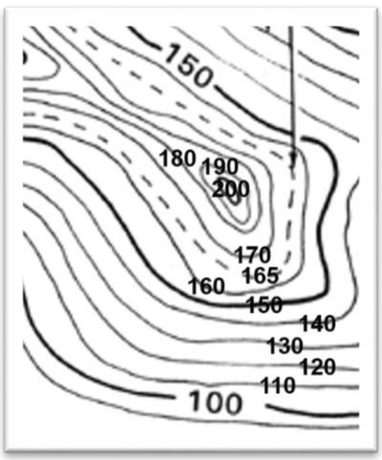


Figure 20 Why Each Contour Line is not Marked

To determine an elevation for a point on the map,

1. *Find the contour interval on the marginal map info*
2. *Find the nearest INDEX contour and its elevation*
3. *Determine if you are going lower or higher to the point you are concerned about*
4. *Count up or down to determine the correct elevation, using the contour interval*

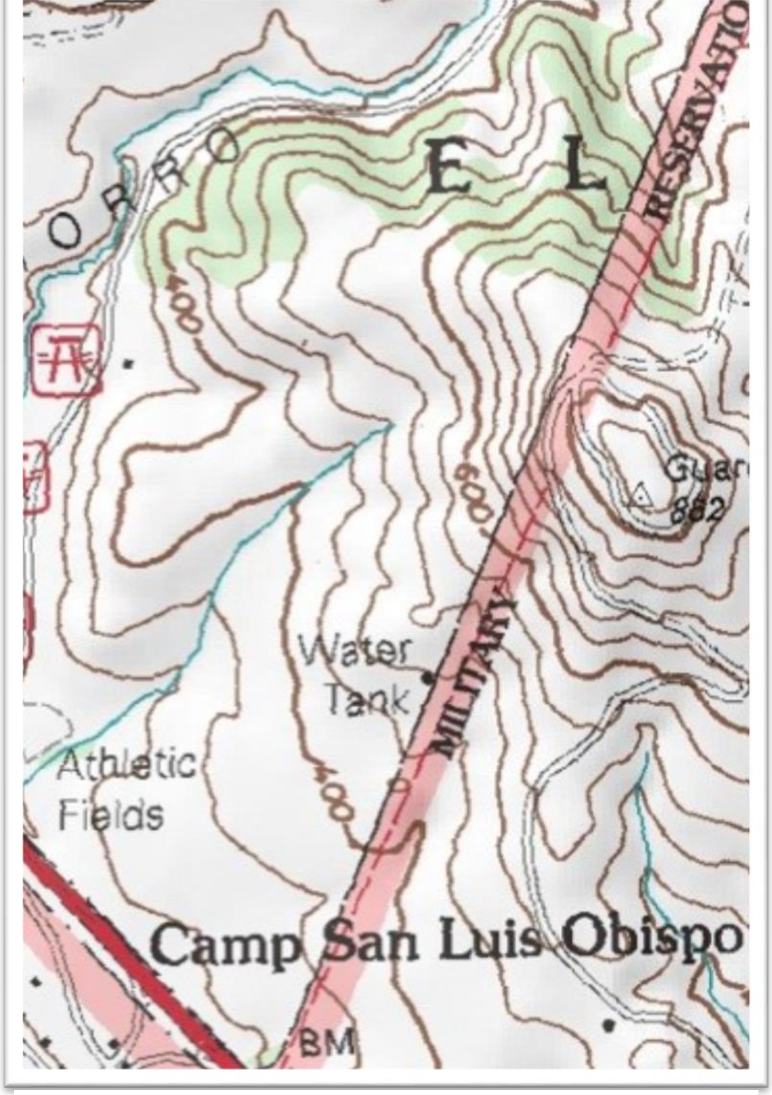


Figure 21 Sample Map

What's the contour interval on this map? Even though we don't have the marginal information, you can tell by comparing the Index contour lines. You can see a 400' Index Contour, then a 600' Index Contour.

600-400 = 200 feet between Index Lines. 200 ÷ 5 = 40'

So the Contour Interval is 40 feet. Each contour line represents a point that's 40 feet higher than the contour line below it.

Can you determine the elevation of the Water Tank?

It's on the second contour line up from the 400' Index, so it's 480 feet.

How about the hilltop?

If the hilltop didn't have its elevation marked (882'), you would estimate it by finding the contour line that defines the hilltop (no other contour lines within it), then add half of the contour interval. That gives us an estimate of 860 feet. It's nice when they put the exact height of hilltops!

Sometimes, you will see a notation such as "BM 214" on a map. That means that map makers have measured that particular spot on the earth's surface to be exactly 214 feet above sea level. Some benchmarks have actual markers on the ground, but often the markers aren't there anymore.

Terrain Features

Terrain features are identified in the same manner on all maps, regardless of the contour interval, but you must realize that a hill in the Rocky Mountains will be much bigger than one in south Florida. You must be able to recognize all the terrain features to locate a point on the ground or to navigate from one point to another.

The five major terrain features are: Hill, Ridge, Valley, Saddle, and Depression.
The three minor terrain features are: Draw, Spur and Cliff.
The two supplementary terrain features are: Cut and Fill.

Terrain features can be learned using the fist or hand to show what each would look like on the ground:

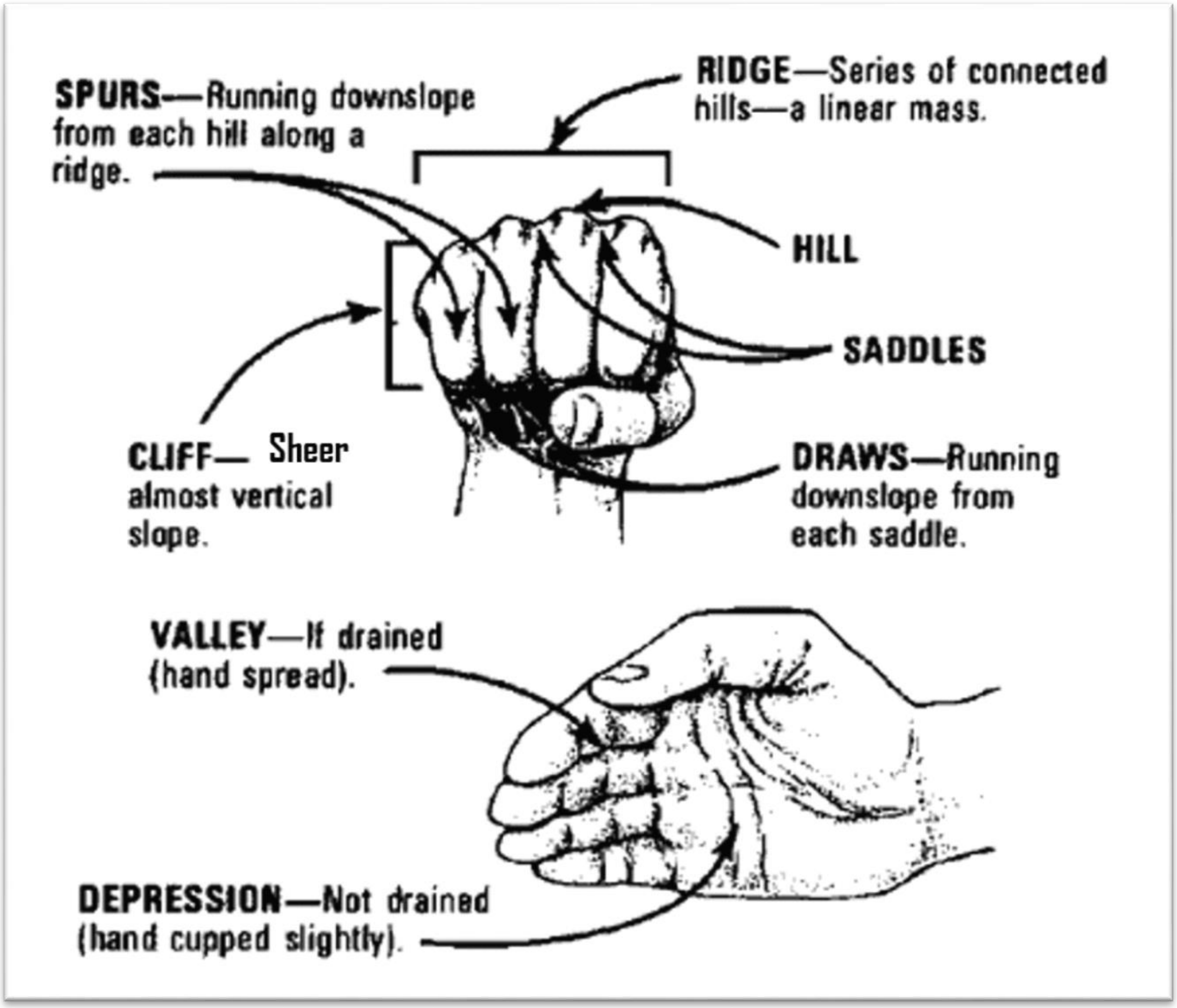


Figure 22 How to Remember Terrain Features

A **HILL** is a point or small area of high ground. When you are on a hilltop, the ground slopes down in all directions.

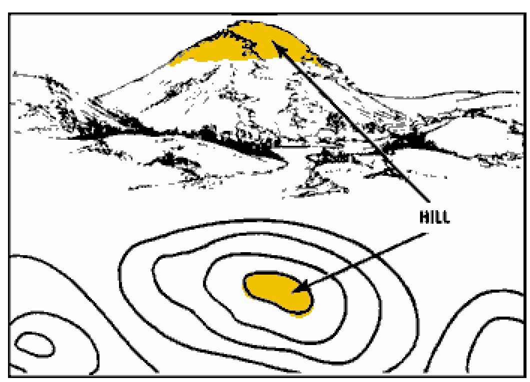


Figure 23 Hill

A **RIDGE** is a line of high ground with height variations along its crest. The ridge is not simply a line of hills; all points of the ridge crest are higher than the ground on both sides of the ridge.

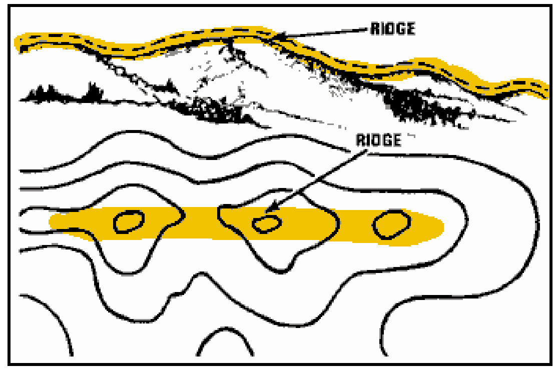


Figure 24 Ridge

A **VALLEY** is reasonably level ground bordered on the sides by higher ground. A valley may or may not contain a stream course. Contour lines indicating a valley are U-shaped and tend to parallel a stream before crossing it.

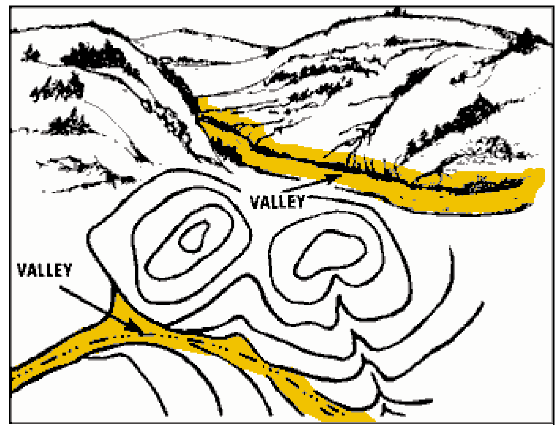


Figure 25 Valley

A **SADDLE** is a dip or low point along the crest of a ridge. A saddle is not necessarily the lower ground between two hilltops; it may be a break along an otherwise level ridge crest.

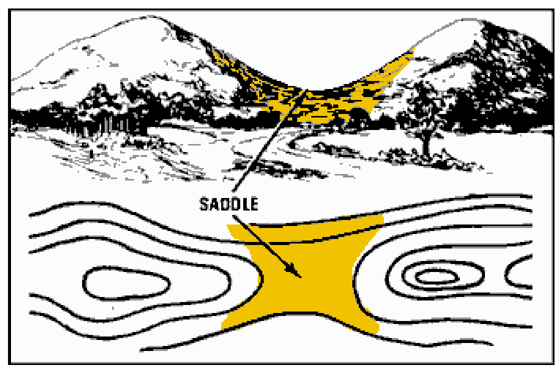


Figure 26 Saddle

A **DEPRESSION** is a low point or hole in the ground, surrounded on all sides by higher ground.

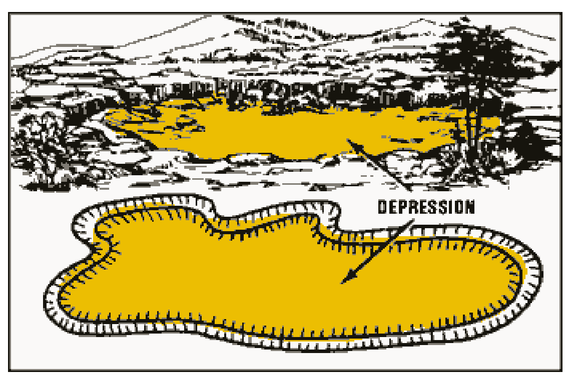


Figure 27 Depression

A **DRAW** is similar to a valley, except that it normally is a less developed stream course in which there is generally no level ground and, therefore, little or no **maneuver** room. The ground slopes upward on each side and toward the head of the draw.

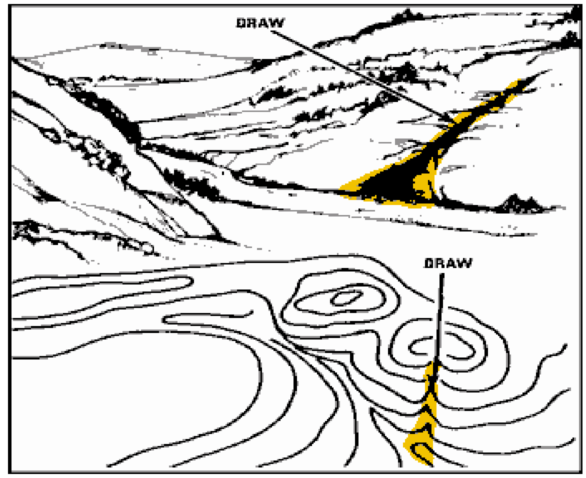


Figure 28 Draw

A **SPUR** is a usually short, continuously sloping line of higher ground, normally jutting out from the side of a ridge. A spur is often formed by two thoroughly parallel streams cutting draws down the side of a ridge.

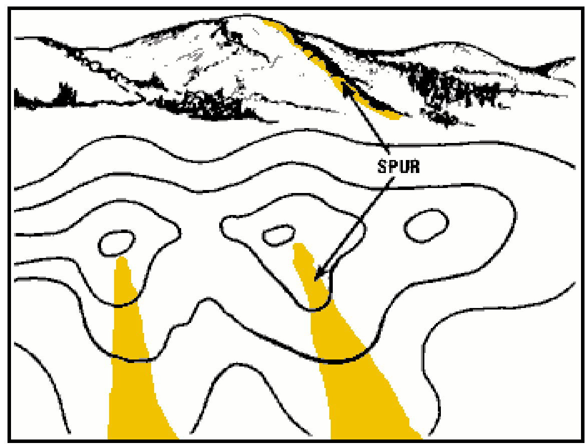


Figure 29 Spur

A **CLIFF** is a vertical or near-vertical slope. A cliff may be shown on a map by contour lines being close together, touching, or by a ticked "carrying" contour line. The ticks always point toward lower ground.

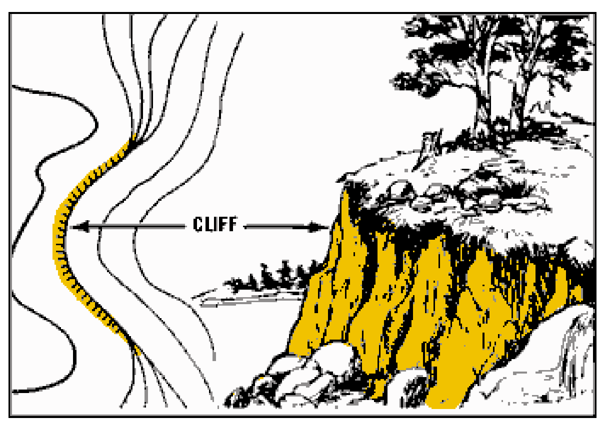


Figure 30 Cliff

CUT and FILL is a feature where terrain has been cut away – essentially a minor cliff, and where it has been filled in, creating more level ground than would normally be seen on the natural terrain feature. Often done to create a stable platform for a road or railroad.

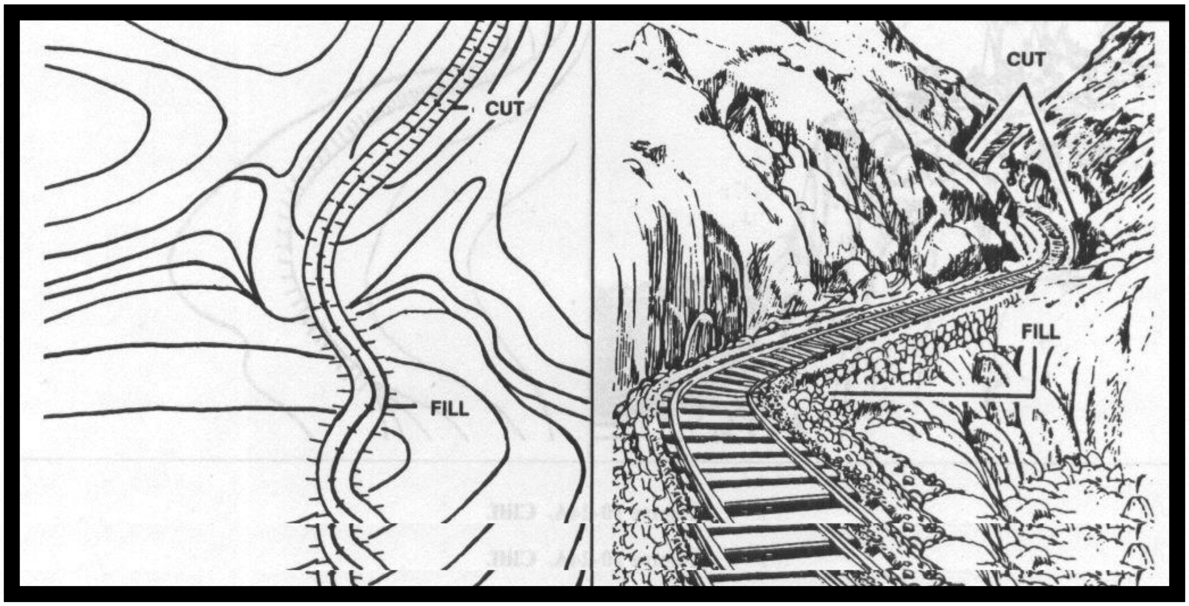
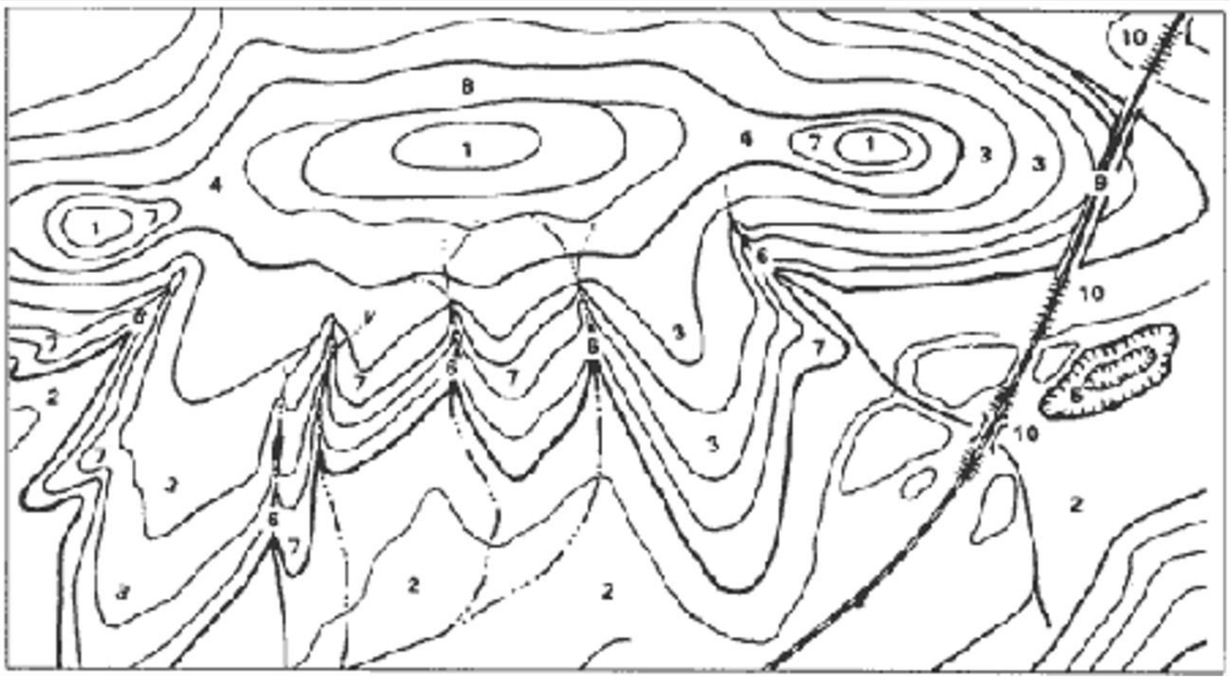


Figure 31 Cut and Fill

A method to help identify terrain features is **SOSES**:

- **S**hape of the feature at its base
- **O**rientation of the object from your viewpoint
- **S**ize of the feature
- **E**levation of the feature
- **S**lope of the sides of the feature

Figure 32 displays all the terrain features in one graphic. Study them until you understand the shapes and differences.



1. HILL
2. VALLEY
3. RIDGE
4. SADDLE
5. DEPRESSION
6. DRAW
7. SPUR
8. CLIFF
9. CUT
10. FILL

Figure 32 Multiple Terrain Features

A4. Grid Coordinates

Grid lines are a series of straight lines intersecting at right angles forming squares on a topographic map. Horizontal grid lines are numbered west to east. Vertical lines are numbered south to north. The basic rule about reading grid coordinates is to read right on the vertical grid lines, then up on the horizontal grid lines, or "Read Right then Up"

Read Right then Up!

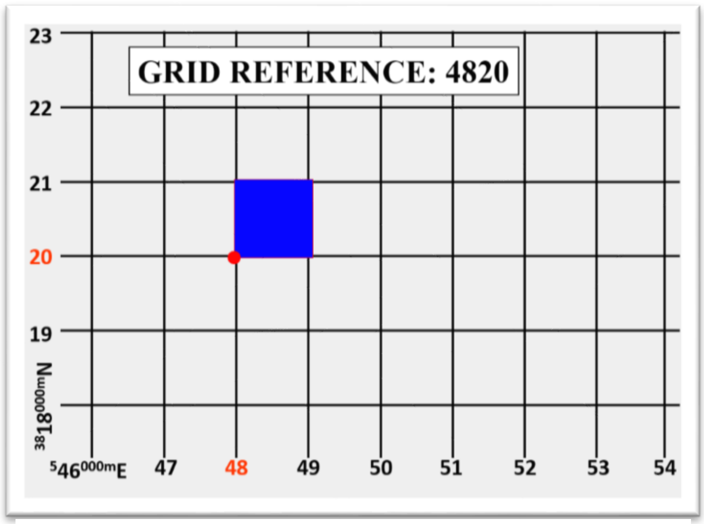


Figure 33 Grid Map

The map has vertical lines (top to bottom) and horizontal lines (left to right). These lines form small squares 1,000 meters on each side called grid squares. The lines that form grid squares are numbered along the outside edge of the map picture. No two grid squares have the same number.

A grid square's coordinates are found by combining the identities of the horizontal and vertical grid lines that intersect at the lower left hand corner of the grid.

Your address is grid square **4820**. How do you know this? Start from the left and read right until you come to 48, the first half of your address. Then read up to 20, the other half. Your address is somewhere in grid square 4820.

Grid square 4820 gives your general neighborhood, but there is a lot of ground inside that grid square. To make your address more accurate, just add another number to the first half and another number to the second half - so your address has six numbers instead of four. To get those extra numbers, pretend that each grid square has ten lines inside it running north and south, and another 10 running east and west. This makes 100 smaller squares. You can estimate where these imaginary lines are. Suppose you are halfway between grid line 48 and grid line 49. Then the next number is 5 and the first half of your address is 485. Now suppose you are also 3/10 of the way between grid line 20 and grid line 21. Then the second half of your address is 203. Your address is **485203**.

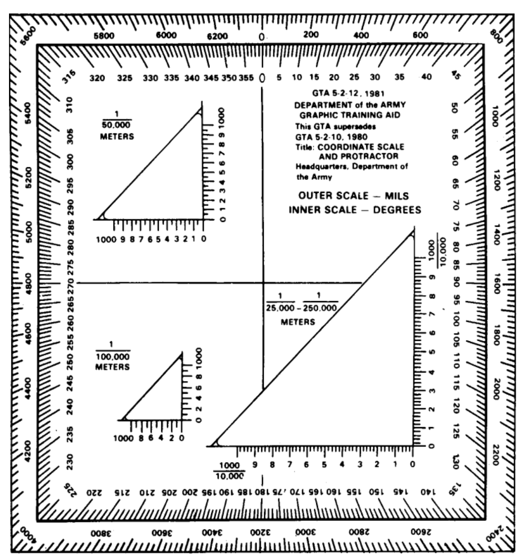


Figure 34 Coordinate Scale & Protractor

The most accurate way to determine the coordinates of a point on a map is to use a coordinate scale. You do not have to use imaginary lines; you can find the exact coordinates using a Coordinate Scale and **Protractor**.

First, locate the grid square in which the point is located. The number of the vertical grid line on the left (west) side of the grid square is the first and second digits of the coordinates.

The number of the horizontal grid line on the bottom (south) side of the grid square is the fourth and fifth digits of the coordinates.

To determine the third and sixth digits of the coordinates, place the coordinate scale on the bottom horizontal grid line of the grid square containing Point A, with the vertical scale going through the point. Line up the vertical line so it goes through your point, leaving the horizontal line along the horizontal grid line.

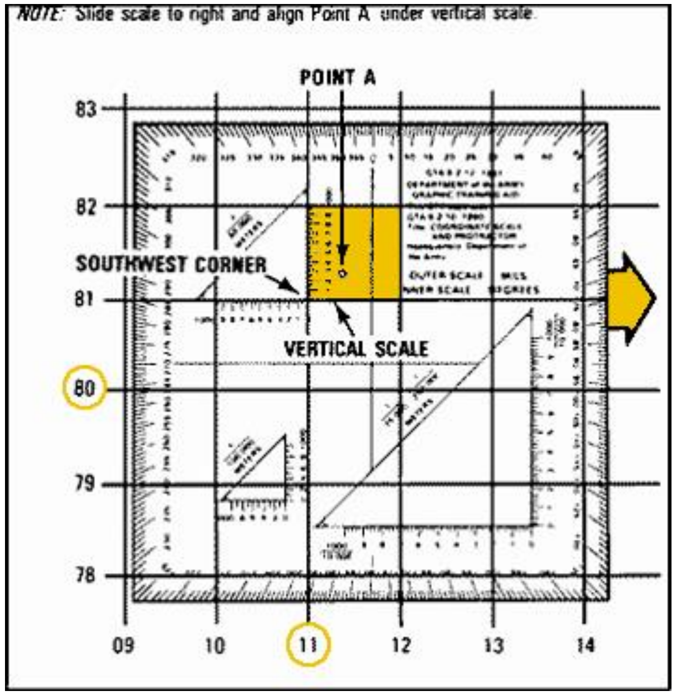


Figure 35 Protractor Alignment

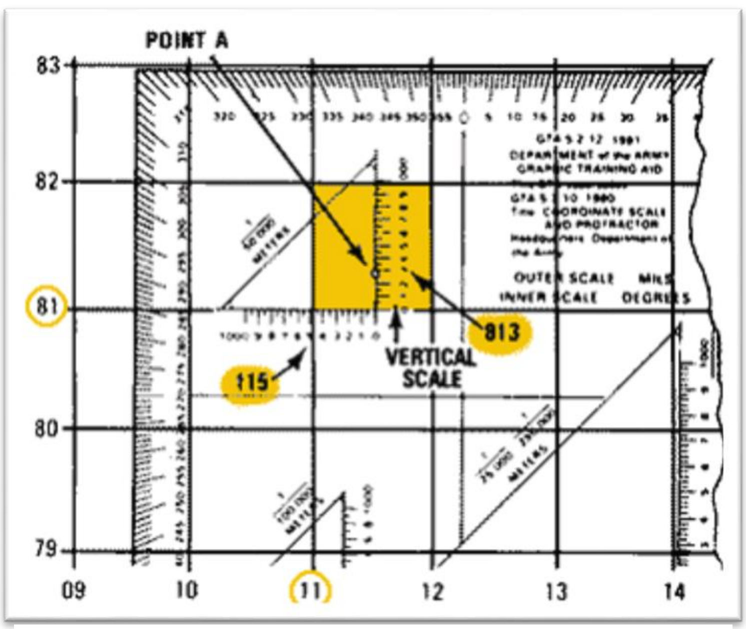


Figure 36 Protractor Interpolation

On the bottom scale, the 100 meter mark nearest the vertical grid line provides the third digit, 5. On the vertical scale, the 100 meter mark nearest Point A provides the sixth digit, 3. Therefore the six-digit grid coordinate is **115813**.

Grid squares are 1000 meters square.

They are subdivided into 100 meter and 10 meter marks.

The Grid Coordinate Scale helps you measure the grid square and determine a more accurate grid coordinate.

A 4-digit grid coordinate is accurate to **1000** meters
A 6-digit grid coordinate is accurate to **100** meters
An 8-digit grid coordinate is accurate to **10** meters

To find the grid coordinate of a point:

- ► Determine the scale of your map. Find the correct scale to use on your protractor.
- ► Determine the grid square the point is in.   This gives 4 digits: **12**xx**56**xx.
- ► Next, using the correct scale on your protractor, align the bottom right corner of the protractor scale to the bottom right corner of the grid square.
    - ▪ Slide the protractor to the left until the line forming the right edge of the scale intersects the point.
    - ▪ Read off the horizontal and vertical position:
        - ► 49551885

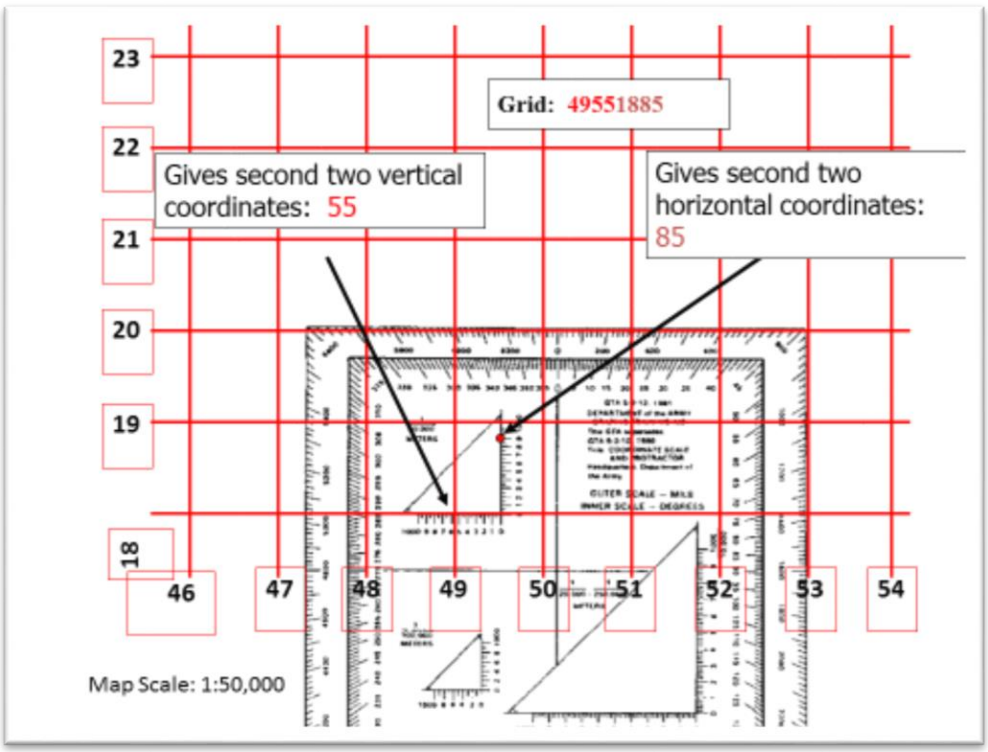


Figure 37 Use of Protractor to Determine Position

Finally, a grid coordinate isn't complete without the Grid Zone Designator. This is a 2-letter designation that is unique to a 100,000 meter area. (This is where the grid numbers start over again at 00.) The Grid Reference Box in the Marginal Data shows the Grid Zones that are on that map. The correct depiction of a grid coordinate ALWAYS includes the Grid Zone. i.e. ET 99450076, which is 100,000 meters from FT 99450076.

A5. Measuring Distance

You can use your map to measure the distance between two places. The maps are drawn to scale. This means that a certain distance on a map equals a certain distance on the earth. The scale is printed at the bottom and top of each map (i.e. Scale 1:50,000). This means that 1 inch on the map equals 50,000 inches on the ground. Or 1 centimeter on the map equals 50,000 centimeters (or 500 meters) on the ground. To change map distance to miles, meters, or yards, use the bar scales at the bottom of the map.

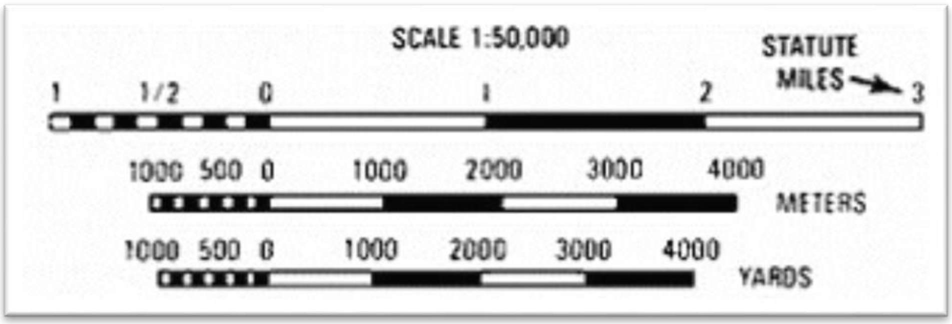


Figure 38 Map Scale

Take a ruler or the edge of a paper and mark on it the straight line distance between your two points.

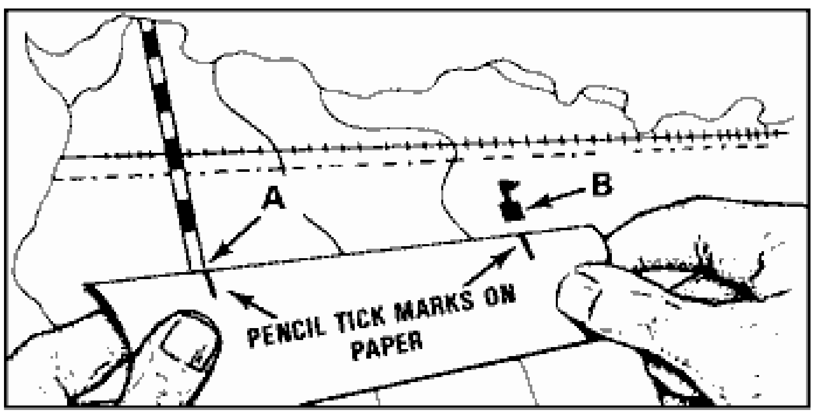


Figure 39 Use Paper to Measure Two Points

Then, put the ruler or the paper just under one of the bar scales and read the ground distance, in miles, meters, or yards. The bar scale here shows a ground distance of 1500 meters.

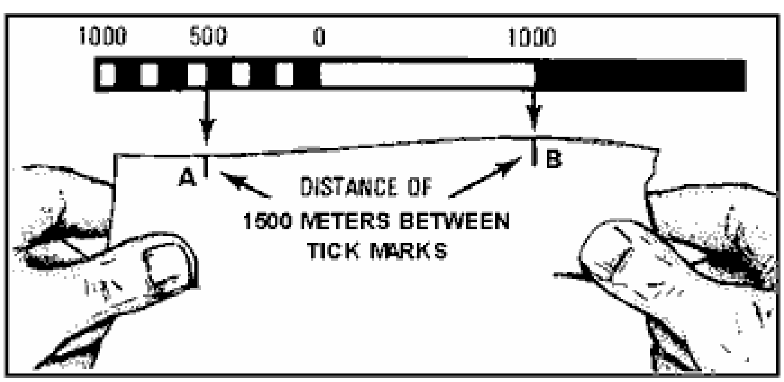


Figure 40 Use Scale to Measure Distance

To measure distance along a road that isn't straight, break up the road into little bits that are more or less straight, measure each leg, and add them together. You can do this on your straight piece of paper by making a tick mark where the road turns, then rotate the paper and make the next tick mark at the next turn. In the end, you have a series of tick marks, but one complete line on your paper.

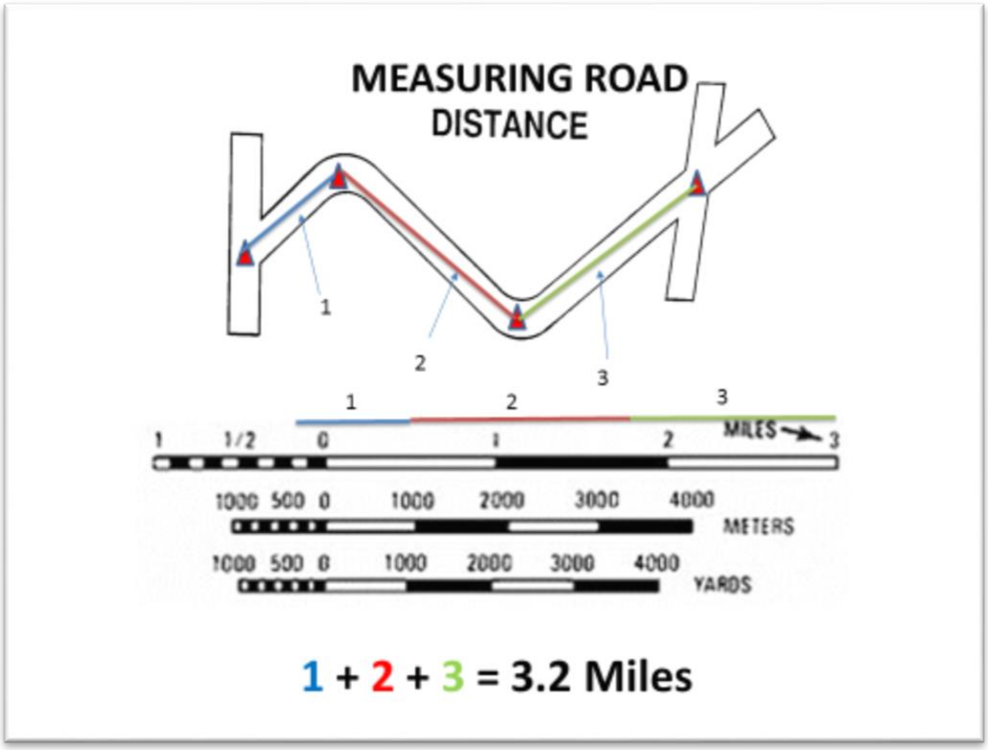


Figure 41 Measuring Distance Along a Crooked Path

A6. Direction

Direction – a course along which someone or something moves – is usually expressed in map reading as a **degree** or **azimuth**, or as a variant of **North, South, East**, and **West**. From any point on a plane, there are 360 degrees leading out from it in a circle. In almost all coordinate systems, north is portrayed at 0 degrees.

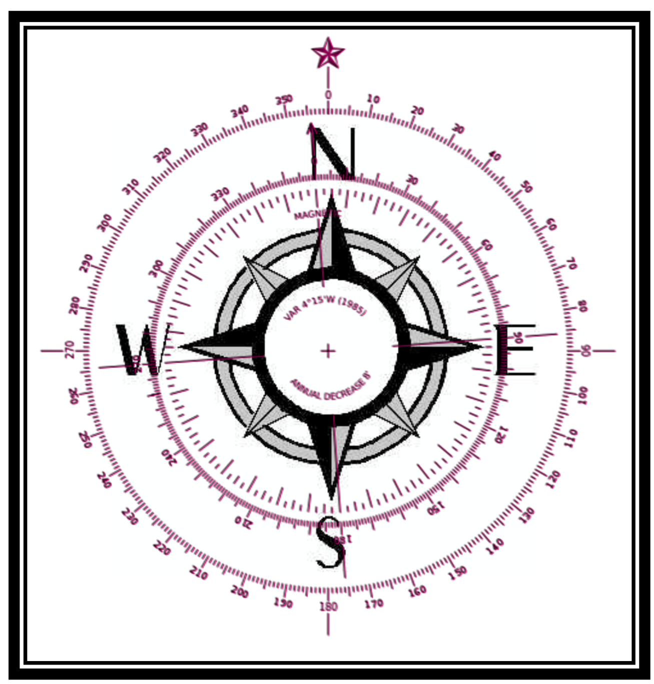


Figure 42 Compass Rose

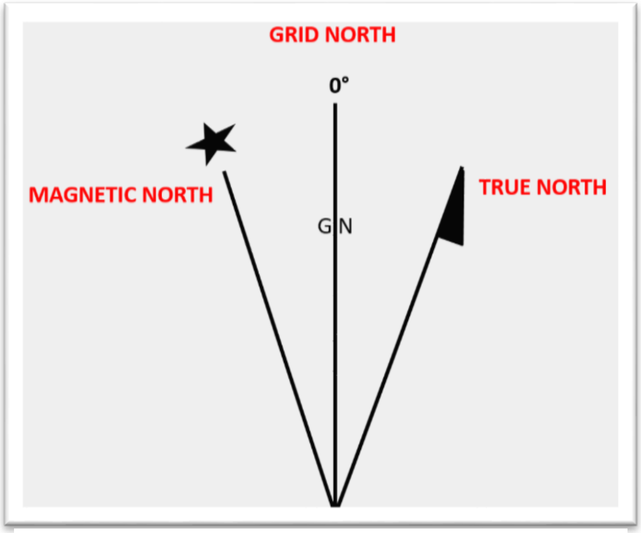


Figure 43 Types of North

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. True North is usually symbolized in marginal information with a star.

Magnetic North, as shown by the compass needle, points to the north magnetic pole, which is not the same as the geographic North Pole. It is shown in marginal information as a half-arrow.

Grid North is the north that mapmakers put on a map, dependent of the map projection used. It is shown in the marginal information by the letters GN on a vertical line.

The Compass

We generally use one of two types of compass in the Cadet Corps – the lensatic compass or the Silva compass – and sometimes both depending on what we're doing. There are many styles and types of compass, but they all share one thing: they point you to Magnetic North. In this lesson, we'll use a Silva Compass, but we'll cover the use of the lensatic compass later on.

Figure 44 Military Style Lensatic Compass

The lensatic compass is the compass used by the military in field operations. It is simple to use and more accurate than most other simple compasses. It includes a sight, sighting wire and lens to more easily focus on the target and read the dial, luminous features for use in the dark, a thumb ring to hold it steady, and a straight edge for measuring distance on 1:50,000 maps. It folds up for protection, and the rear sight locks the needle, which extends the compass life. The movable bezel ring can be used to preset an azimuth.

The Silva Compass, or models like it, is a simple, inexpensive compass that's great for map reading and orienteering. Some have an adjustable baseplate that allows you to adjust for declination, so you can ignore converting grid to magnetic azimuths and back. The compass has direction lines that help align the compass on your map, and assist in pointing along your route. It is not as accurate as a lensatic compass, but works well in an orienteering environment where terrain association is your primary method of finding your way.

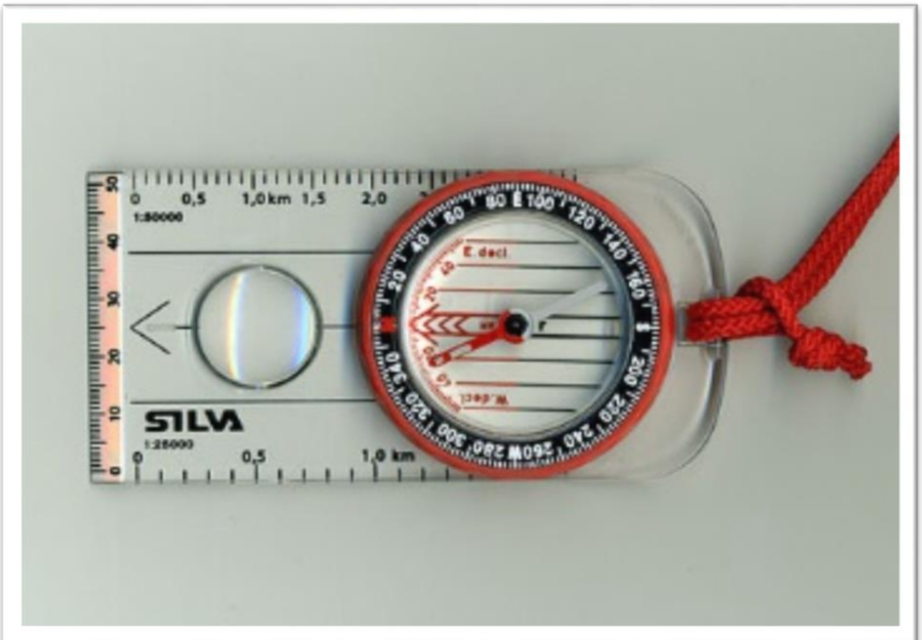


Figure 45 Silva Compass

The key **thing to know about a compass is that it points toward Magnetic North. On a Silva Compass, it's the red part of the compass needle that points north.**

You've got a dial that turns on your compass. We call it the *compass housing* (it may also be referred to as a *bezel ring*. On the edge of the compass housing, you will probably have a scale from 0 to 360. Those are the degrees or the *azimuth* (or you may also call it the bearing in some contexts). And you might have the letters N, S, W and E for North, South, West and East. If you want to go in a direction between two of these, you would combine them. If you would like to go in a direction just between North and West, you simply say: *"I would like to go Northwest "*.

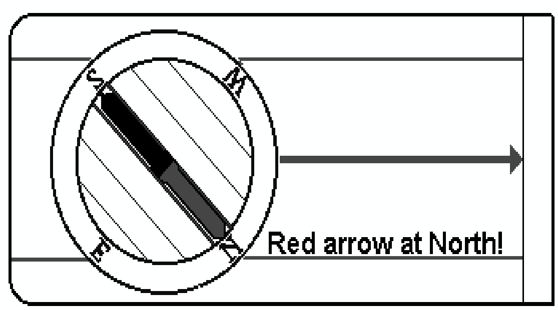


Figure 46 How to Travel NorthWest

Turn the compass housing so that northwest on the housing comes exactly there where the large *direction of travel- arrow* meets the housing. Hold the compass in your hand. And you'll have to hold it quite flat, so that the compass needle can turn. Then turn yourself, your hand, the entire compass, just make sure the compass housing doesn't turn, and turn it until the compass needle is aligned with the lines inside the compass housing.

Now, time to **be careful!**. It is e*xtremely* important that the red, north part of the compass needle points at north in the compass housing. If south points at north, you would walk off in the exact opposite direction of what you want! And it's a very common mistake among beginners. So always take a second look to make sure you did it right!

A second problem might be local magnetic attractions. If you are carrying something of iron or something like that, it might disturb the arrow. Even a staple in your map might be a problem. Make sure there is nothing of the sort around.

When you are sure you've got it right, walk off in the direction the direction of travel-arrow is pointing. To avoid getting off the course, make sure to look at the compass every hundred steps or so.

Once you have the direction, aim on some point in the distance, and go there without staring down at the compass.

If you are out there without a map, and you don't know exactly where you are, but you know from your experience in the area that there is a road, trail, stream, river or something long and big you can't miss if you go in the right direction…

Then all you need to do is to turn the compass housing so that the direction you want to go in is where the direction of travel-arrow meets the housing. And follow the steps you were just shown.

But why isn't this sufficient? First, it is not very accurate. You are going in the right direction, and you won't go around in circles, but you're very lucky if you hit a small spot this way.

And, this requires you to have a mental image of the area you are in and what direction those landmarks might be in.

That's why using the compass with a map is much, much better.

How to "shoot an azimuth" in three easy steps:

1. Turn the dial of the compass to the given azimuth
2. Keep the compass flat in front of you with the "Direction of Travel Arrow" pointing straight ahead.
3. Turn your body so the red (north pointing) needle of the compass lines up inside the red housing on the base of the compass.

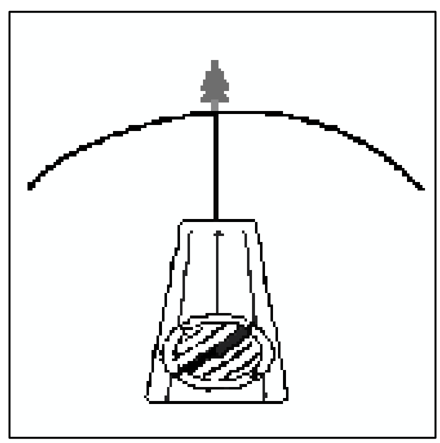


Figure 47 Shooting an Azimuth

There are three kinds of azimuth:

> ***Magnetic Azimuth***: direction expressed as the angular difference between Magnetic North and the direction line (i.e. 140°)
>
> ***Grid Azimuth***: the angle measured between Grid North and a line plotted between two points on a map.
>
> ***Back Azimuth***: the opposite direction of an azimuth. The back azimuth is 180° from an azimuth. For azimuths more than 180°, subtract 180. For azimuths less than 180°, add 180. A back azimuth of 180° is either 0° or 360°.

The Protractor. There are several types of protractors – circular, half-circle, square, and rectangular.

All have a scale around the outer edge and an index mark in the middle.

On military protractors, you read the inner of the two scales because it is broken into degrees from 0 to 360. Each tick mark on the degree scale represents one degree.

You have several coordinate scales for measuring grid coordinates, one for each of the most common map scales you might use.

Index – where the N/S and E/W lines cross in the middle. It's the central point from which you measure an azimuth.

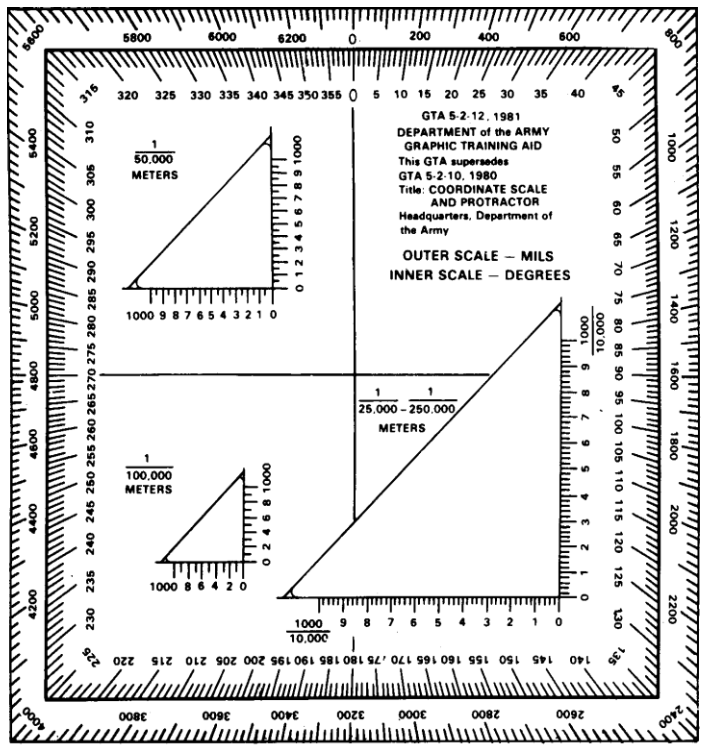


Figure 48 Protractor

360 Degrees - usually the inner of two types of direction marks

Mils – the outer measuring marks found on Army protractors. Used in field artillery plotting. You can ignore them (or even carefully cut them off your protractor!)

Next, we'll learn how to use the protractor to determine an azimuth between two points.

1. Find the two points you want to measure an azimuth between (*Figure 49*).

2. Line up the protractor so the index lines are exactly parallel to the map's grid lines (*Figure 50*).

3. Align a straight edge along both points. Check carefully to see where it crosses the protractor's degree scale. 39°! (*Figure 51*).

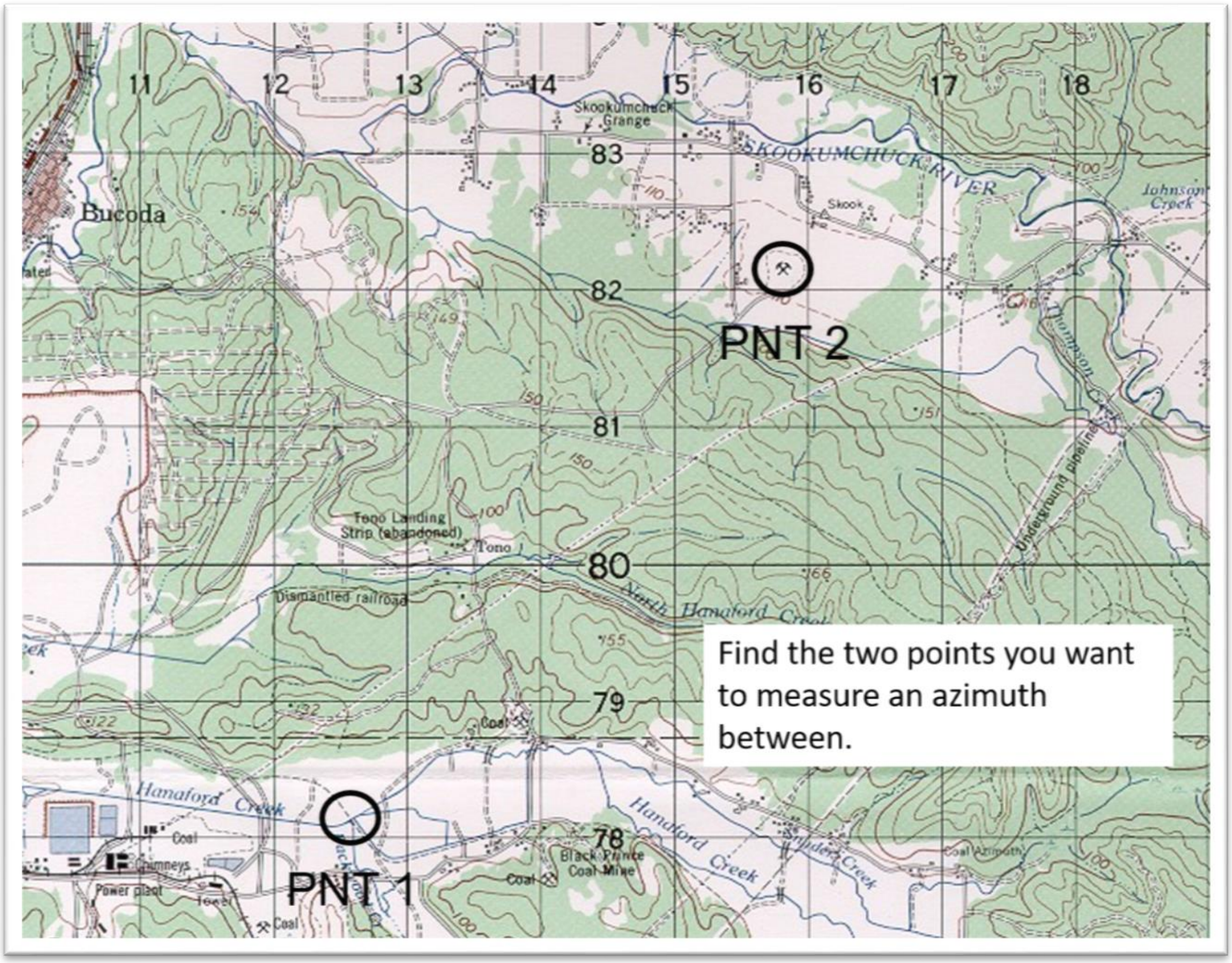


Figure 49 Determining an Azimuth, Step 1

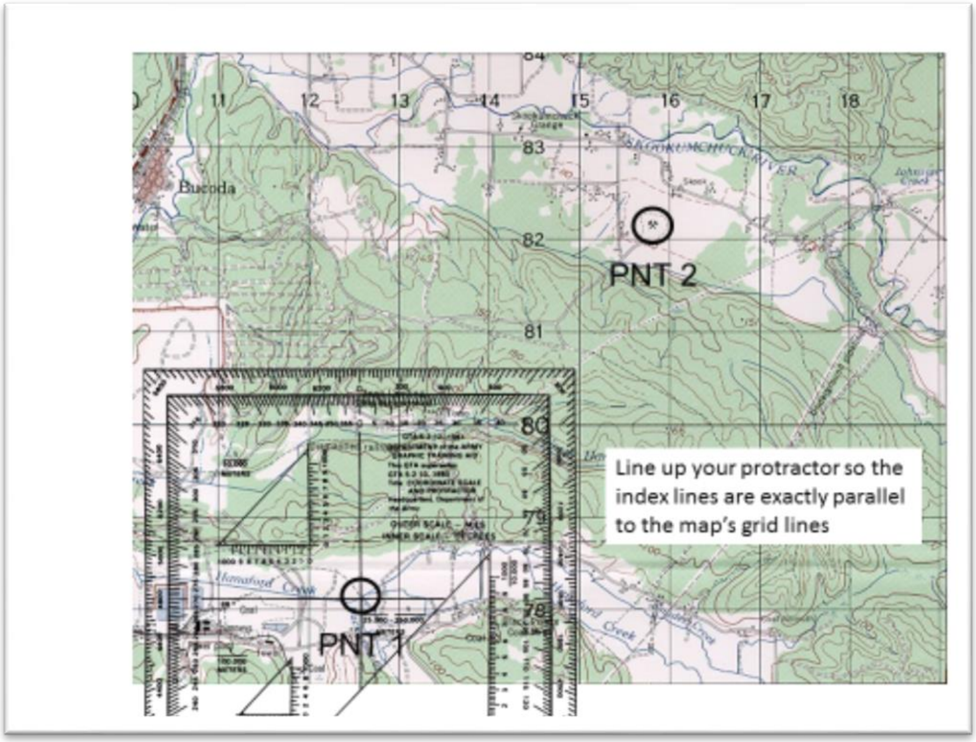


Figure 50 Step 2

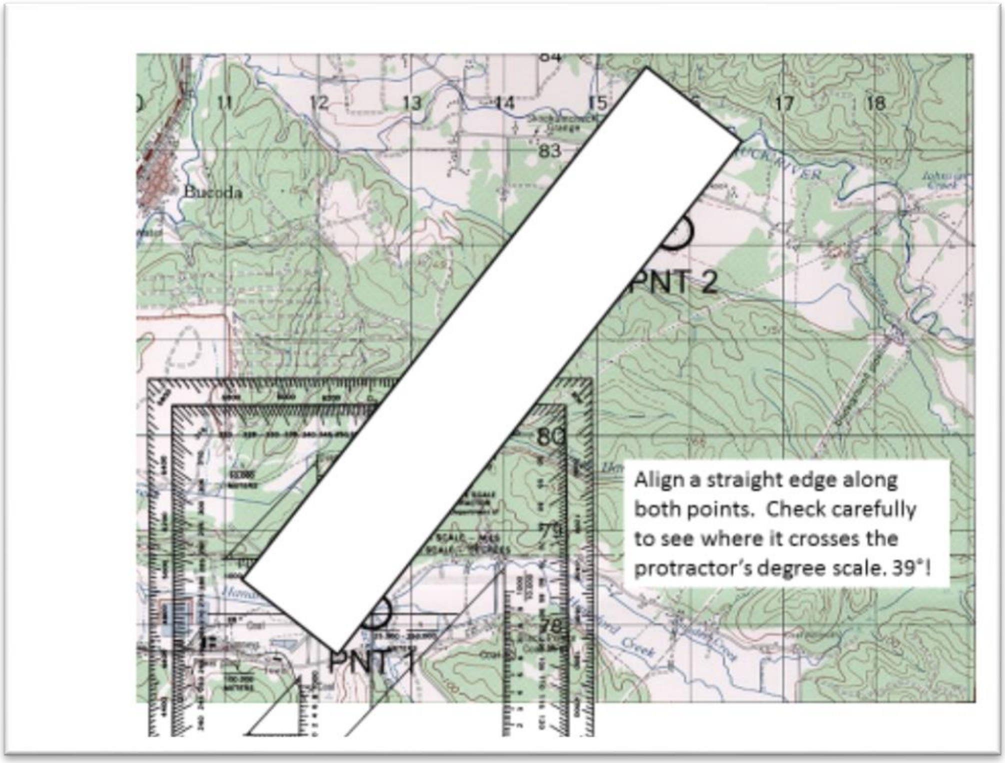


Figure 51 Step 3

A7. Polar Coordinates

A method of locating or plotting an unknown position from a known point by giving a direction and a distance along that direction line is called polar coordinates. The following elements must be present when using polar coordinates.

- Current known location on the map
- Azimuth (grid or magnetic)
- Distance (in meters)

This is a common task on a land navigation (Land Nav) course!

1. Place the index mark of the protractor at the center of mass on the point from which you are measuring. *Figure 52*

2. Locate the desired azimuth on the protractor scale and place a dot on the map at this azimuth. In our example, this will be 56°. *Figure 53*

3. Remove the protractor and connect the point and dot with a straight line. *Figure 54*

4. Select the appropriate scale measurement (we'll use meters) and place a paper straight edge on the scale. *Figure 55*

5. Determine the desired distance to measure from the scale and mark the paper at this distance using tick marks. We'll use 3400 meters. *Figure 56*

6. Align the straight edge with the azimuth line. Ensure the first tick mark is center of mass on the known point. *Figure 57*

7. Place a dot on the map at the second tick mark from the straight edge on the map. The position of the second tick mark is the position of the unknown point. *Figure 58*

8. Remove the straight edge and determine the grid coordinate to the second point. *Figure 59*

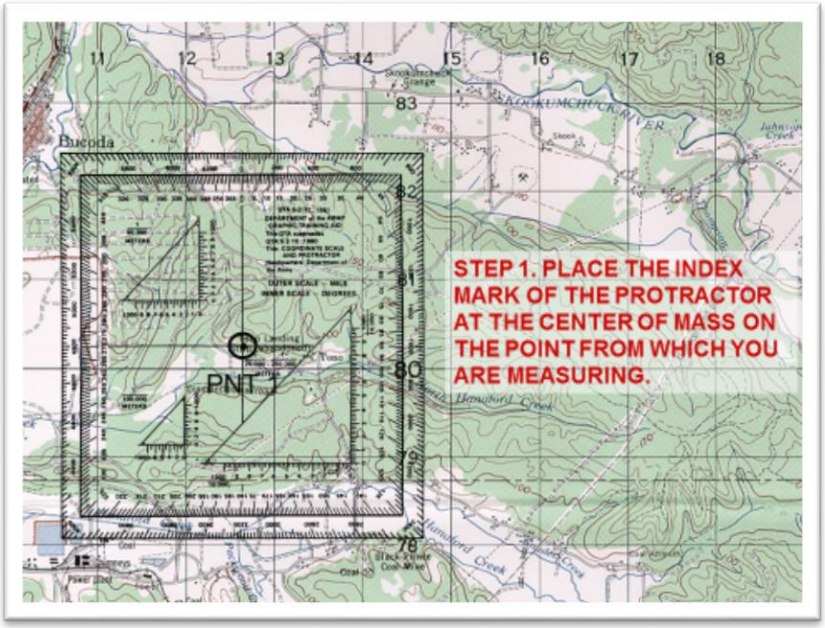


Figure 52 Polar Coordinates Step 1

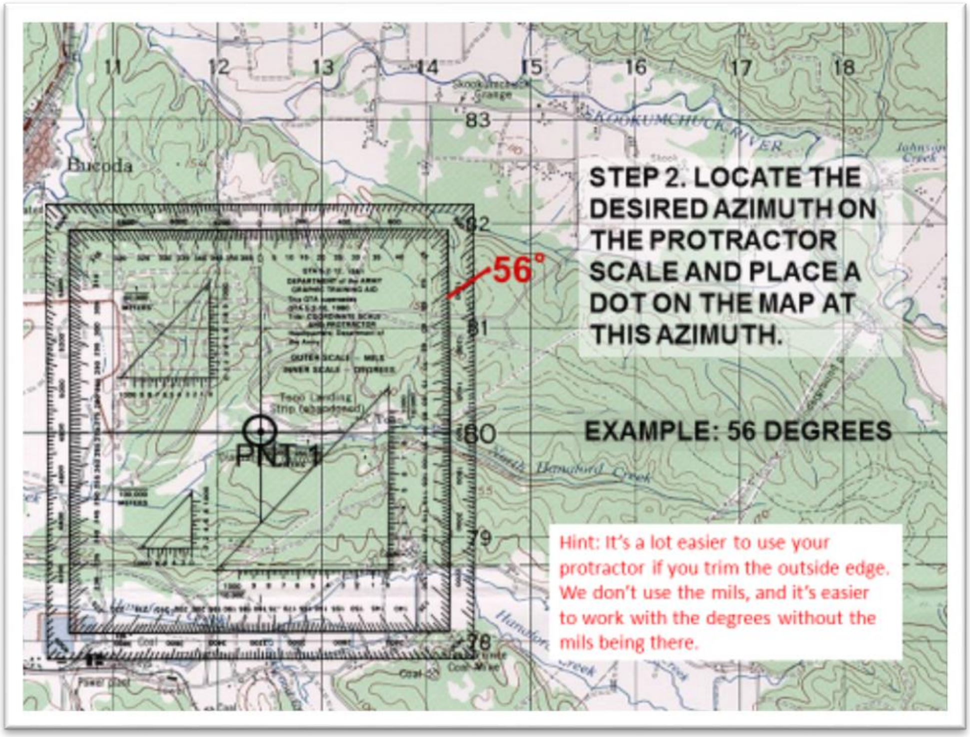


Figure 53 Polar Coordinates Step 2

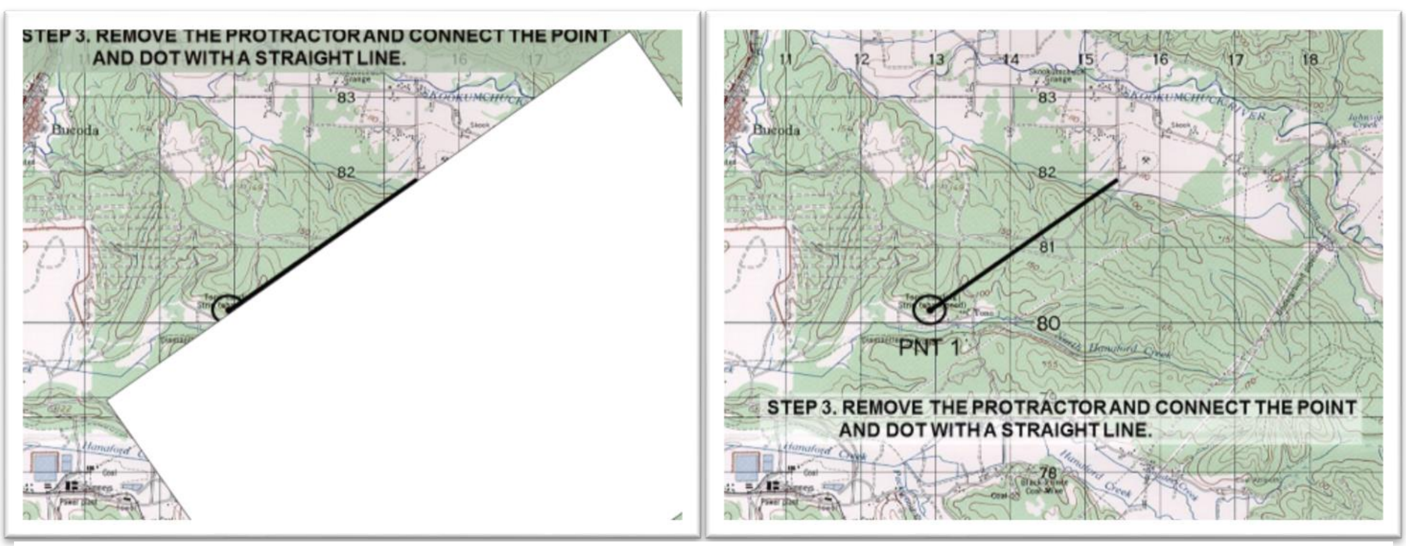


Figure 54 Polar Coordinates Step 3

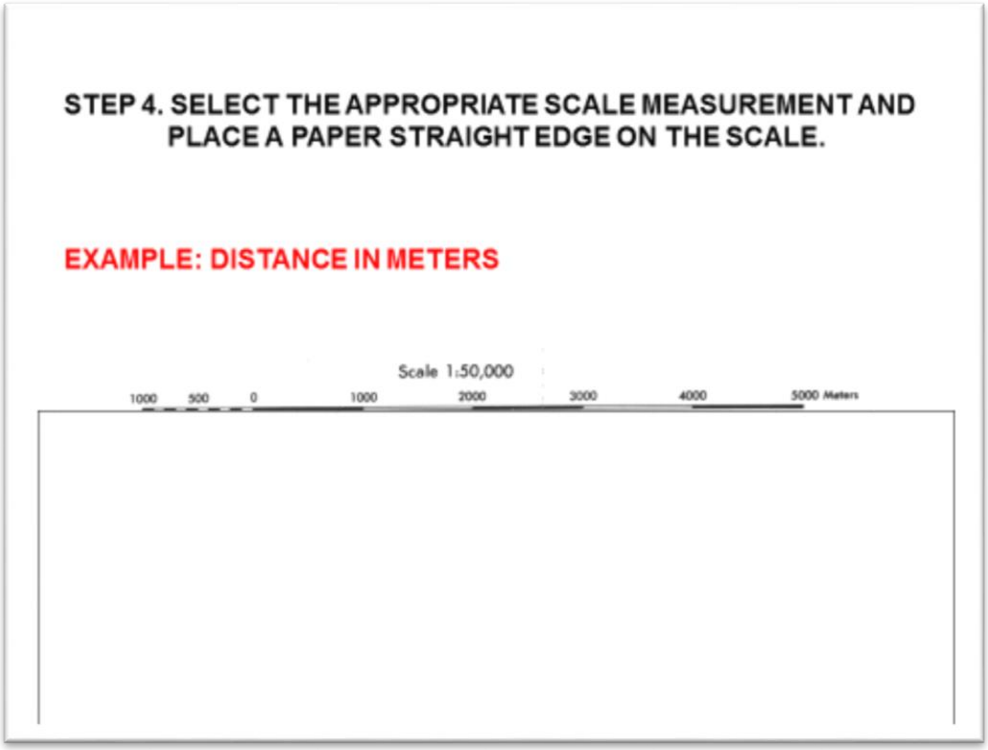


Figure 55 Polar Coordinates Step 4

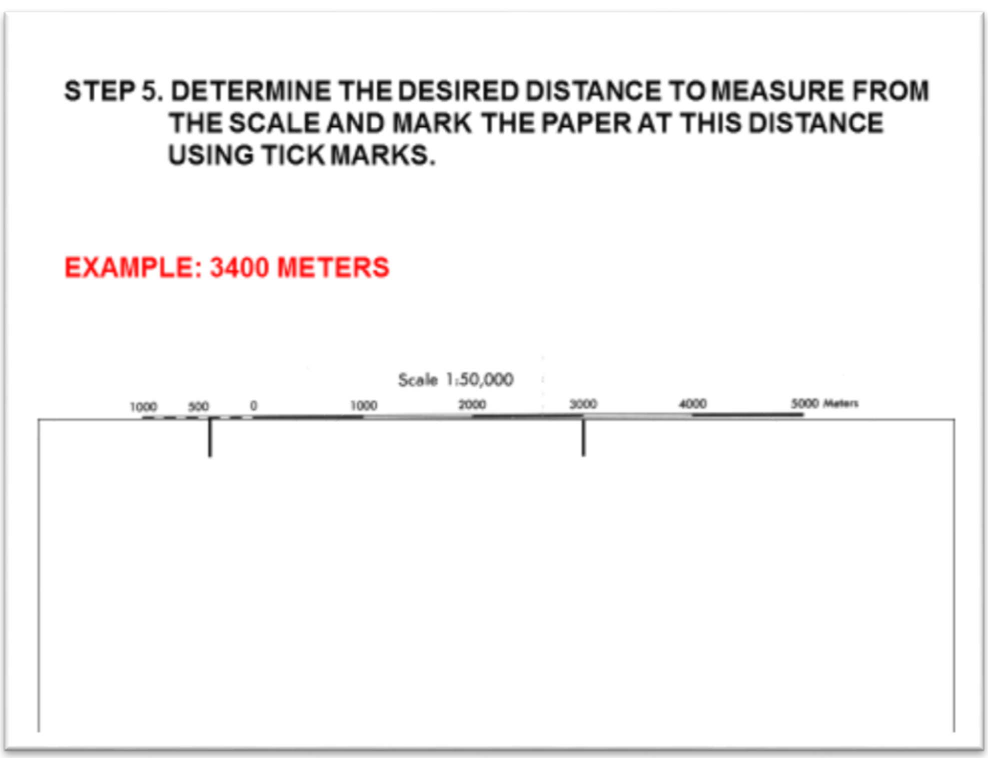


Figure 56 Polar Coordinates Step 5

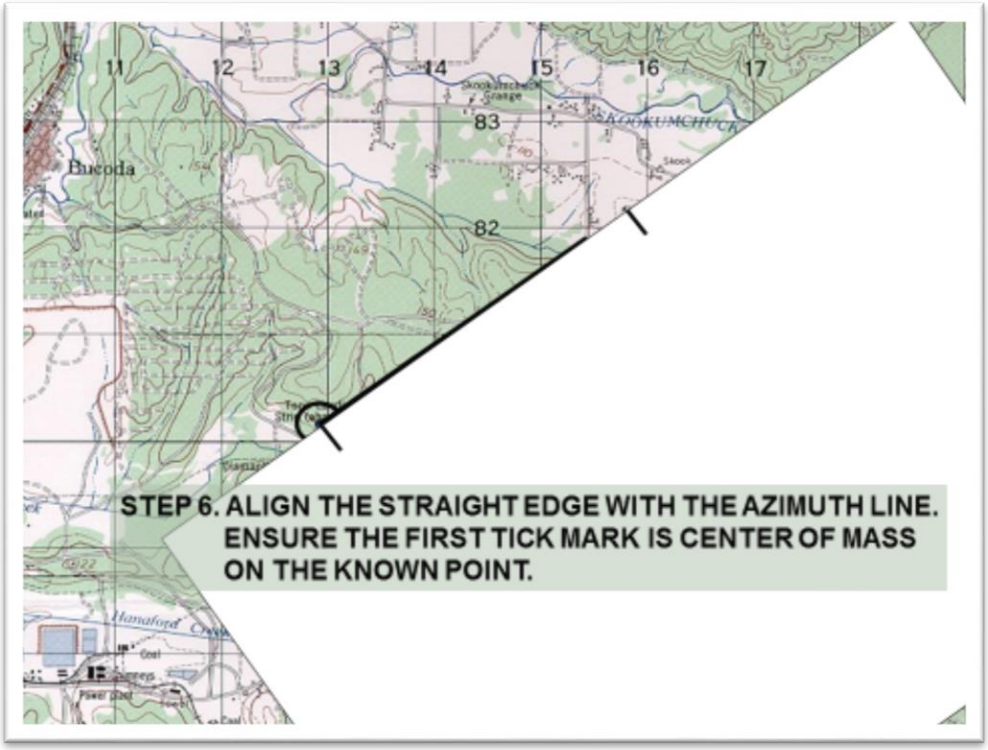


Figure 57 Polar Coordinates Step 6

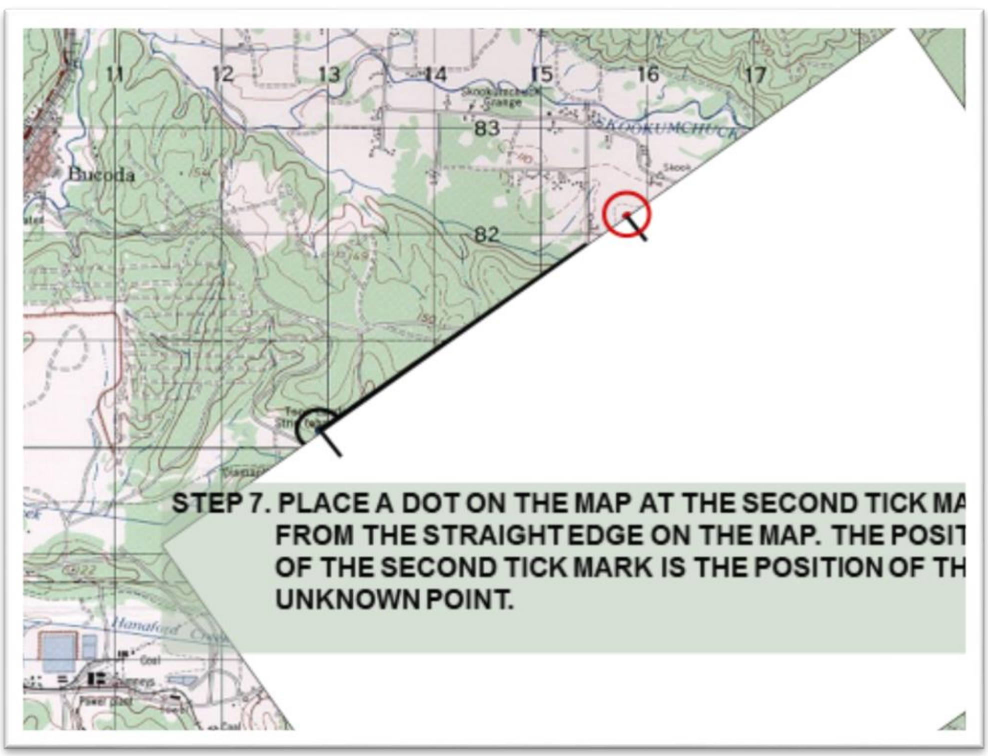


Figure 58 Polar Coordinates Step 7

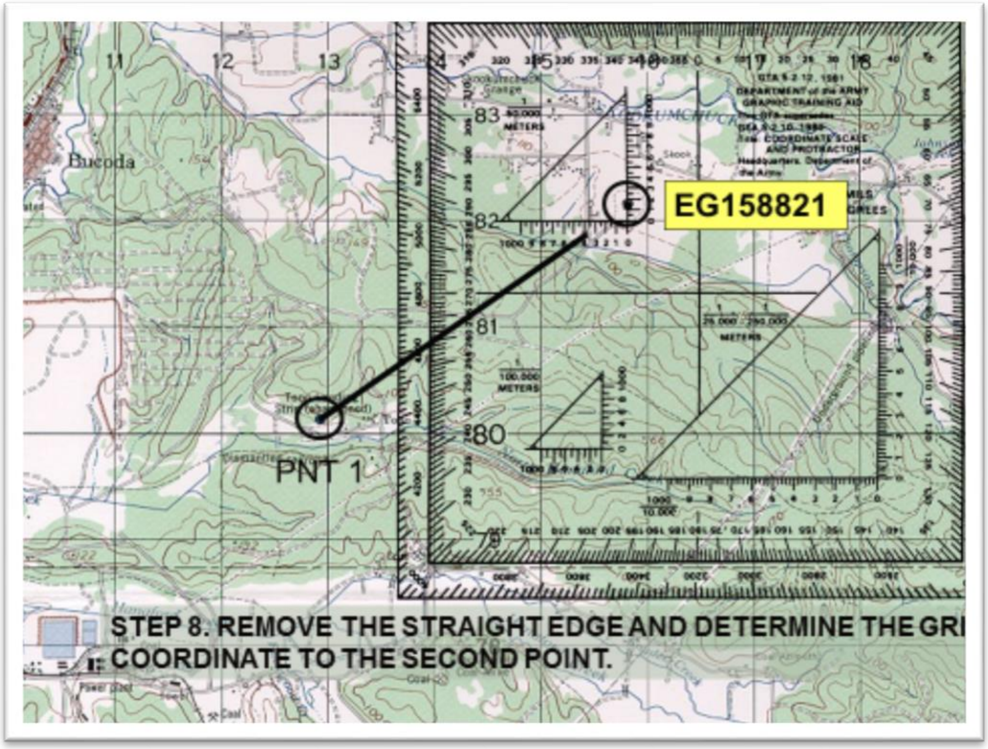


Figure 59 Polar Coordinates Step 8

A8. G-M Angle: Declination Diagram

If you're going to use a map and compass together, you must know how to make the information compatible. The map shows Grid North. The compass shows Magnetic North. The **Declination Diagram** on the marginal information shows the relationship between the three norths, and how to determine the G-M Angle.

The Declination Diagram:

- Shows the 3 norths
- Tells you the G-M Angle (21° in this case)
- Tells you how to convert:

East G-M Angle:

- Magnetic to Grid – ADD
- Grid to Magnetic – SUBTRACT

West G-M Angle:

- Magnetic to Grid – SUBTRACT
- Grid to Magnetic – ADD

This example is an EAST G-M Angle (the Magnetic North is east of Grid North)

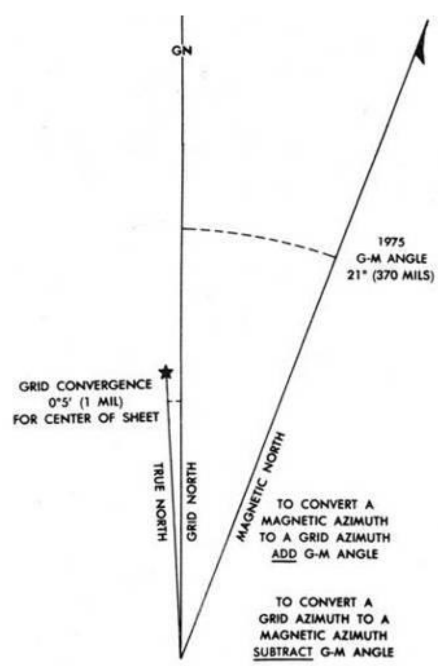


Figure 60 Declination

Why does every map need a declination diagram?

Because different parts of the globe have different declinations (and they also change over time). For example, the declination varies from 16 degrees west in Maine, to 6 in Florida, to 0 degrees in Louisiana, to 4 degrees east in Texas. Without knowing the G-M Angle, you can't really use a map and compass together. If Magnetic North (MN) is West of Grid North (GN), you subtract when going from magnetic to grid. If MN is East of GN, you add when going from magnetic to grid. And going from grid to magnetic you do the opposite!

It's very handy to have this spelled out on your map!

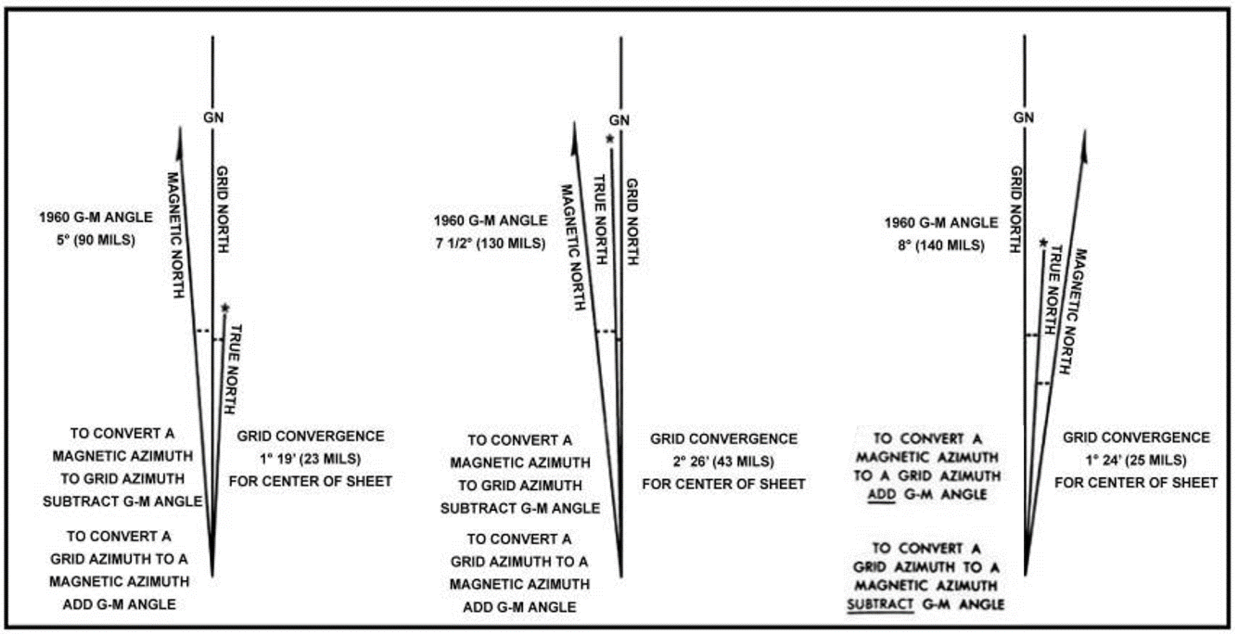


Figure 61 Sample Declination Diagrams

Let's try some conversions!

1. You shoot a magnetic azimuth of 215°. Your G-M Angle is 21° East. Convert your magnetic azimuth to a grid azimuth.

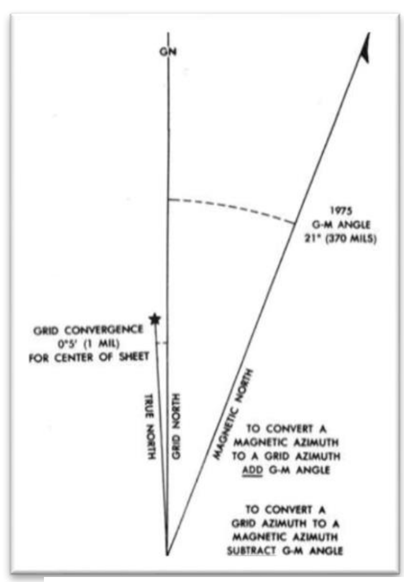


Figure 62 Example 1

- Magnet to Grid – Add in the East.
- 215 + 21 = 236°

2. You have a grid azimuth of 95°. Your G-M Angle is 5° West. Convert your grid azimuth to a magnetic azimuth.

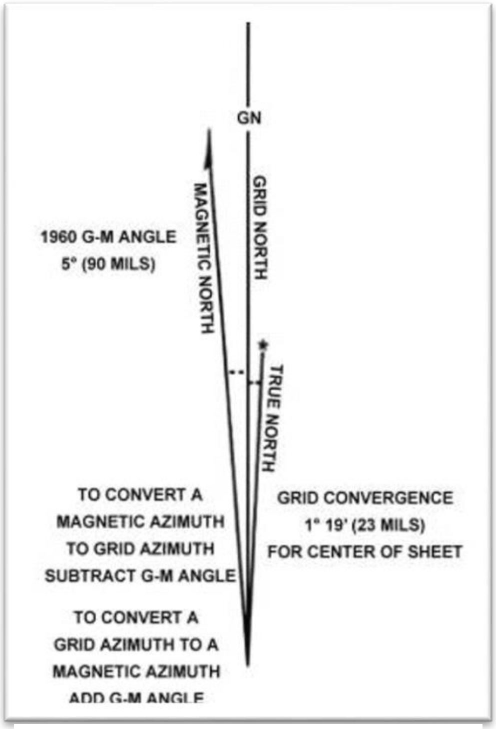


Figure 63 Example 2

- Grid to Magnetic – Add in the West
- 95 + 5 = 100 °

3. You have a grid azimuth of 5°. Your G-M Angle is 21° East. Convert your grid azimuth to a magnetic azimuth.

- Grid to Magnetic – Subtract in the East
- 5° is the same as 365°
- 365 – 21 = 344°

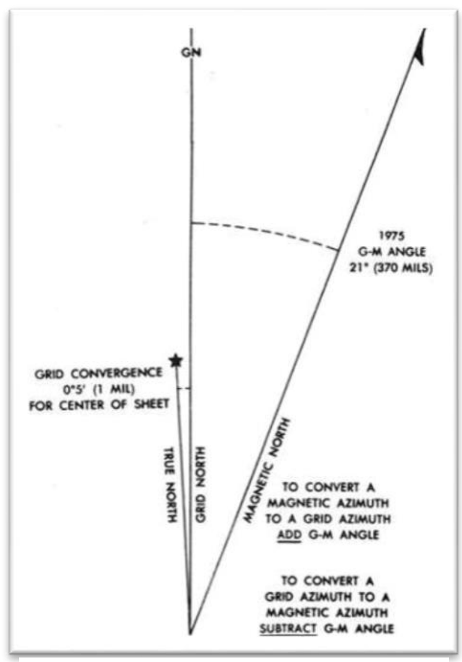


Figure 64 Example 3