# Unit VI – Geography and Survival Skills

## Chapter 1 - Geography, Map Skills, and Environmental Awareness

### Section 5 – Grid-Magnetic Angle and Determining Location

# What You Will Learn to Do

Understand the principles and tools of map reading and land navigation

# Objectives

1. Use a compass and grid to locate a position on a topographic map
2. Apply map reading and land navigation skills to determine location

# Key Terms


CPS Key Term
Questions 1 - 6

# Key Terms

| | |
|---|---|
| **Grid-Magnetic Angle (G-M Angle) -** | Angular difference in direction between grid north and magnetic north; measured east or west from grid north |
| **Grid Convergence -** | The horizontal angle at a point between true north and grid north |
| **Field-Expedient -** | Adapting to a particular situation by using available materials and/or resources |

# Key Terms

**Intersection -** The method of locating an unknown point by determining where the azimuths from at least two known points meet (intersect)

**Resection -** The method of locating your unknown position by determining where the back azimuths from two or three well-defined locations on a map meet

# Key Terms

**Polar Coordinates -** The method of locating or plotting an unknown position from a known point by giving a direction and distance along that direction line

# Opening Question

Explain how you measure curved-line distance on a topographic map using the map scale.

1.

2.

3.

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

# Warm Up Questions

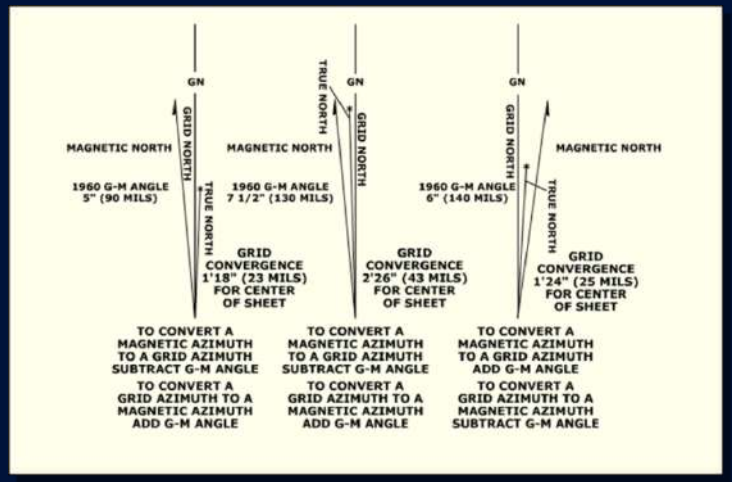

CPS Lesson
Questions 1 - 2

# Converting the Grid-Magnetic Angle

An essential skill that you must learn is how to use the declination diagram to convert grid azimuths to magnetic azimuths (and vice versa).

Converting the Grid-Magnetic Angle (G-M Angle) is one of the most challenging tasks to understand in map reading.

# The Declination Diagram




Mapmakers place the declination diagram in the lower margin of most topographic maps.

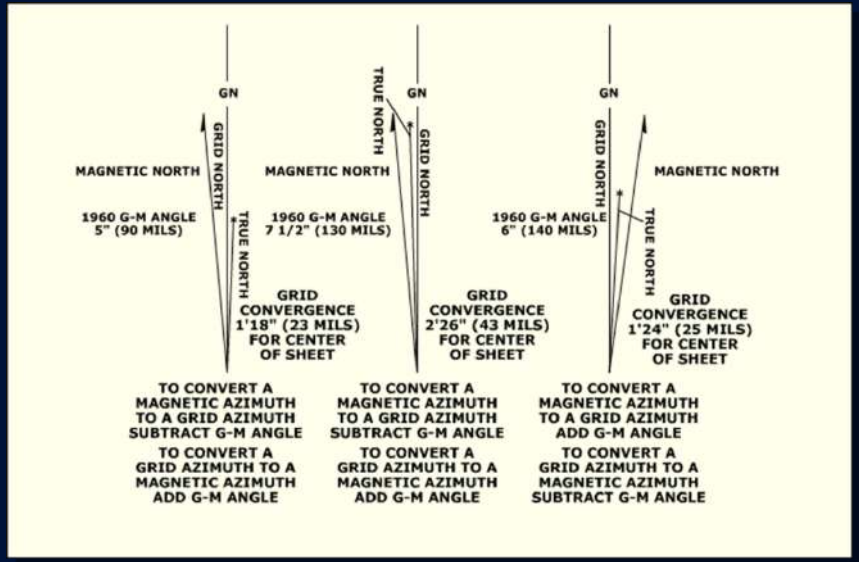
Declination:
the angular difference between true north and either magnetic or grid north

The two declinations:

- magnetic declination
- grid declination

# The Declination Diagram

Note that mapmakers usually do not plot the angles between the prongs exactly to scale.




Although you can obtain the position of the north's in relation to each other from the diagram, you should not measure the numerical value from it.

# The Grid Magnetic G-M Angle

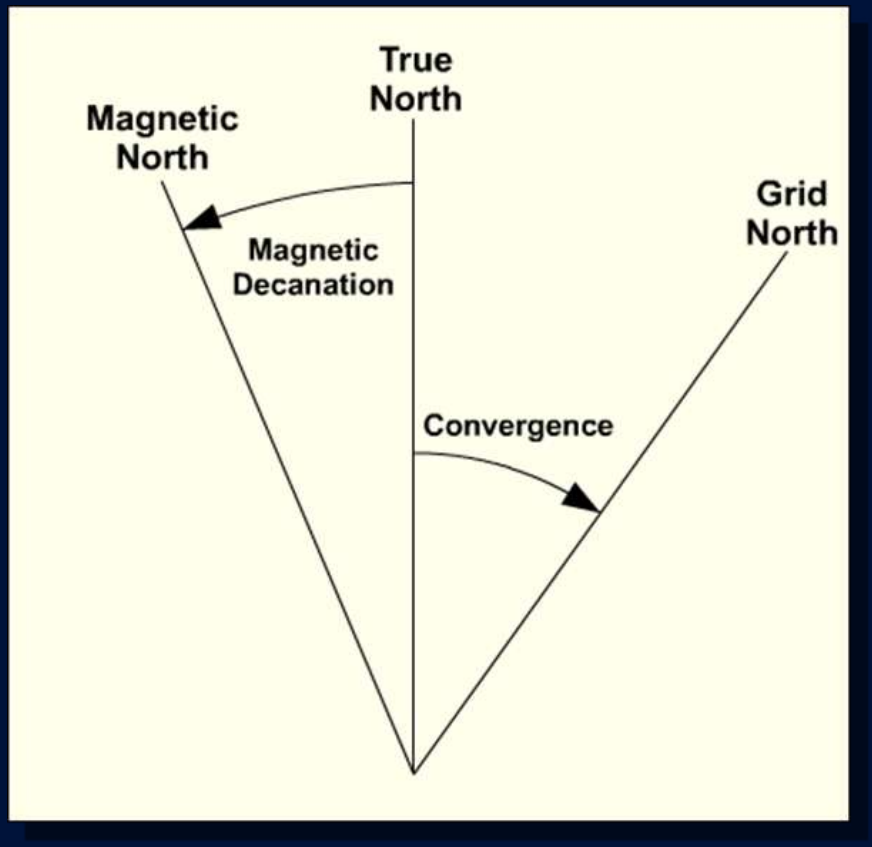
The Grid-Magnetic Angle (G -M Angle), is the angular size that exists in the year that mapmakers prepared the angular size, between: grid north and magnetic north.

It is an arc, indicated by a dashed line, that connects the grid-north and magnetic-north prongs.

# Grid Convergence

Grid convergence is an arc indicated by a dashed line connecting the prongs for true north and grid north.

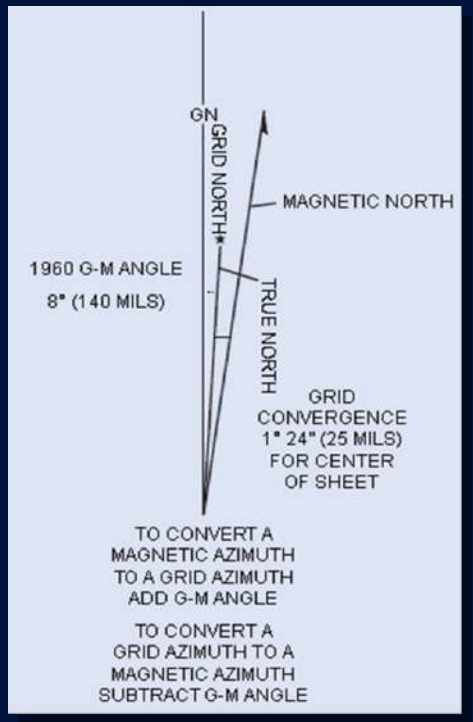
Mapmakers show this data in the form of a grid-convergence note.



# Conversion

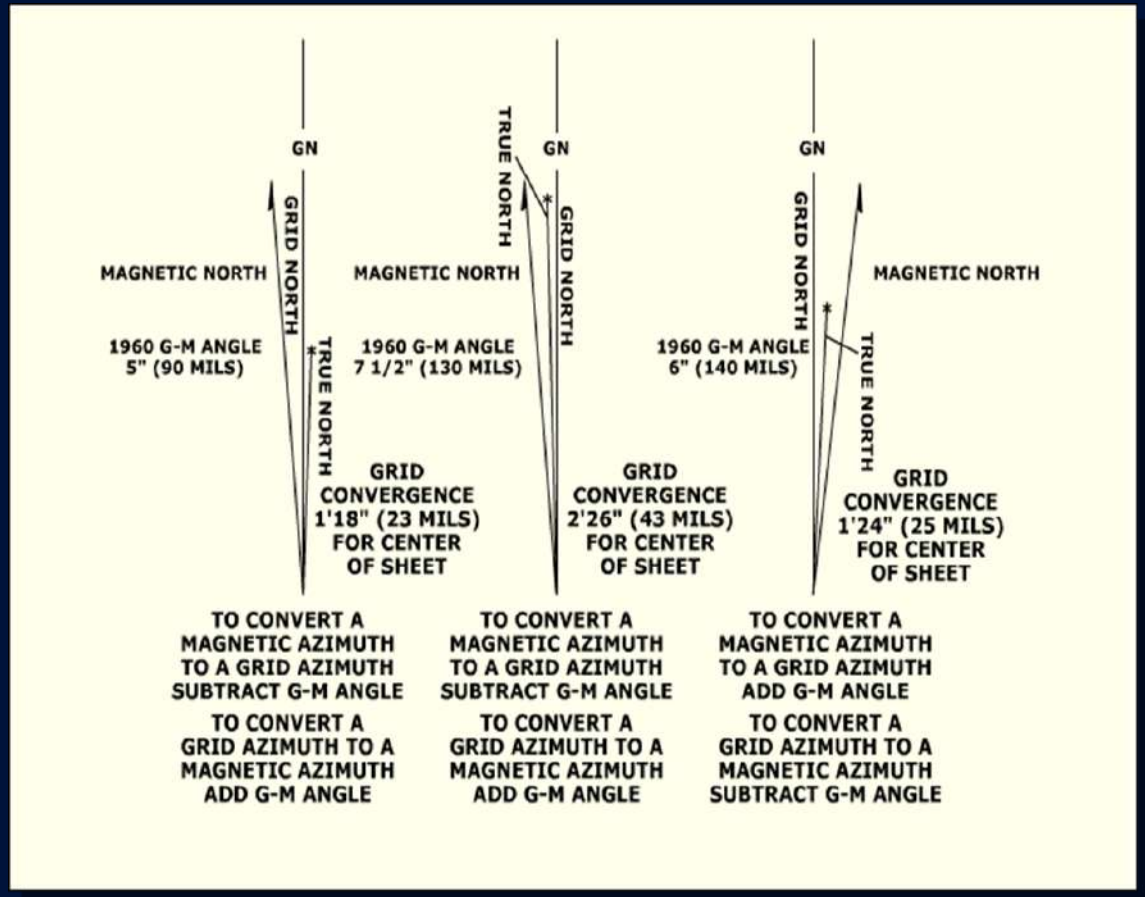
There's an angular difference between the grid north and magnetic north, caused by the attraction of the earth's magnetic field.

Since all compasses point toward magnetic north, the location of this magnetic field does not match exactly with the grid-north lines on maps. Therefore, a conversion from magnetic to grid (or vice versa), is needed.



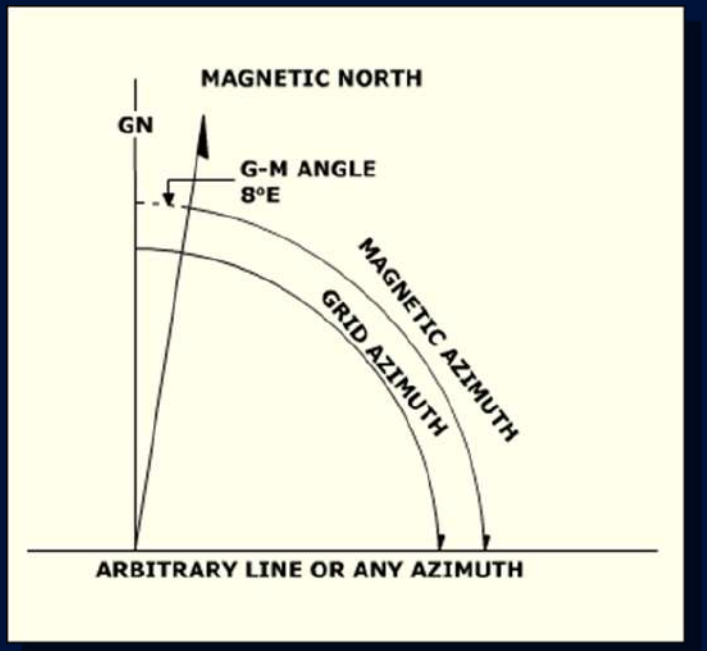
# Conversion with Notes

If the declination diagram on a map provides conversion notes explaining the use of the G-M Angle, simply refer to them.



# Conversion without Notes

Without any conversion notes, it is necessary to convert magnetic azimuth to grid azimuth.




A rule to follow:

*Always start from the reference line, and always measure the angle to the azimuth line in a clockwise direction.*

# Conversion without Notes

1. Draw a vertical, line (prong). Always align this line with the vertical lines on the map.
2. From the base of the grid-north line, draw a direction line at roughly a right angle from north, regardless of the actual value of the azimuth in degrees.
3. Examine the declination diagram on the map and determine the direction of the magnetic north (right-left or east-west) relative to that of the grid-north prong. Draw a magnetic prong from the base of the grid-north line in the desired direction.

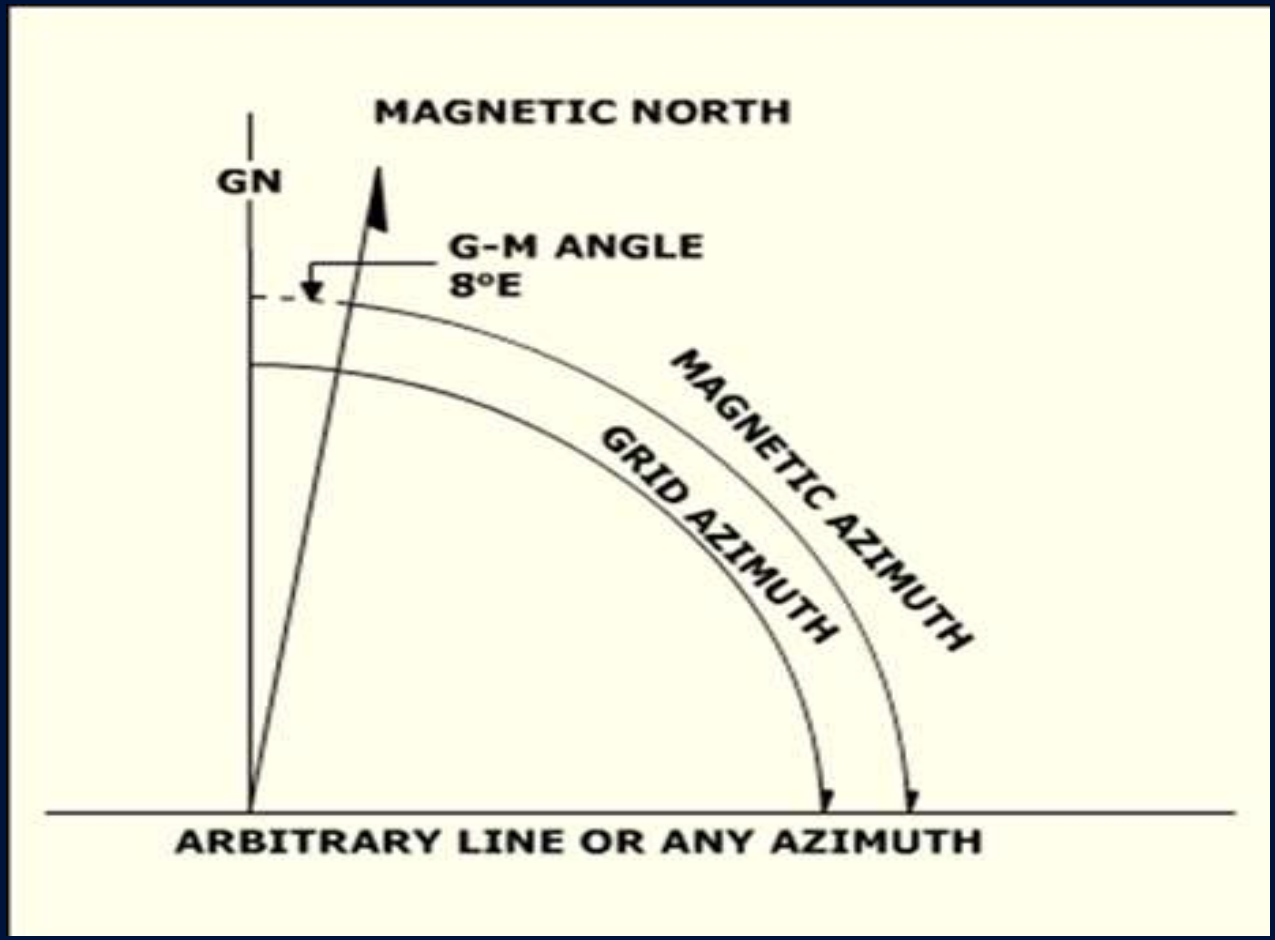
# Conversion without Notes

4. Determine the value of the G-M Angle by drawing an arc from the grid prong to the magnetic prong and placing the value of the G-M Angle above the arc.

5. Complete the diagram by drawing an arc from each reference line to the vertical line you first drew.

6. The inclusion of the true-north prong in relationship to the conversion is of little importance.

# Conversion without Notes

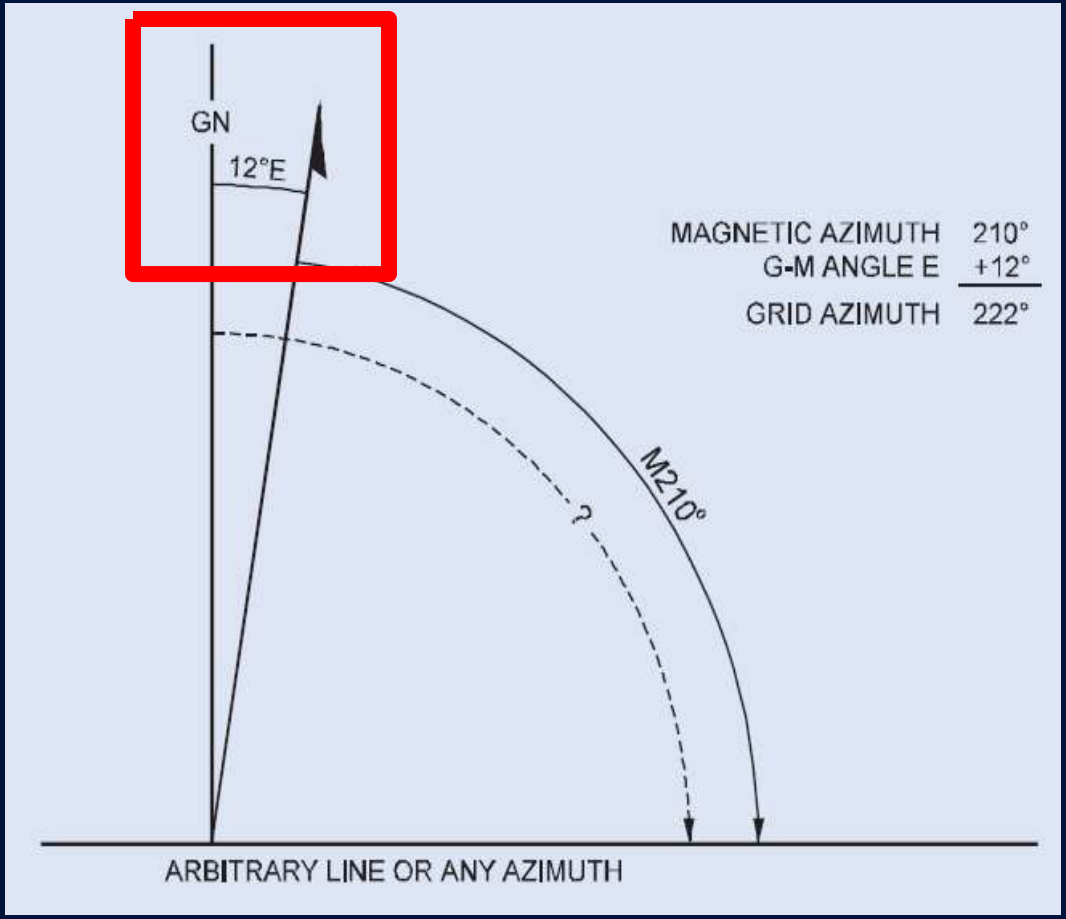


# Working with an East G-M Angle

## Example 1

Convert an east magnetic azimuth to a grid azimuth

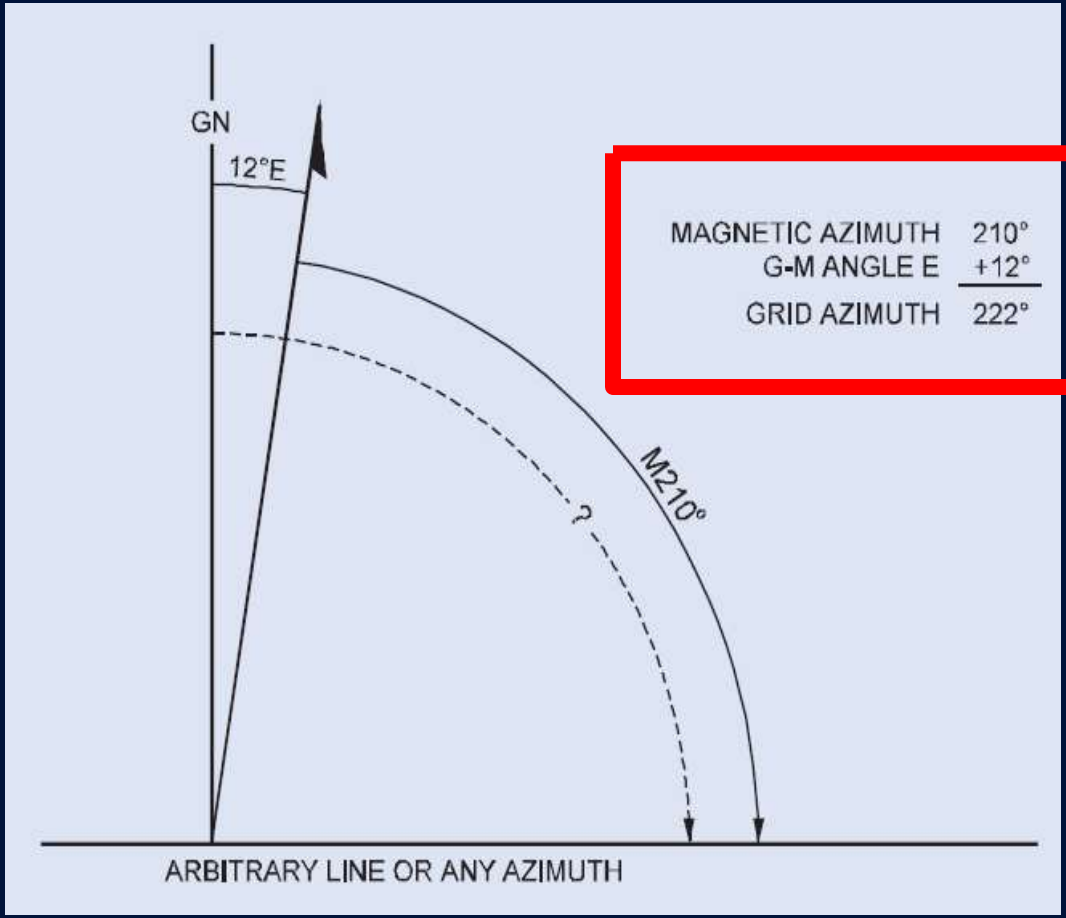
1. Determine the declination in degrees (= 12° east).



# Working with an East G-M Angle

## Example 1

2. Because the arc from magnetic north to the azimuth line is **shorter** than the arc from grid north to the azimuth line, you must **add** the G-M Angle. Yields grid azimuth = 222°



# Working with an East G-M Angle

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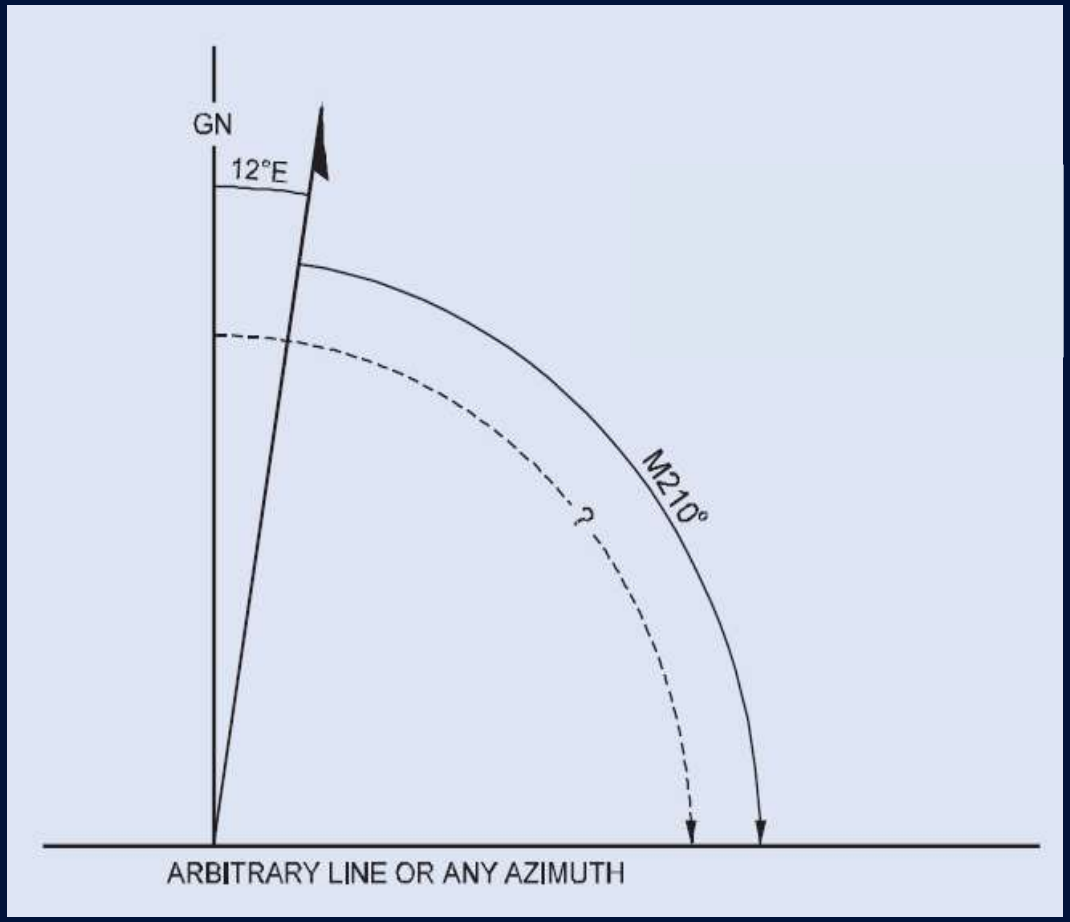
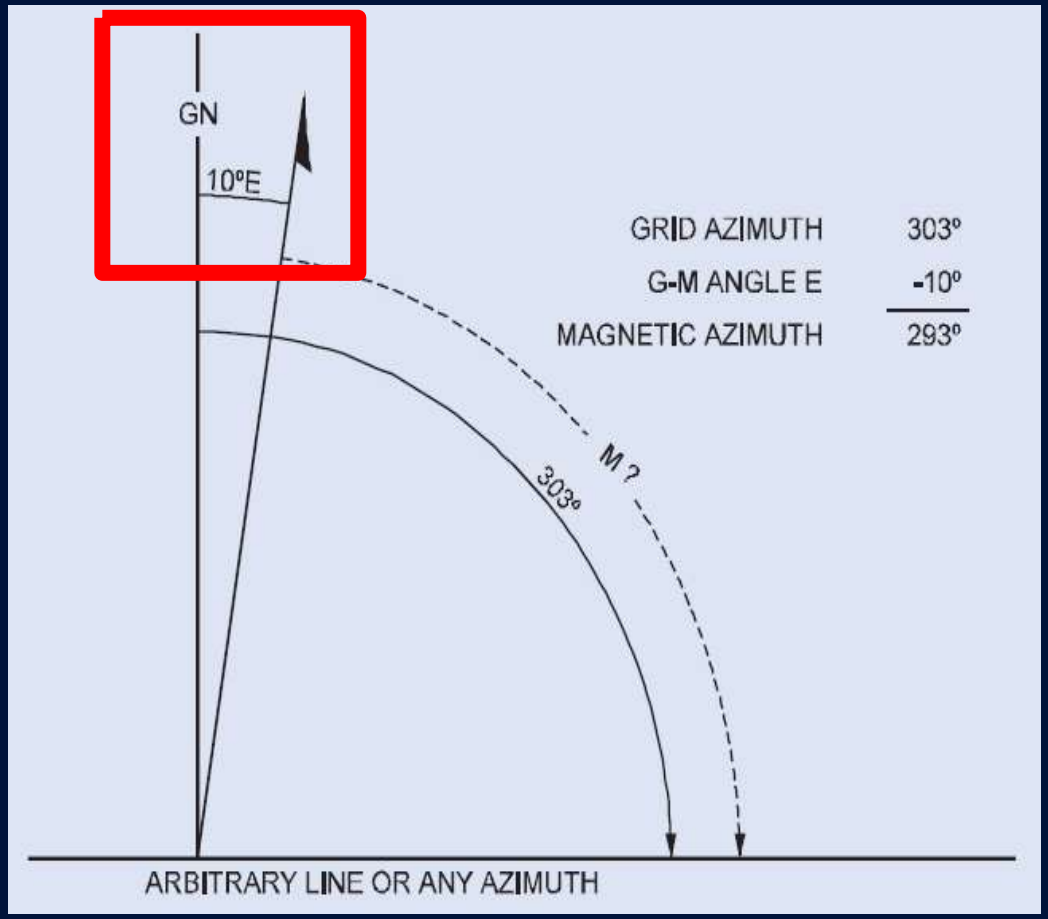


# Working with an East G-M Angle

## Example 2

Convert an east grid azimuth to a magnetic azimuth

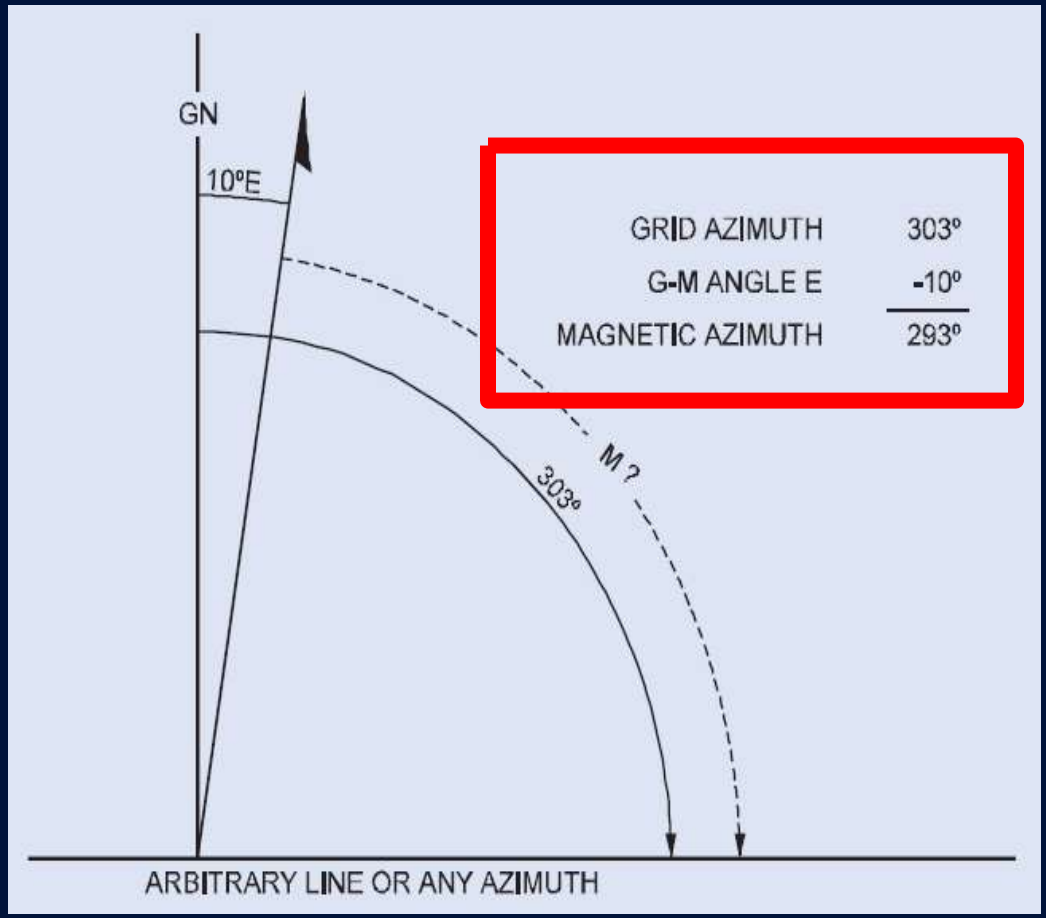
1. Determine the declination in degrees (= 10° east).



# Working with an East G-M Angle

## Example 2

2. Because the arc from grid north to the azimuth line is **longer** than the arc from magnetic north to the azimuth line, you must **subtract** the G-M Angle. Yields magnetic azimuth = 293°

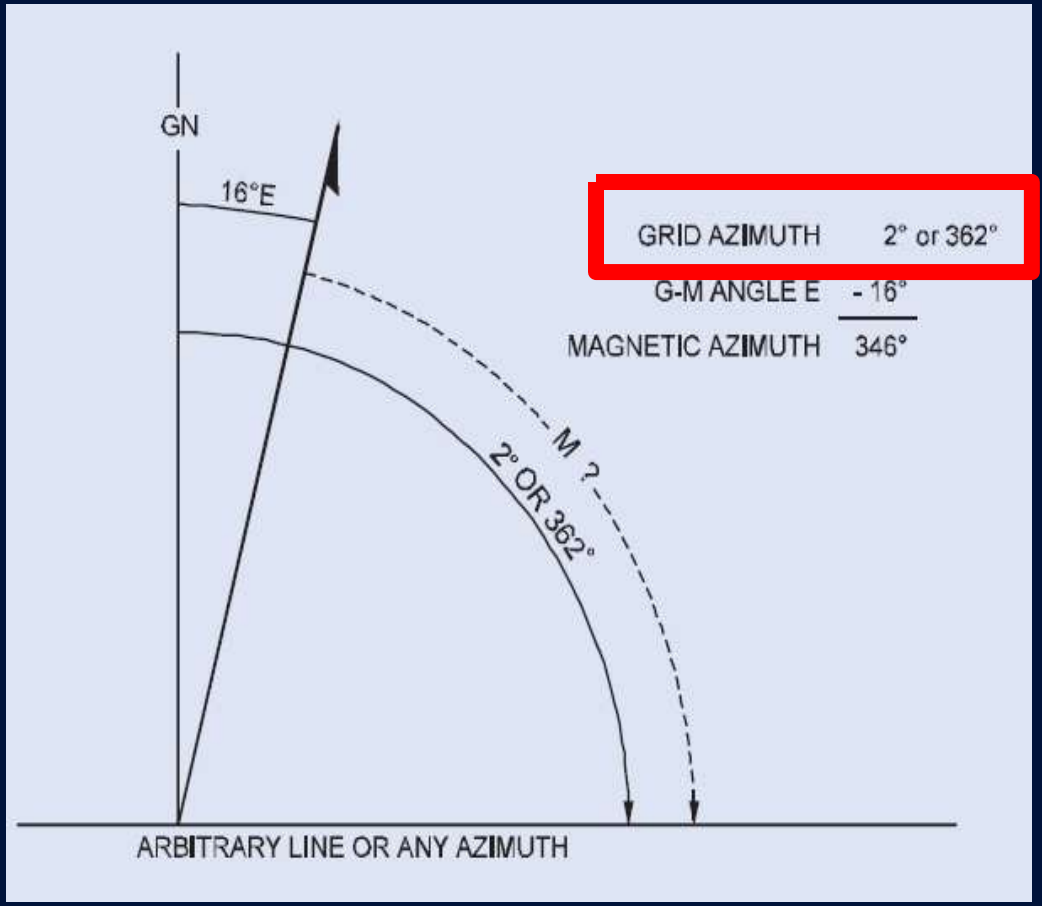


# Working with an East G-M Angle

## Example 3

Convert to a magnetic azimuth when the G-M Angle is **greater than the grid azimuth**…

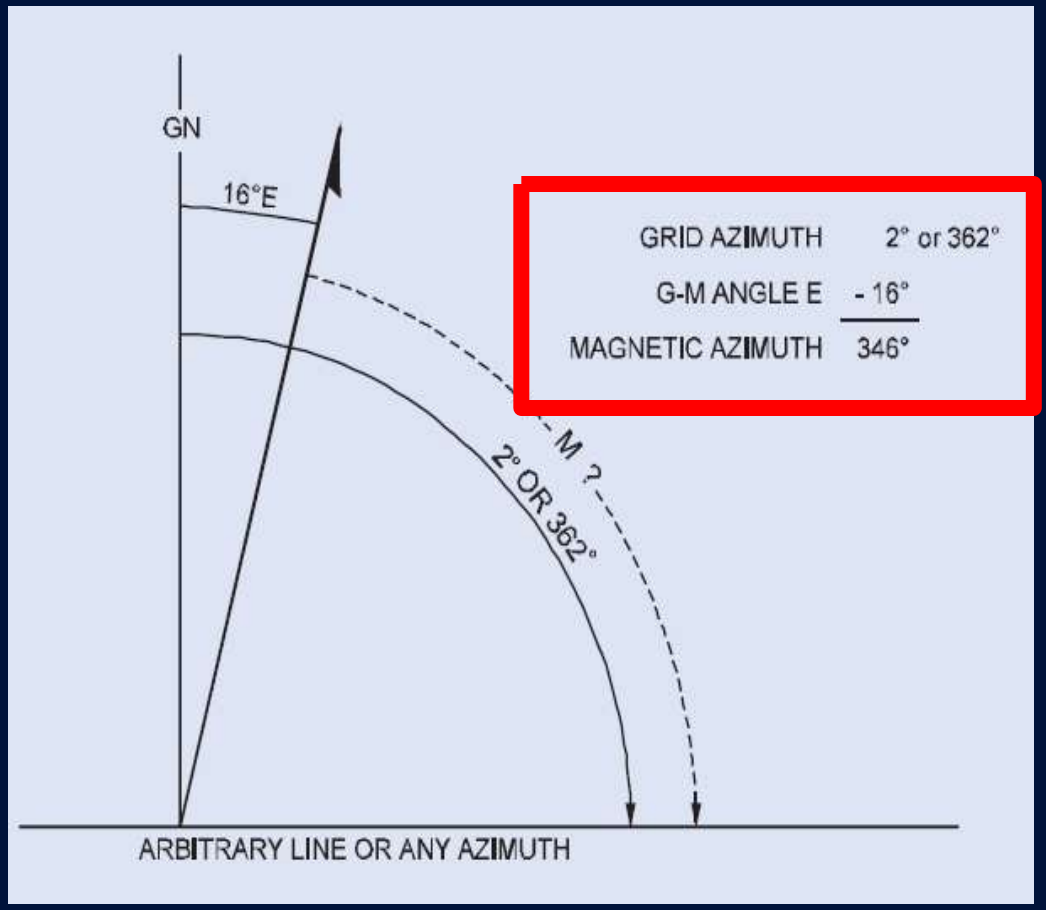
1. Add 360 degrees to the grid azimuth (2° + 360° = 362°).



# Working with an East G-M Angle

## Example 3

2. Because the grid north arc of 362 degrees is longer than the arc from magnetic north to the azimuth line, you must subtract the G-M Angle (362° - 16° = 346°).



# Working with an East G-M Angle

Each time you convert a G-M Angle, construct a G-M Angle diagram that shows the required azimuths.

It's very helpful to practice, to become familiar with the proper procedures to follow, whether there is an east or west G-M Angle, or the G-M Angle is greater than your grid or magnetic azimuth.

The more you practice, the more your skills will improve.

# Check On Learning Questions


CPS Lesson

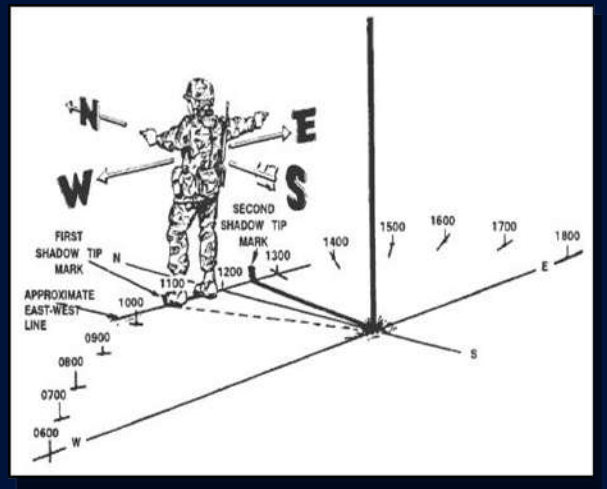
Questions 3 - 4

# Determining Location

Sometimes it is not enough to know how to locate a point to within 1,000 or 100 meters or to just estimate the location of a distant point on the ground. There may be times when you have to determine your location, or a distant point, even more accurately.

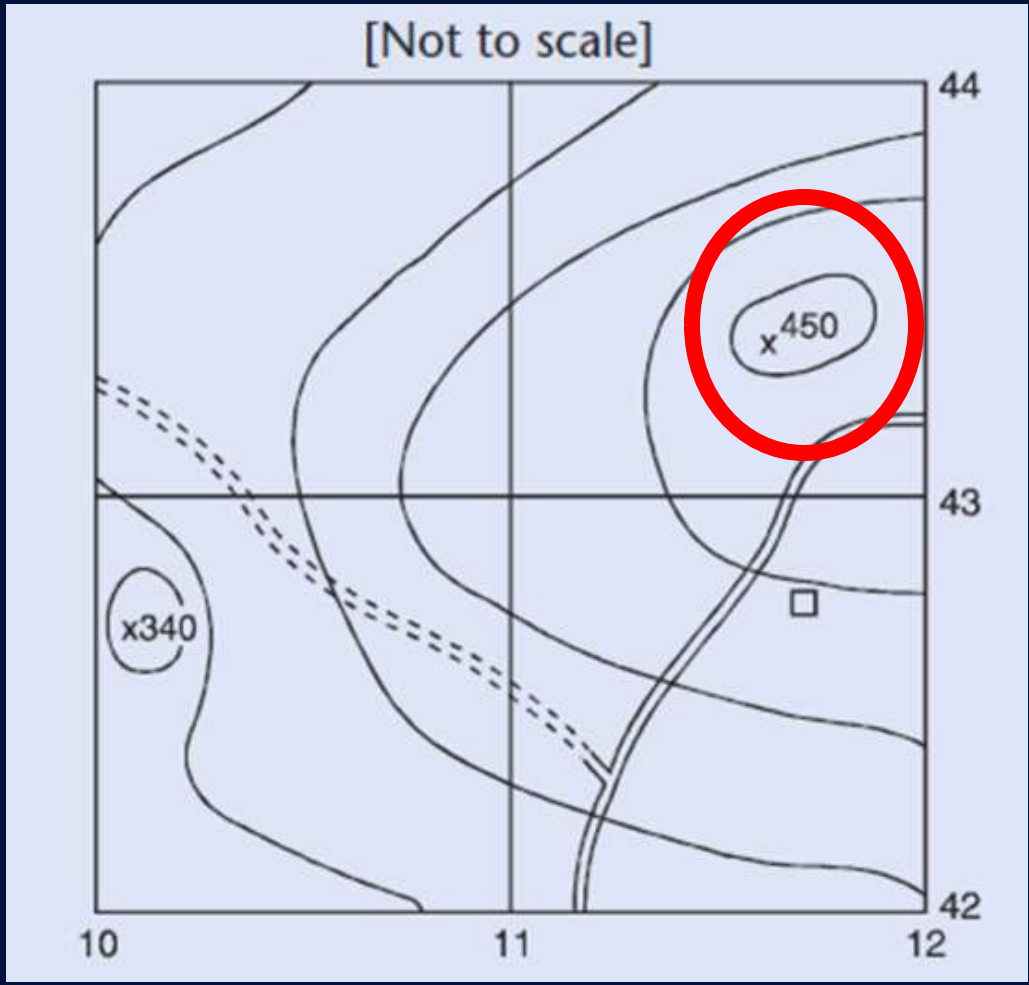
We will look closer at these methods:

- Eight-digit grid coordinate
- Polar coordinates
- Intersection
- Resection
- Field-expedient



# Determining an Eight-Digit Grid Coordinate

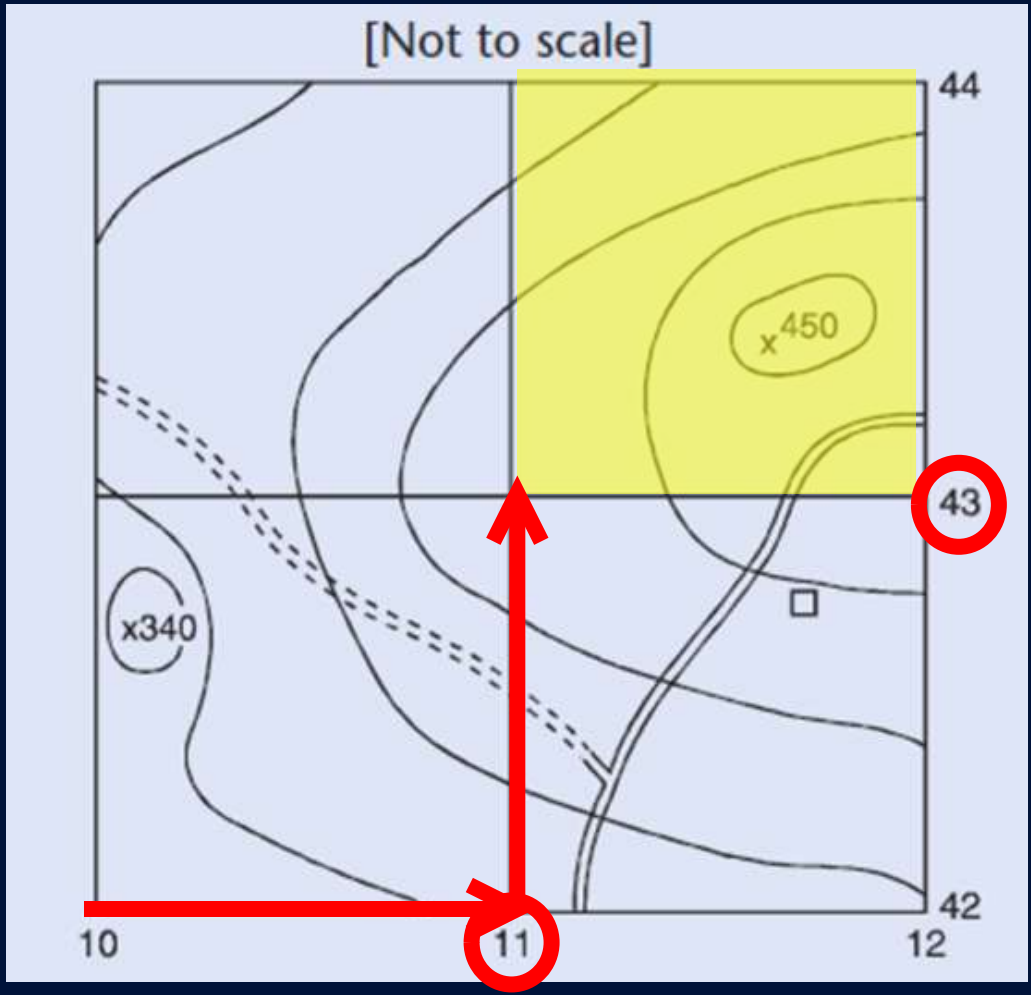
Using a coordinate scale, remember that the scale has 100 meters between each 100-meter mark. To locate spot elevation **(SE)450** in the diagram to within 10 meters, follow these steps:



# Determining an Eight-Digit Grid Coordinate

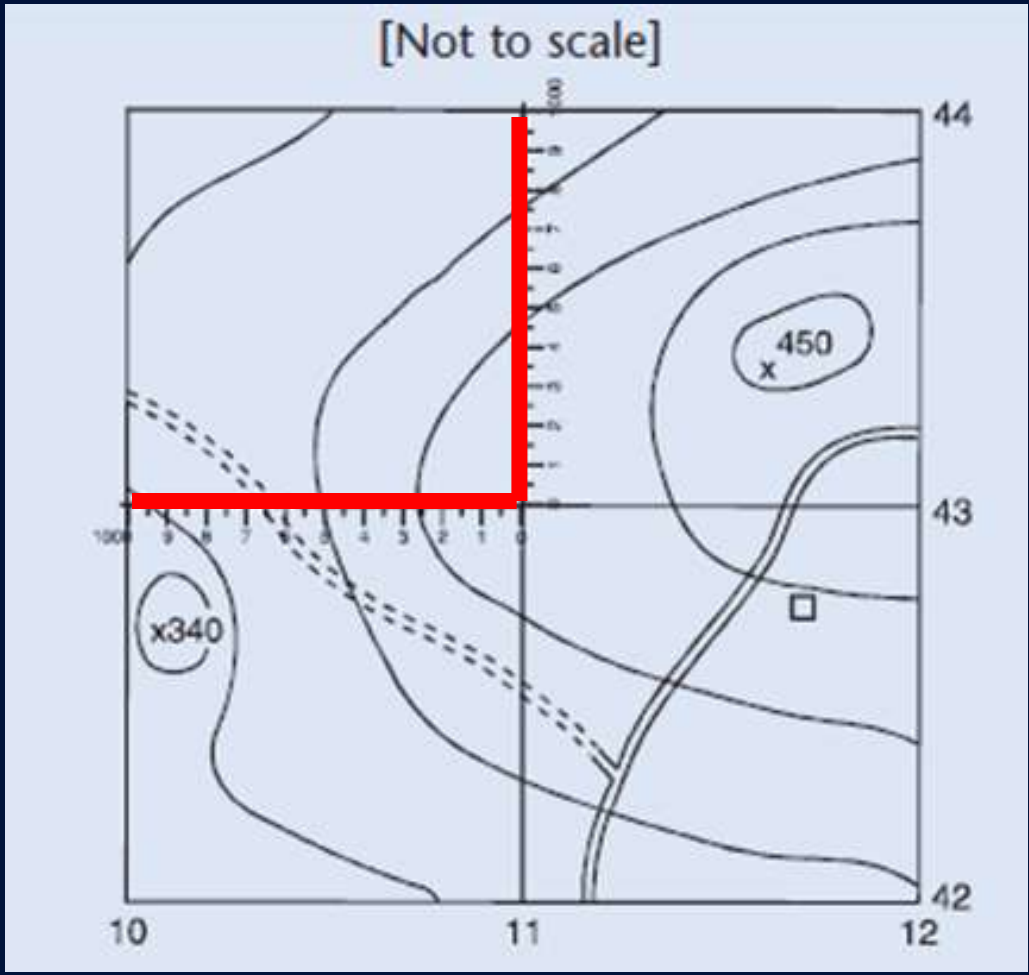
1. Identify the 1,000 meter grid square in which the spot elevation is located.

Read right, then up; YF1143 locates SE450



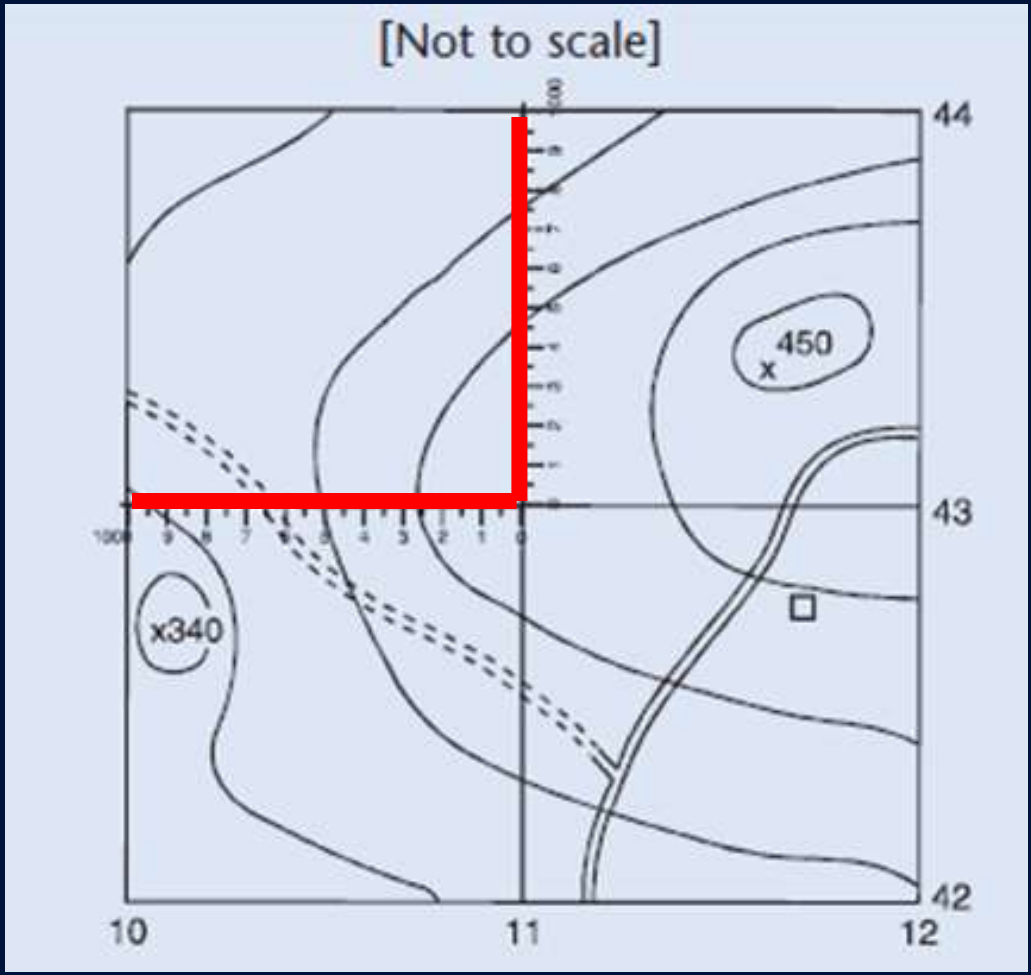
# Determining an Eight-Digit Grid Coordinate

2. Place the coordinate scale parallel to and directly on top of the grid line 43 with the “0 mark” at the lower left corner of grid square YF1143.



# Determining an Eight-Digit Grid Coordinate

3. Keeping the horizontal scale on the top of the 43 grid line, slide the scale to the right into the grid square until the vertical scale intersects the center of mass of SE 450.



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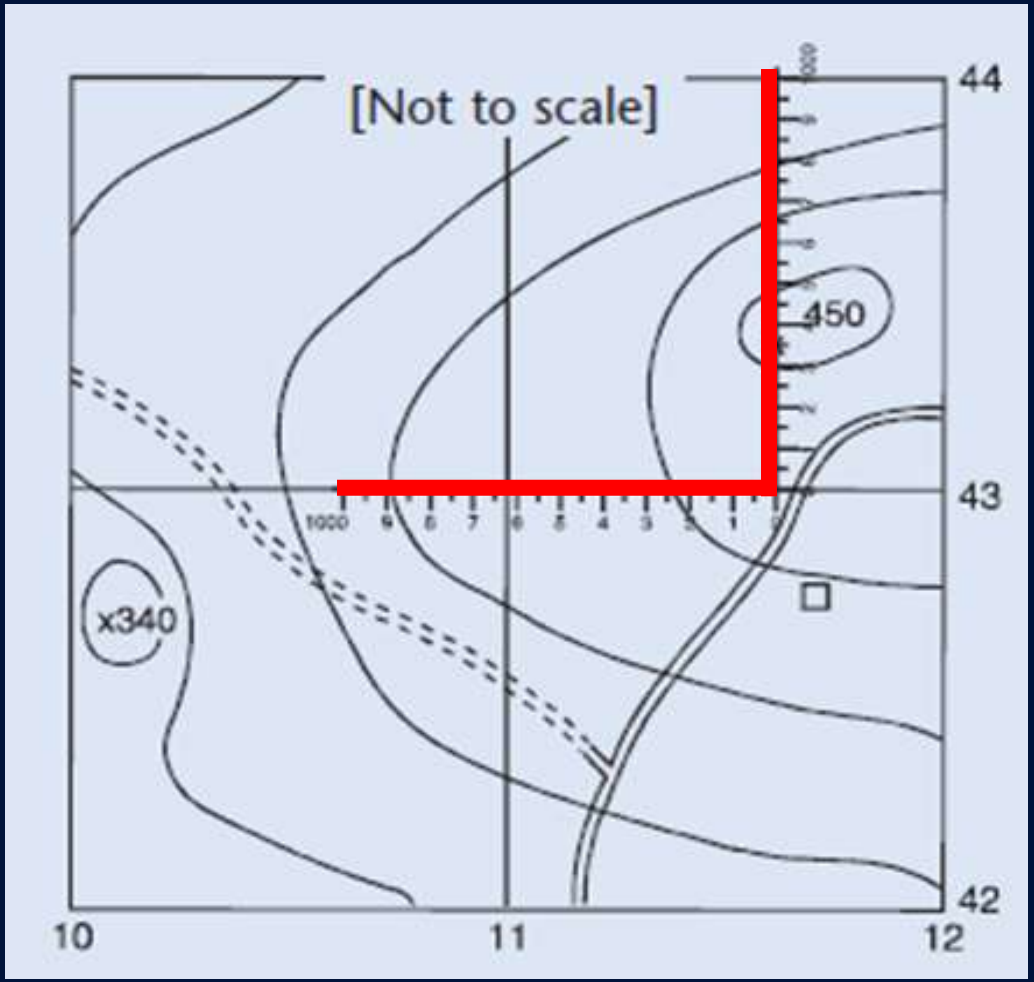
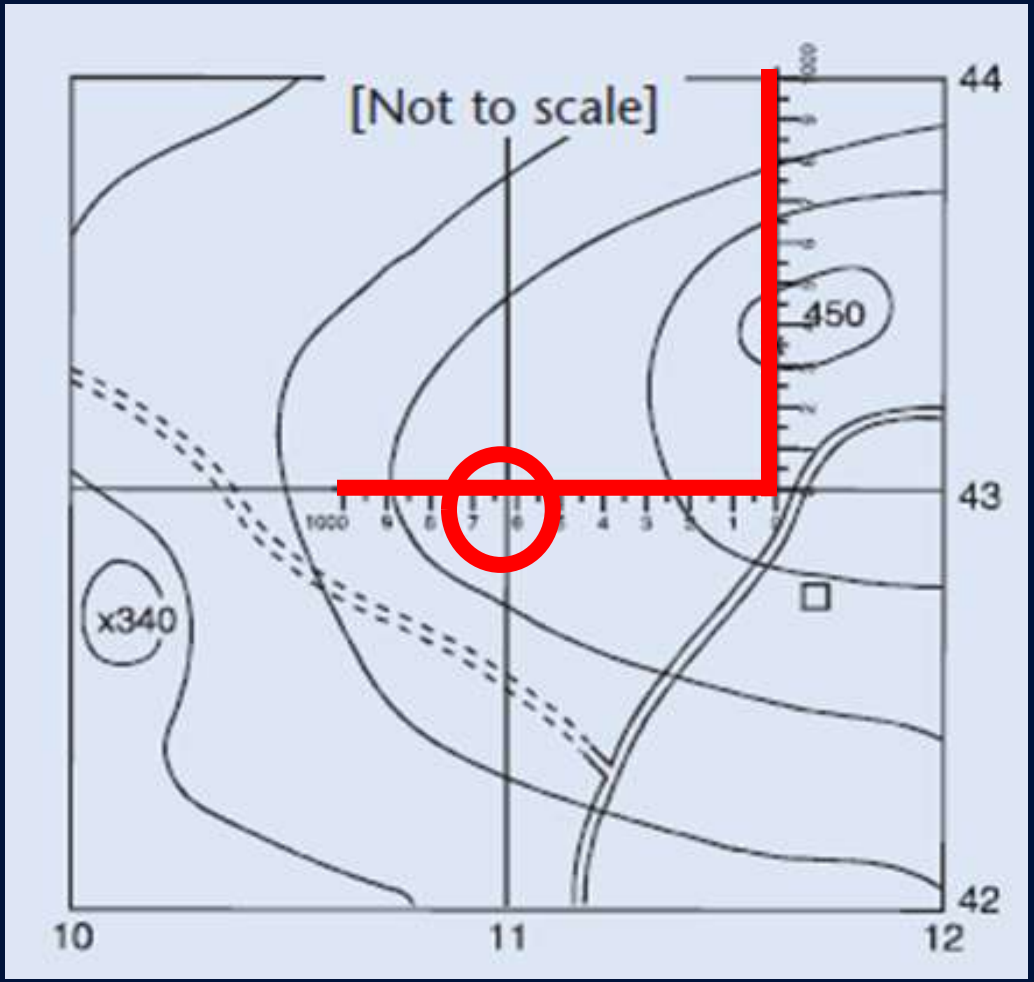


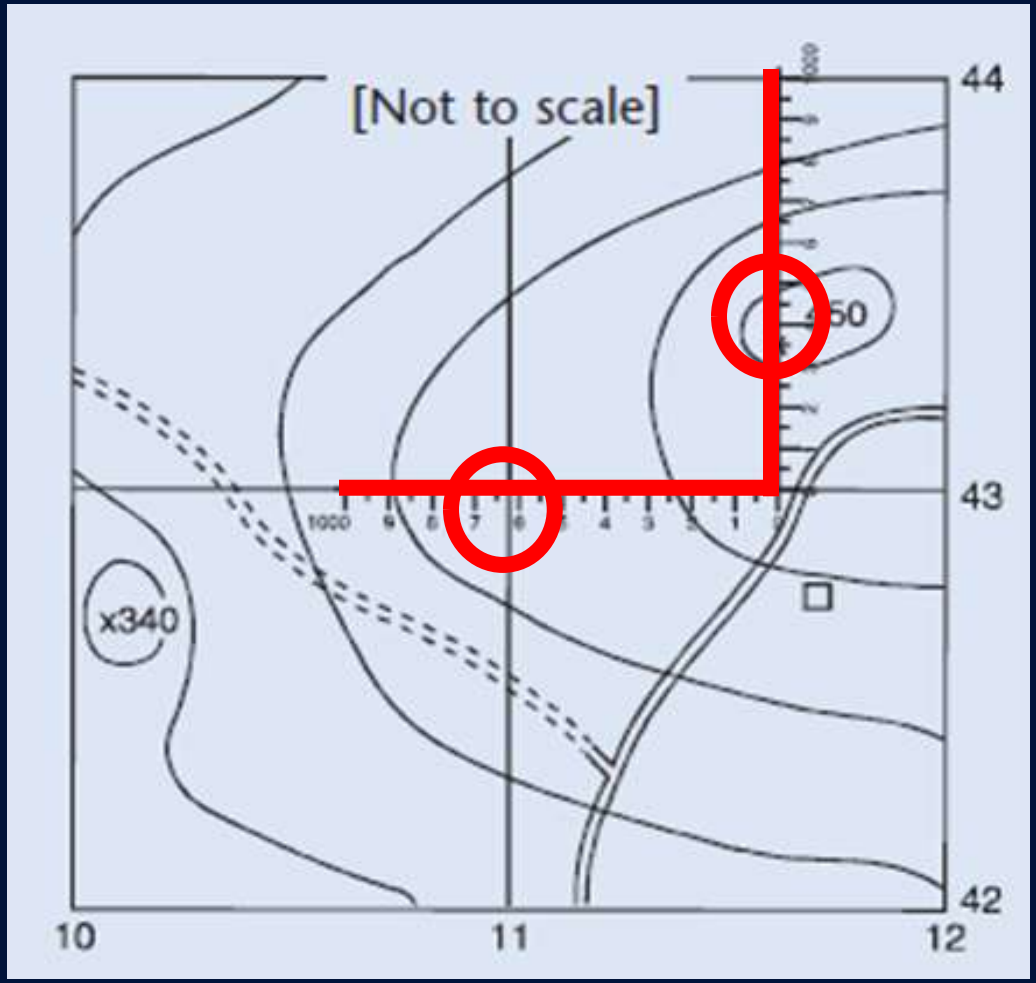
# Determining an Eight-Digit Grid Coordinate

4. Reading from the "0 mark," the right reading shows that SE 450 lies between the 600 and 650 meter mark by approximately 30 meters.



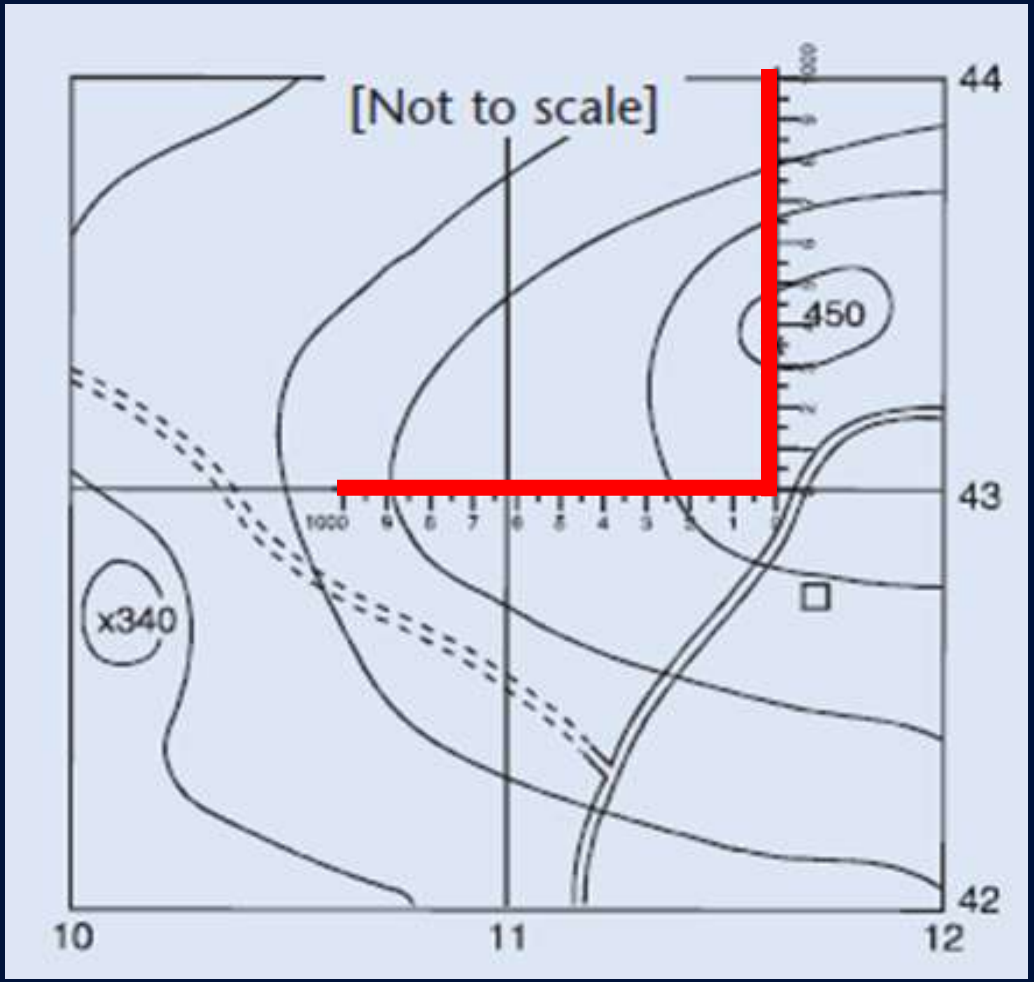
# Determining an Eight-Digit Grid Coordinate

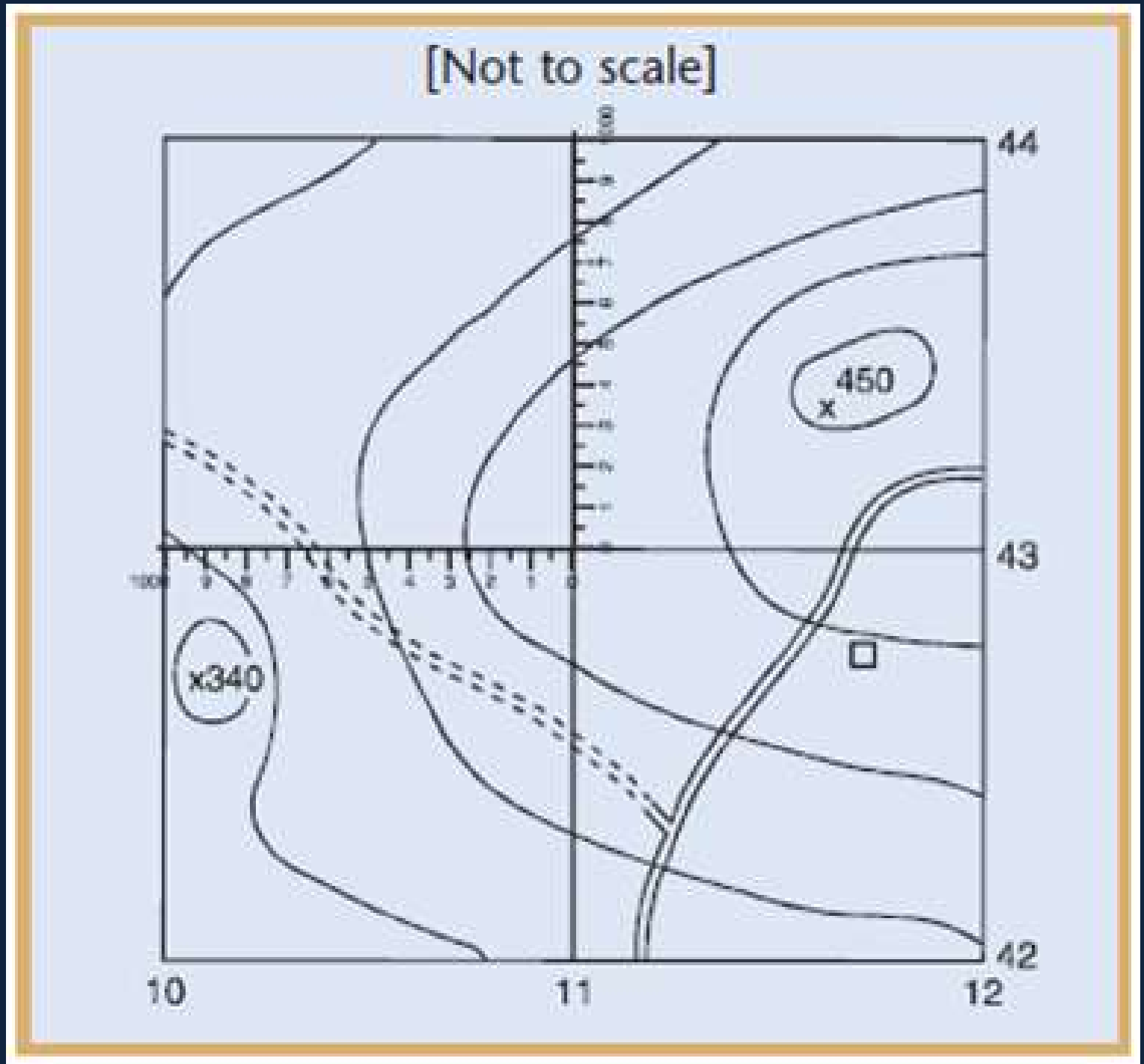
5. Reading up, you can see that SE 450 lies midway between the 300 and 400 meter marks, or 350 meters into the grid square; so, the up reading is 4335.



# Determining an Eight-Digit Grid Coordinate

6. By combining both sets of numbers and adding the 100,000 meter square identifier, the location of SE 450 is YF11634335.
7. You have now correctly located a point to the nearest 100 meters.



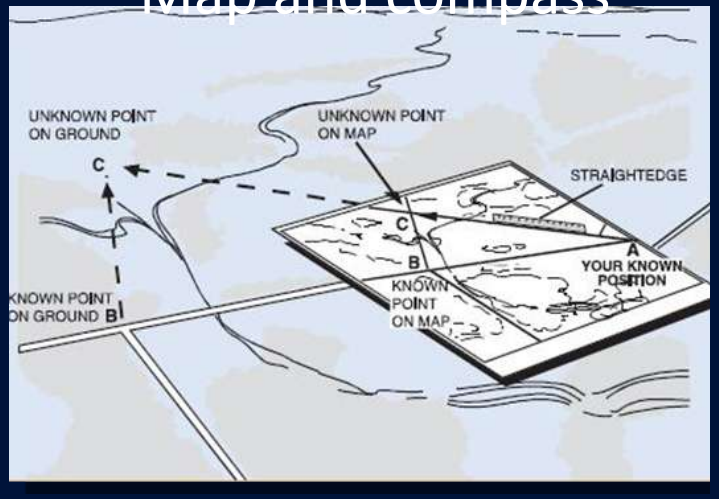

[Not to scale]
44
43
42
10
11
12
450
x340

# Intersection

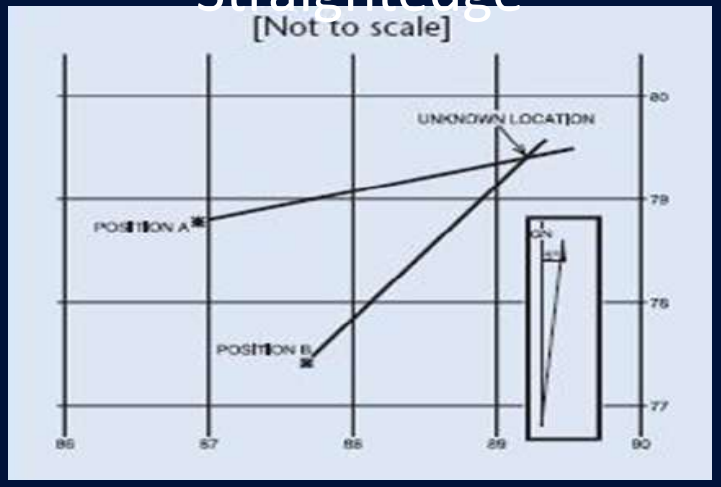
Intersection is used to locate an unknown point by determining the azimuths from where two (preferably three) known positions on the ground intersect.

There are two methods to determine intersection:

Map and compass




Straightedge

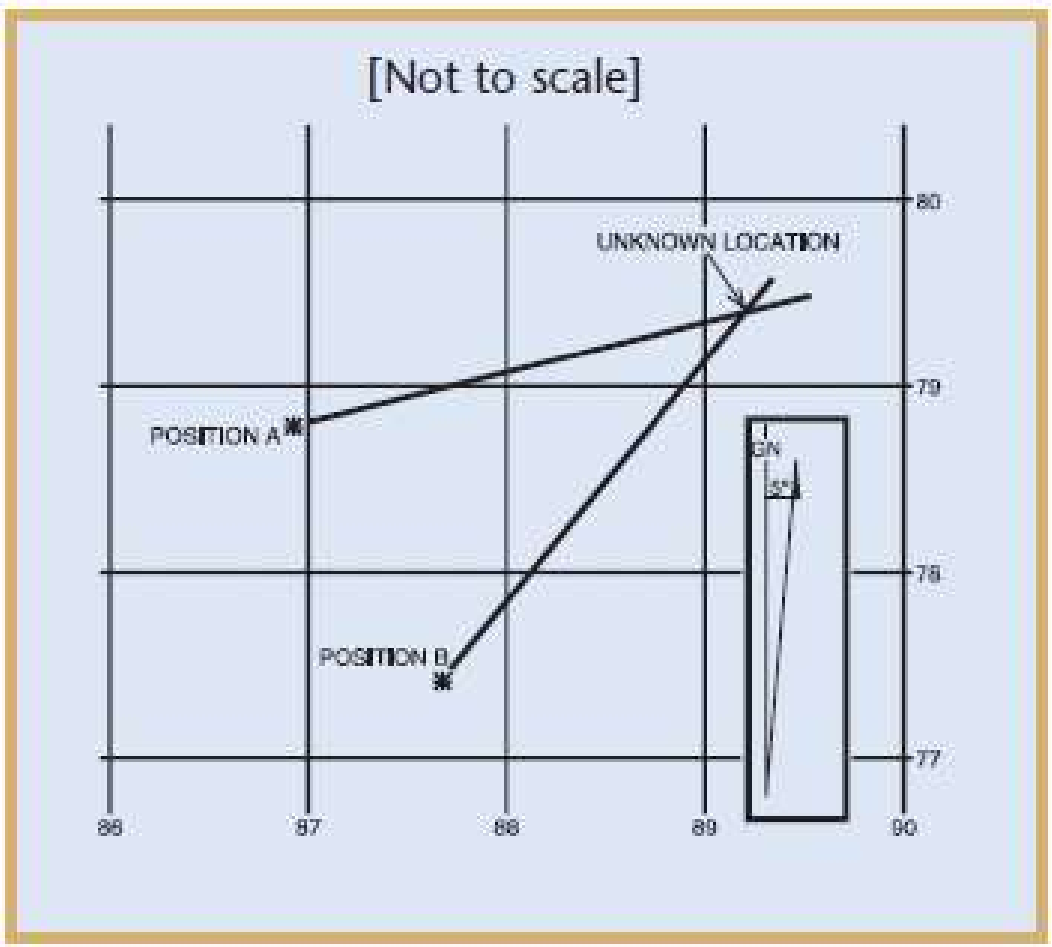


# Intersection – Map and Compass Method

1. Orient the map using the compass.
2. Determine the Grid-Magnetic Angle (G-M Angle) of the map you are using. In this example, the G-M Angle is 5° east.
3. Locate and mark your first known position (Point A) on the map.

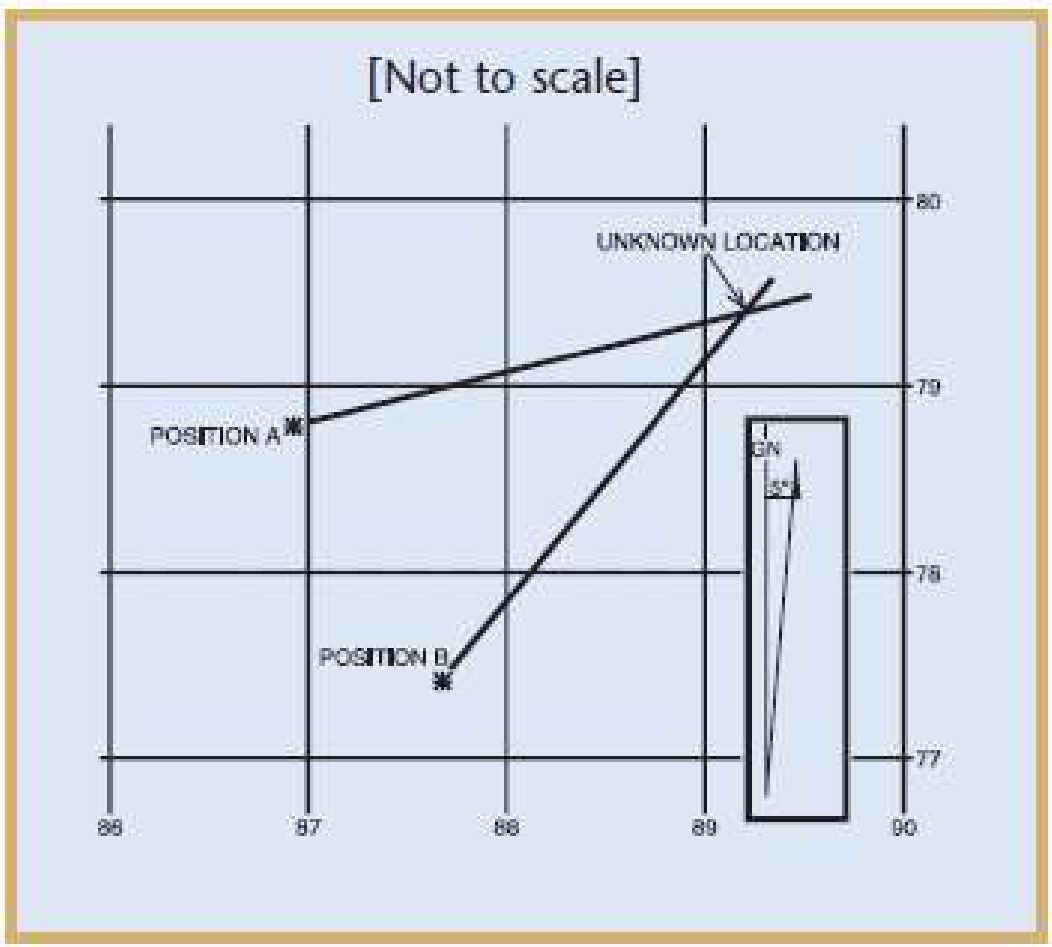
# Intersection – Map and Compass Method

4. Measure the magnetic azimuth from the unknown point to Point A using a compass. In this example, the magnetic azimuth is 251°.



# Intersection – Map and Compass Method

5. Convert the magnetic azimuth to a grid azimuth. In this example, 251° plus 5°equals a 256° grid azimuth.



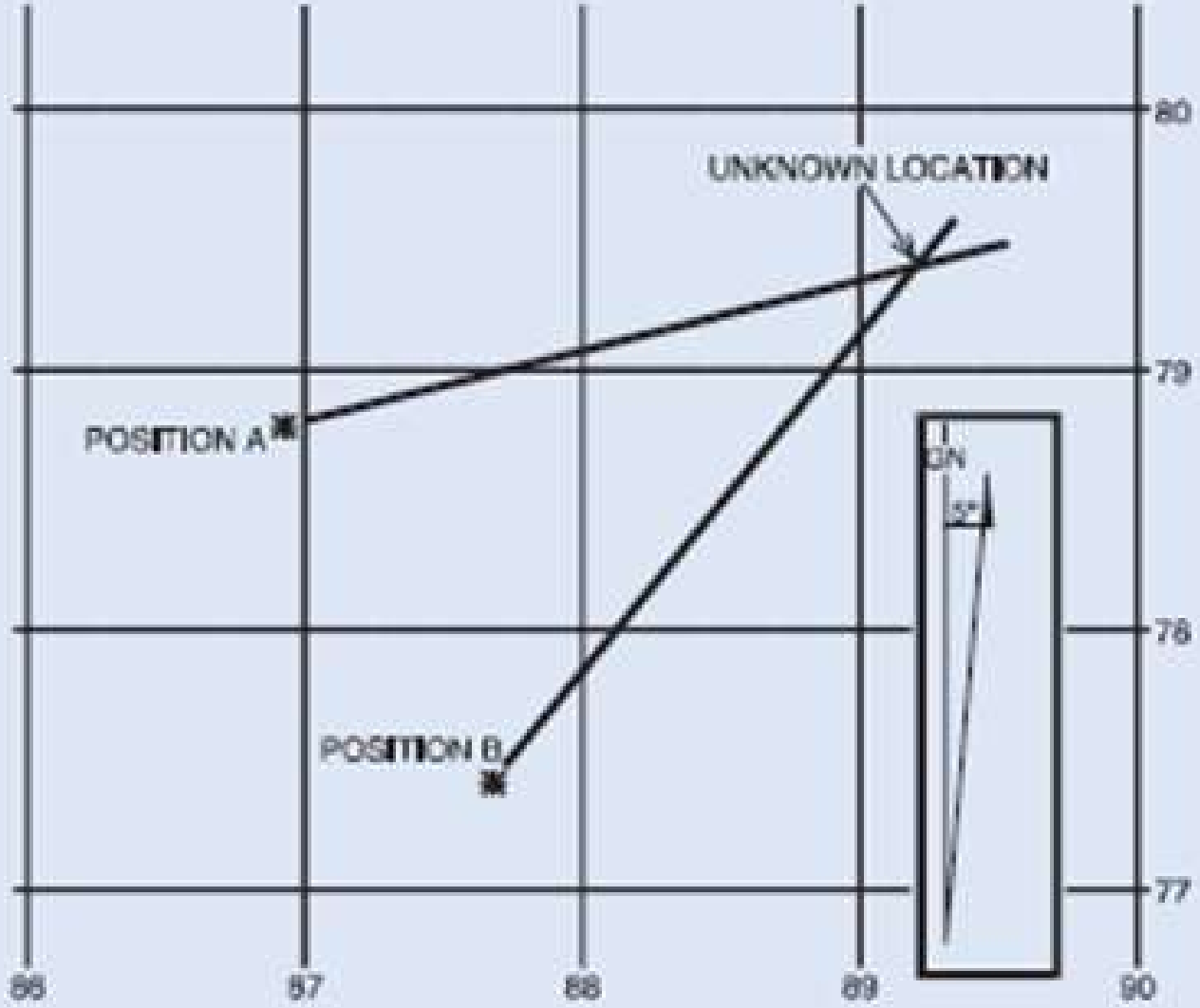
# Intersection – Map and Compass Method

6. Place the coordinate scale on the map, ensuring that the 0° indicator is at the top and the index point is directly over the center of mass of Point A. Place a tick mark at 256° on the map. Draw a line from Point A along the reciprocal of this grid azimuth.

7. Move to Point B and locate it on the map. Repeat steps 4, 5, and 6. Place a tick mark at 220° on the map and draw a line along the reciprocal of that grid azimuth.

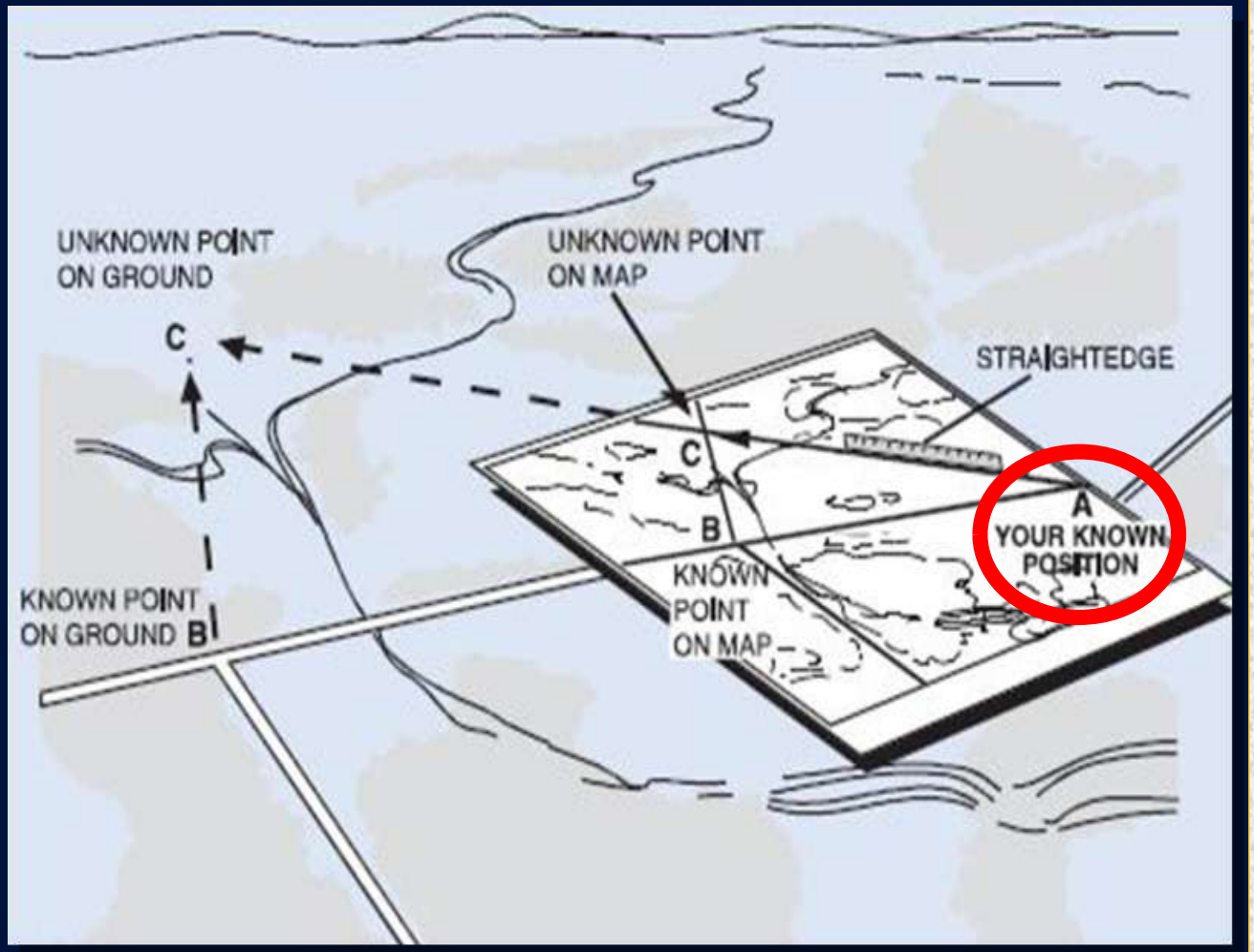
8. The location of the unknown position in where the lines cross on the map. Determine the eight-digit grid coordinate for this position.

[Not to scale]


80
79
78
77
86
87
88
89
90
UNKNOWN LOCATION
POSITION A
POSITION B
52°

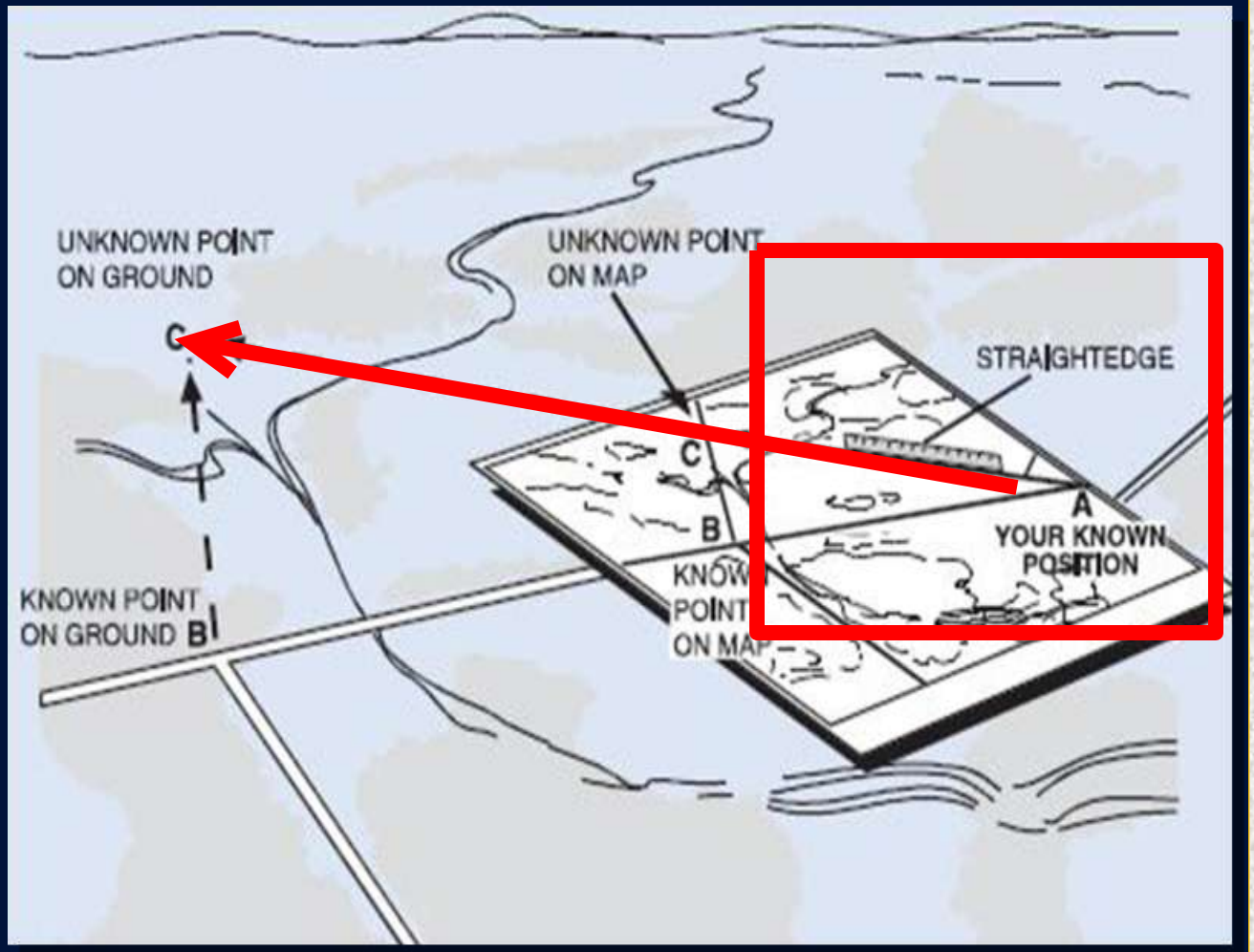
# Intersection – Straightedge Method

1. Orient the map (on a flat surface) to ground by terrain association.
2. Locate and mark your known position on the map (Point A).



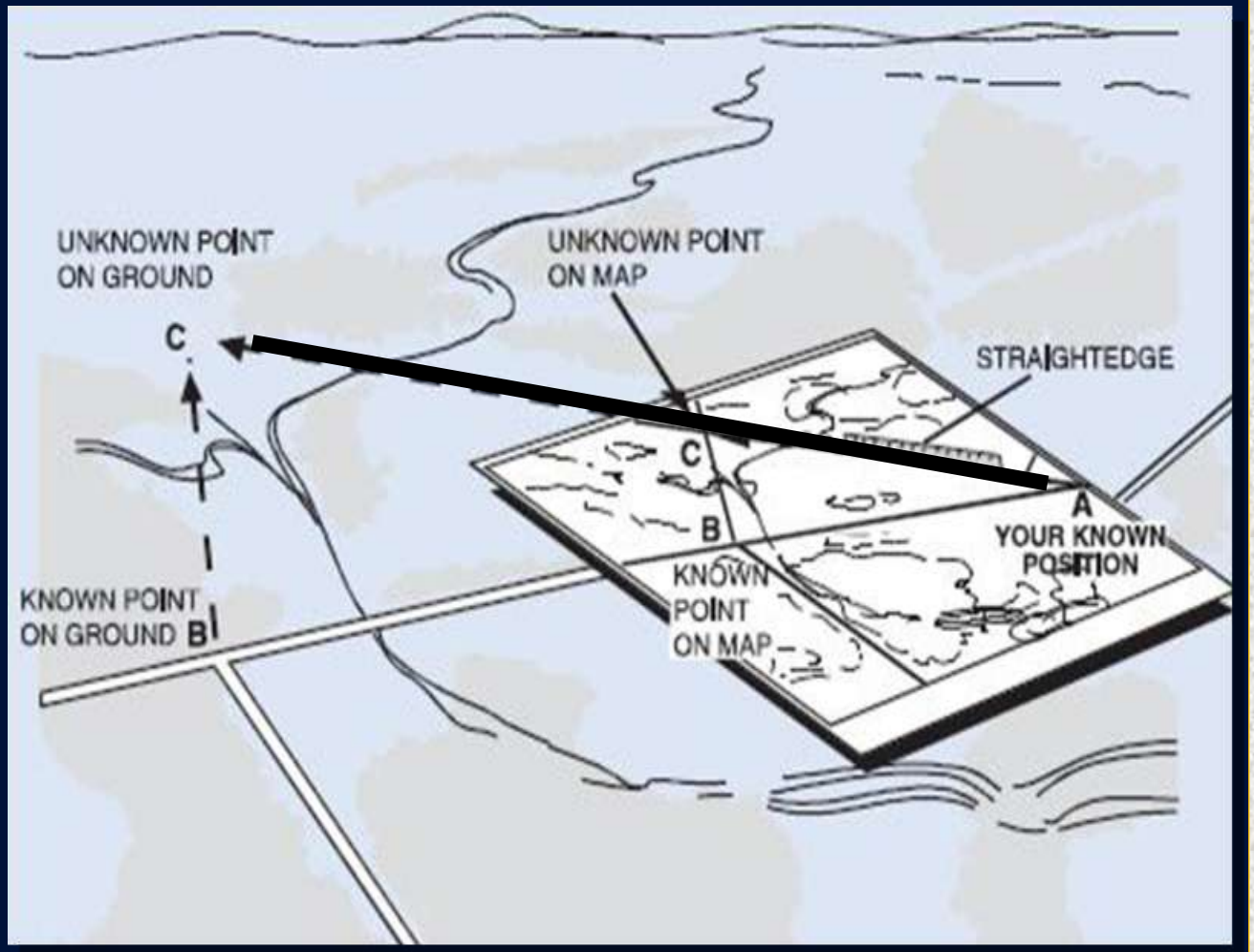
# Intersection – Straightedge Method

3. Place a straightedge on the map with one end at Point A as a pivot point. Rotate the straightedge until the unknown point (Point C) is sighted along the edge.



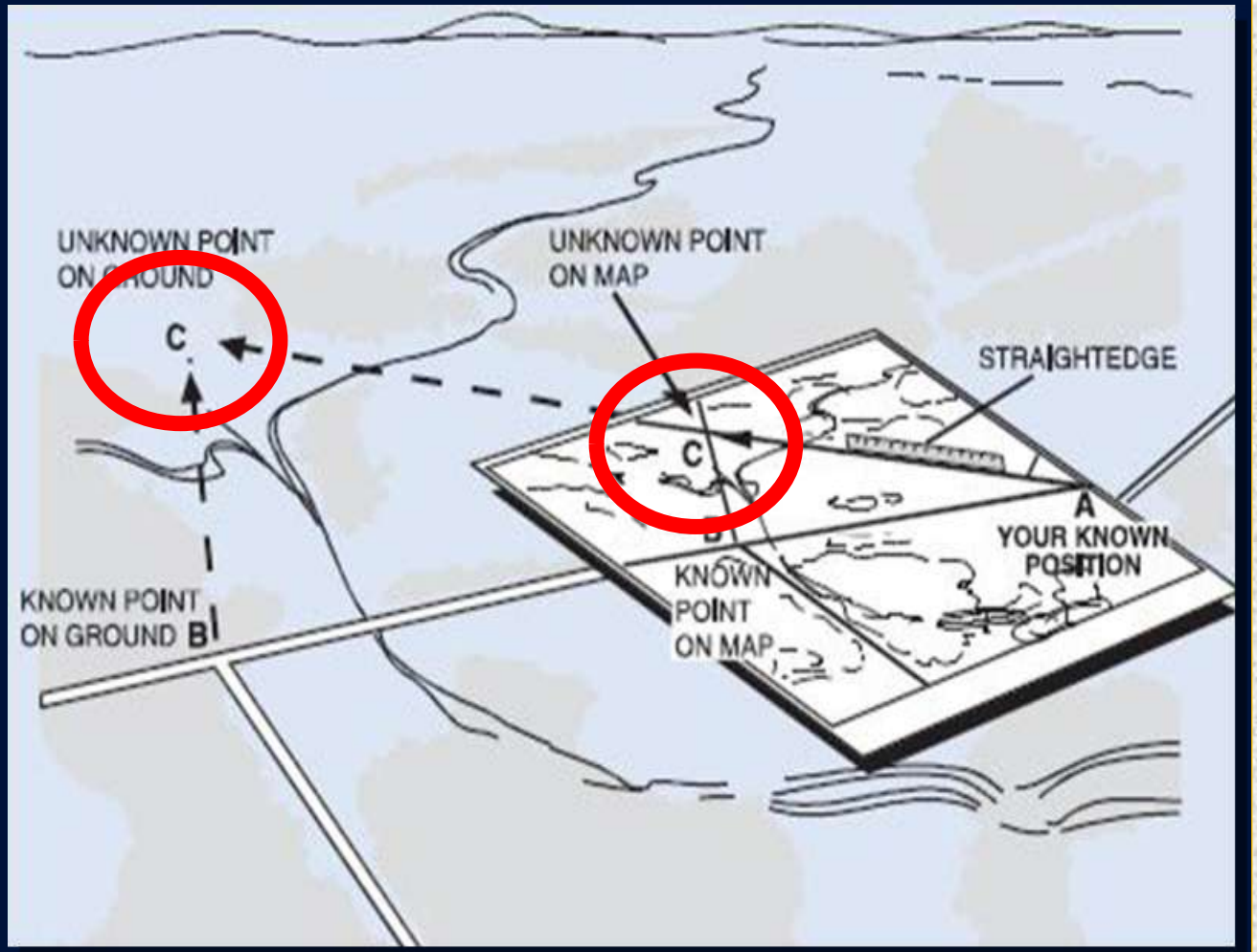
# Intersection – Straightedge Method

4. Draw a line along the straightedge.



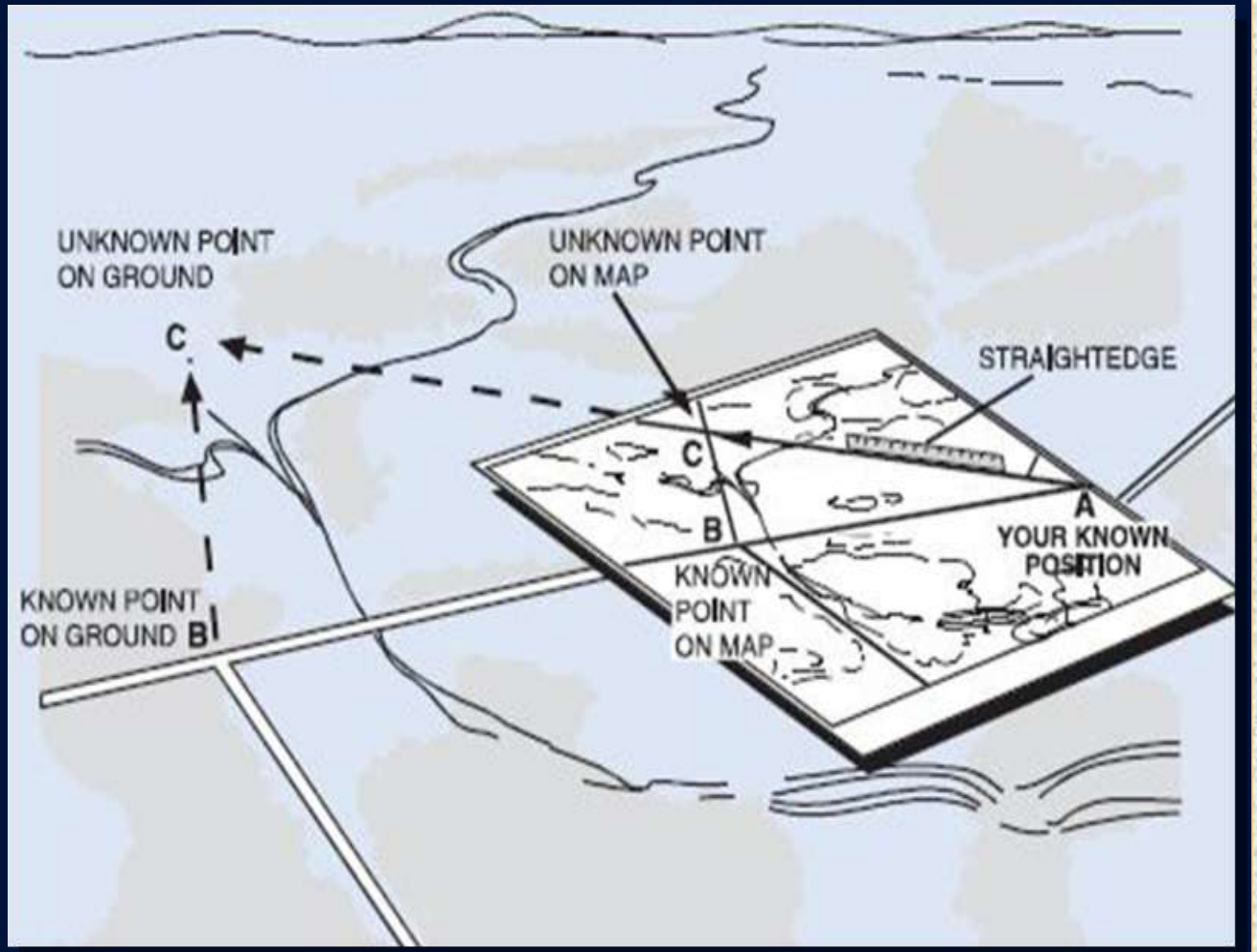
# Intersection – Straightedge Method

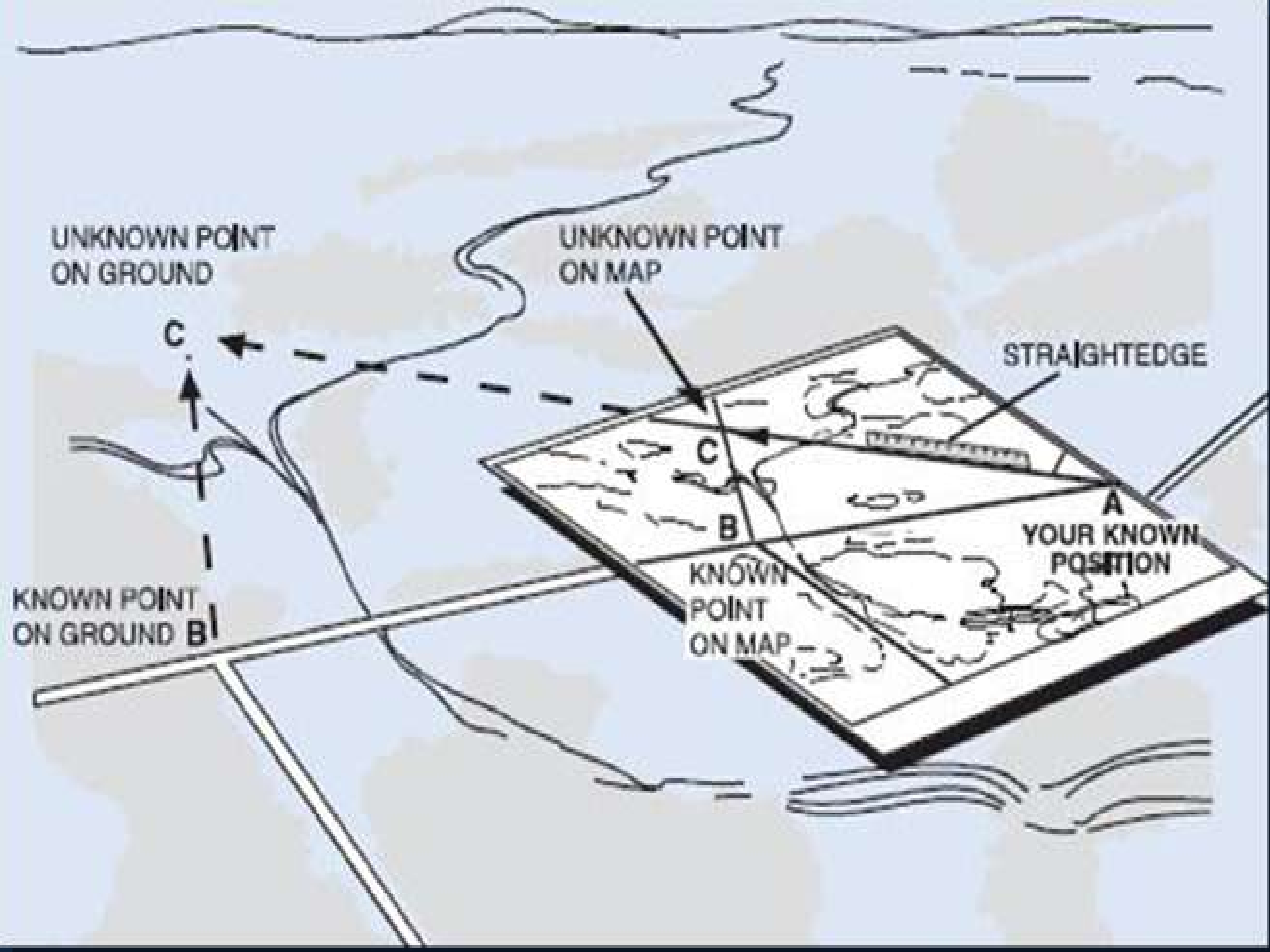
5. Repeat steps 3 and 4 with the second known position (Point B) and check for accuracy. The intersection of these lines on the map is the location of the unknown point (Point C).



# Intersection – Straightedge Method

6. Determine the six- or eight-digit grid coordinate (depending upon the desired degree of accuracy) for the unknown point.




UNKNOWN POINT
ON GROUND
C
UNKNOWN POINT
ON MAP
STRAIGHTEDGE
C
B
A
YOUR KNOWN
POSITION
KNOWN
POINT
ON MAP
KNOWN POINT
ON GROUND B

# Check On Learning Questions


CPS Lesson

Questions 5 - 6

# Resection

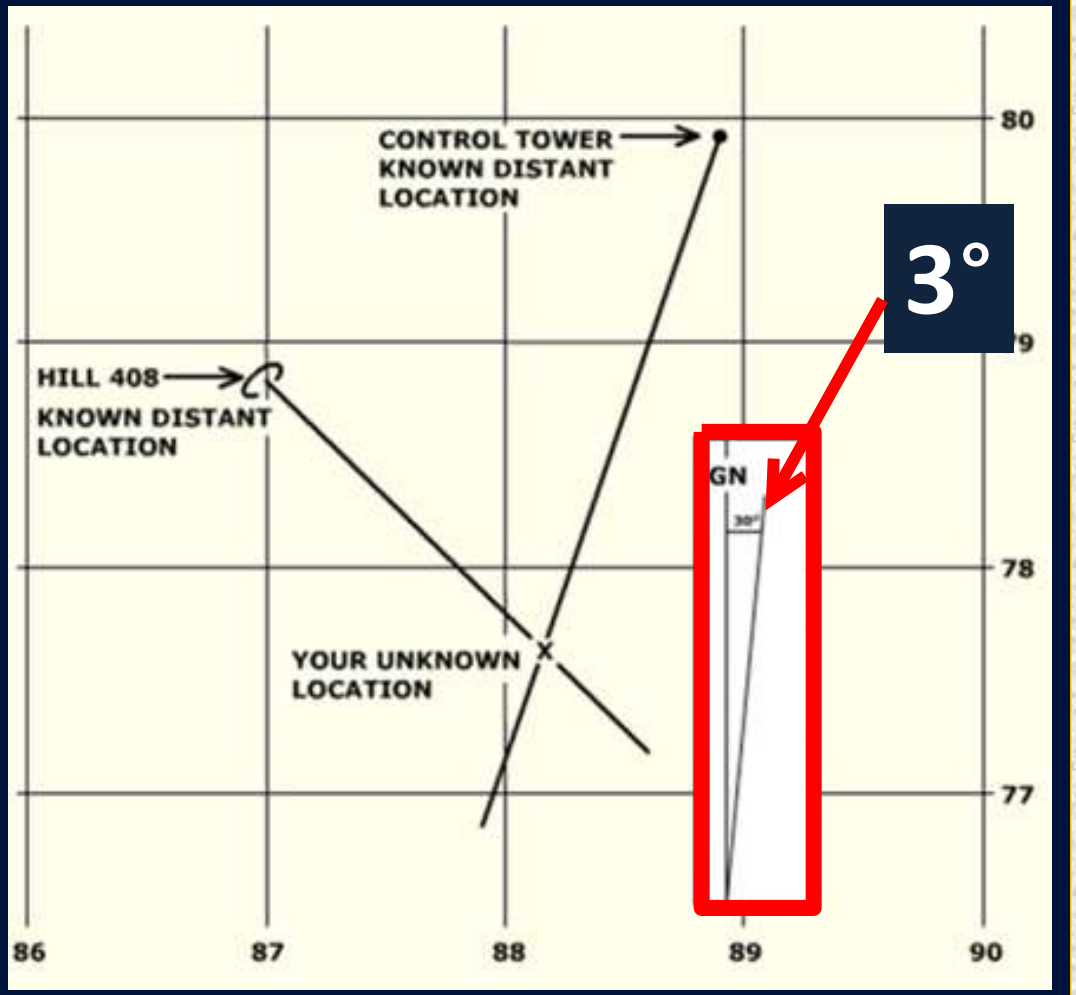
Resection is used to locate an unknown point by determining the grid azimuth to at least two well-defined locations on the map.

There are three methods for use with resection:

- Map and compass
- Modified resection
- Straightedge

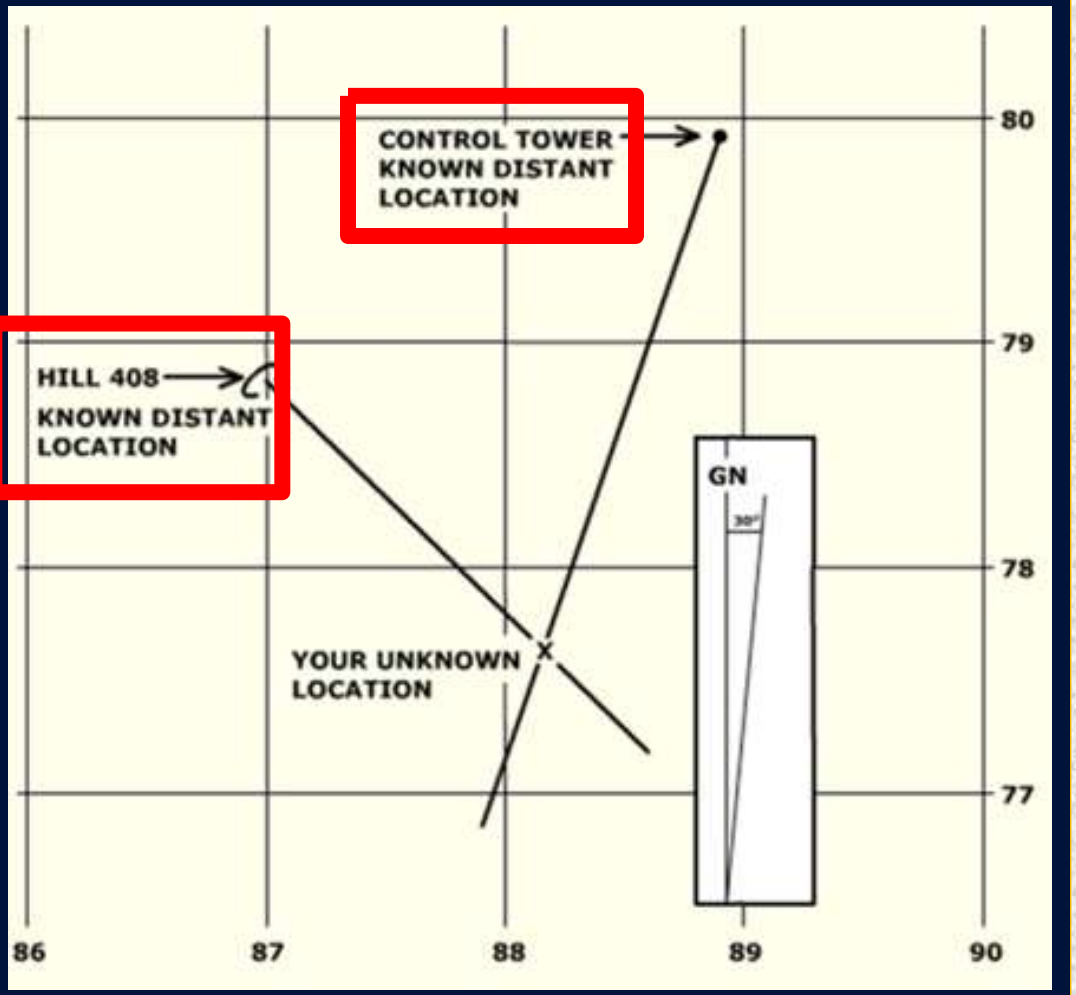
# Resection – Map and Compass

1. Orient the map using the compass
2. Determine the G-M Angle of the map you are using. In this example, the G-M Angle is 3° east.



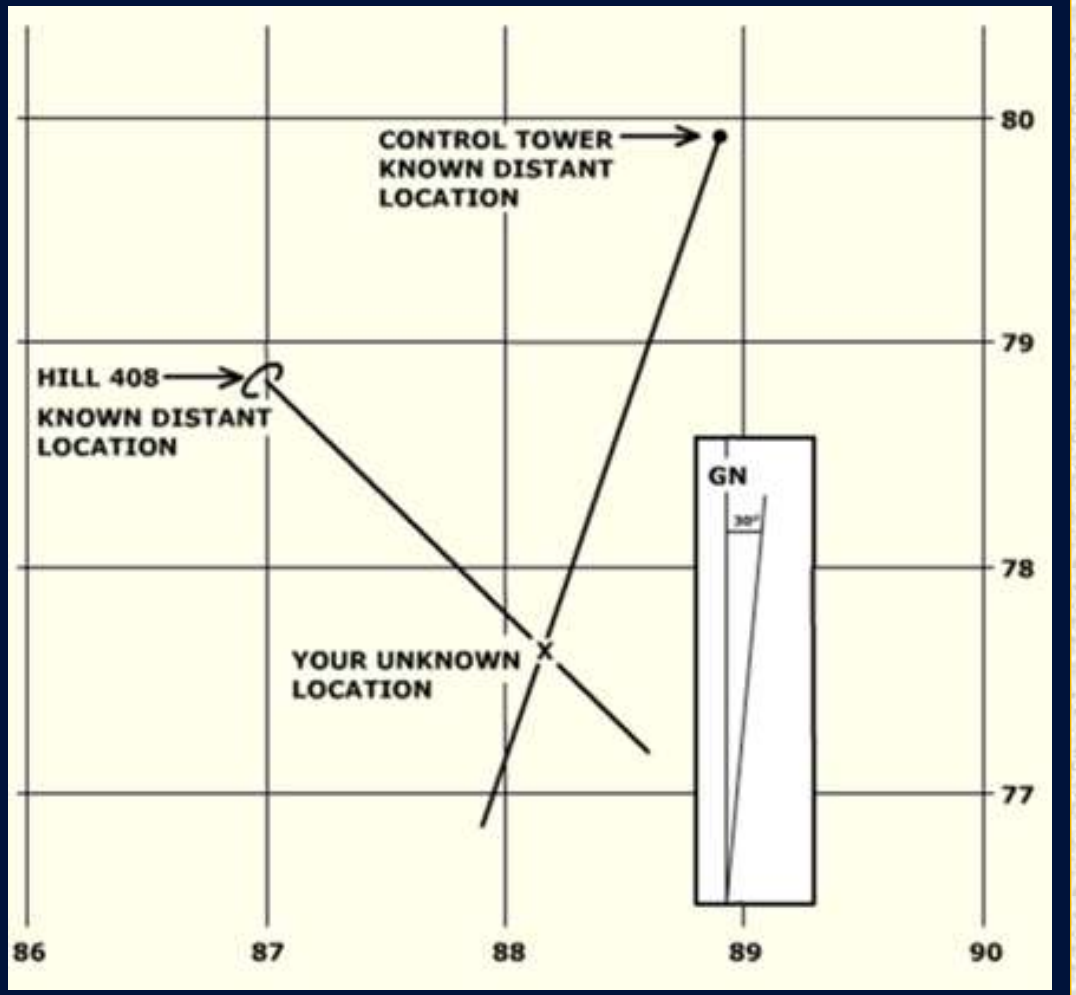
# Resection – Map and Compass

3. Identify 2-3 known locations on the ground. Mark them on the map, such as Hilltop 408 and the control tower.



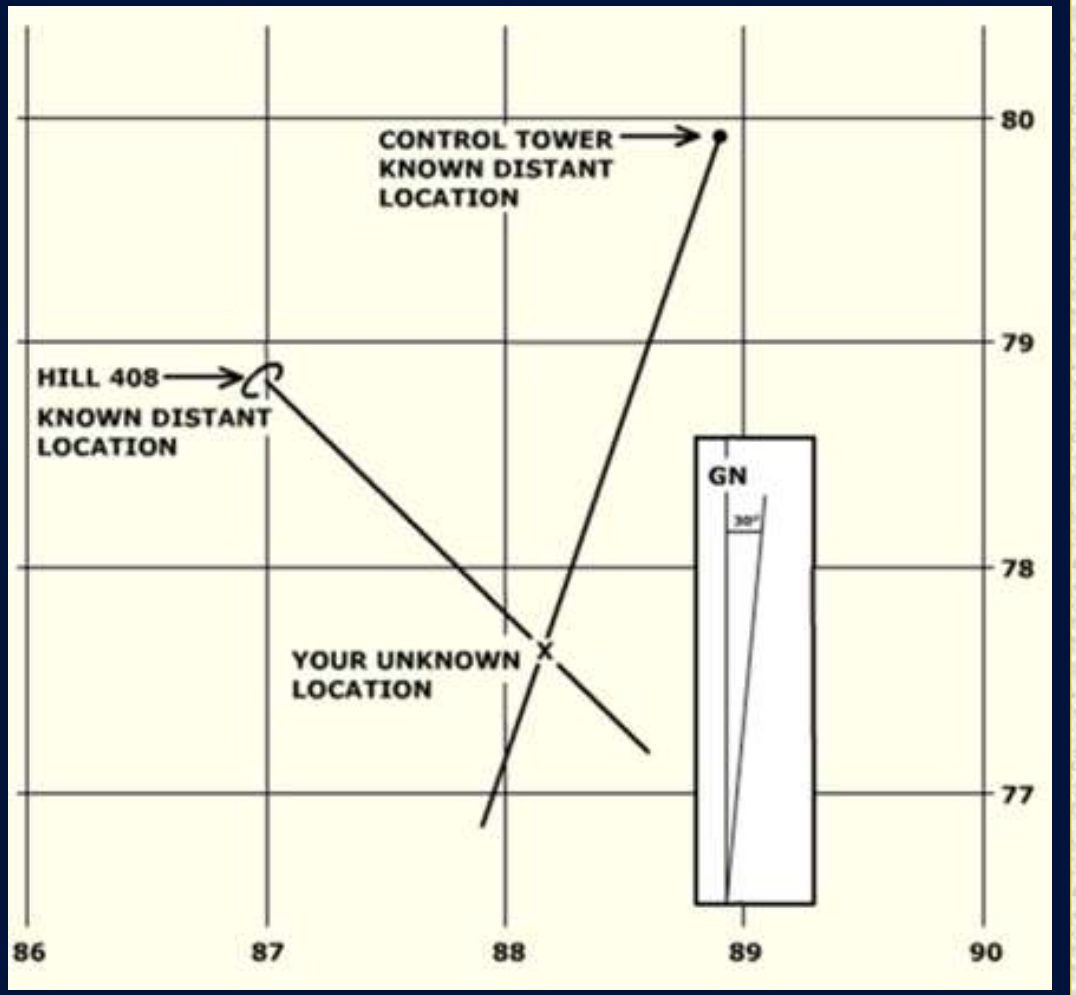
# Resection – Map and Compass

5. Convert the magnetic azimuth to a grid azimuth.
6. Convert the grid azimuth to a back azimuth by adding or subtracting 180 degrees.



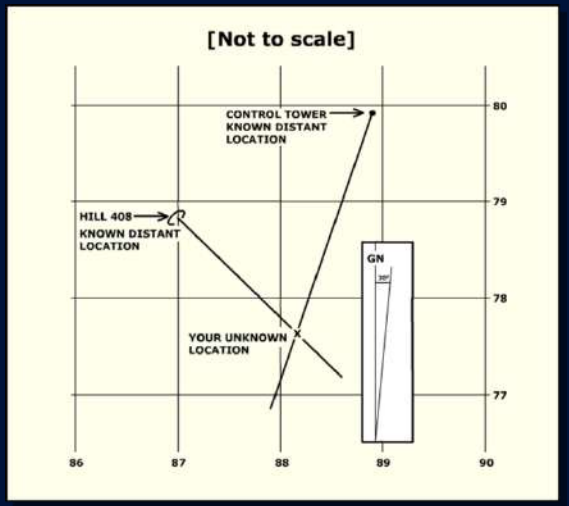
# Resection – Map and Compass

4. Measure the magnetic azimuth to one of the known positions from your location using a compass.

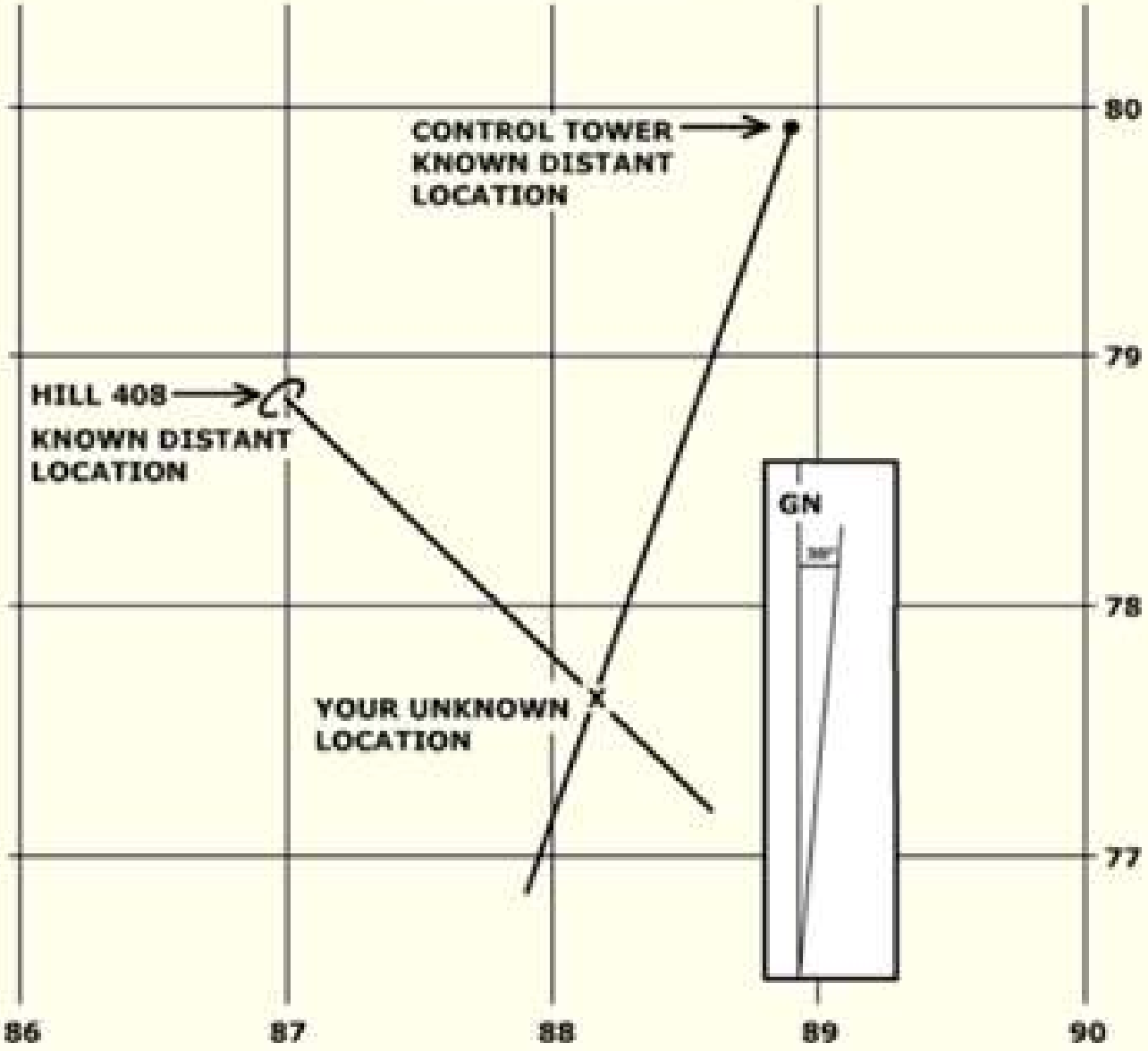


# Resection – Map and Compass

7. Place the coordinate scale on the map, ensuring that the zero-degree indicator is at the top and the index point is directly over the center of mass of the known point. Place a tick mark at 135°. Draw a line on the map from the known position back toward your unknown location.
8. Repeat steps 4, 5, 6, and 7 for the second known position (control tower).
9. The intersection of these two lines is your location. Determine the eight-digit grid coordinate for your position.



# [Not to scale]


CONTROL TOWER
KNOWN DISTANT
LOCATION
HILL 408
KNOWN DISTANT
LOCATION
YOUR UNKNOWN
LOCATION
GN
80
79
78
77
86
87
88
89
90

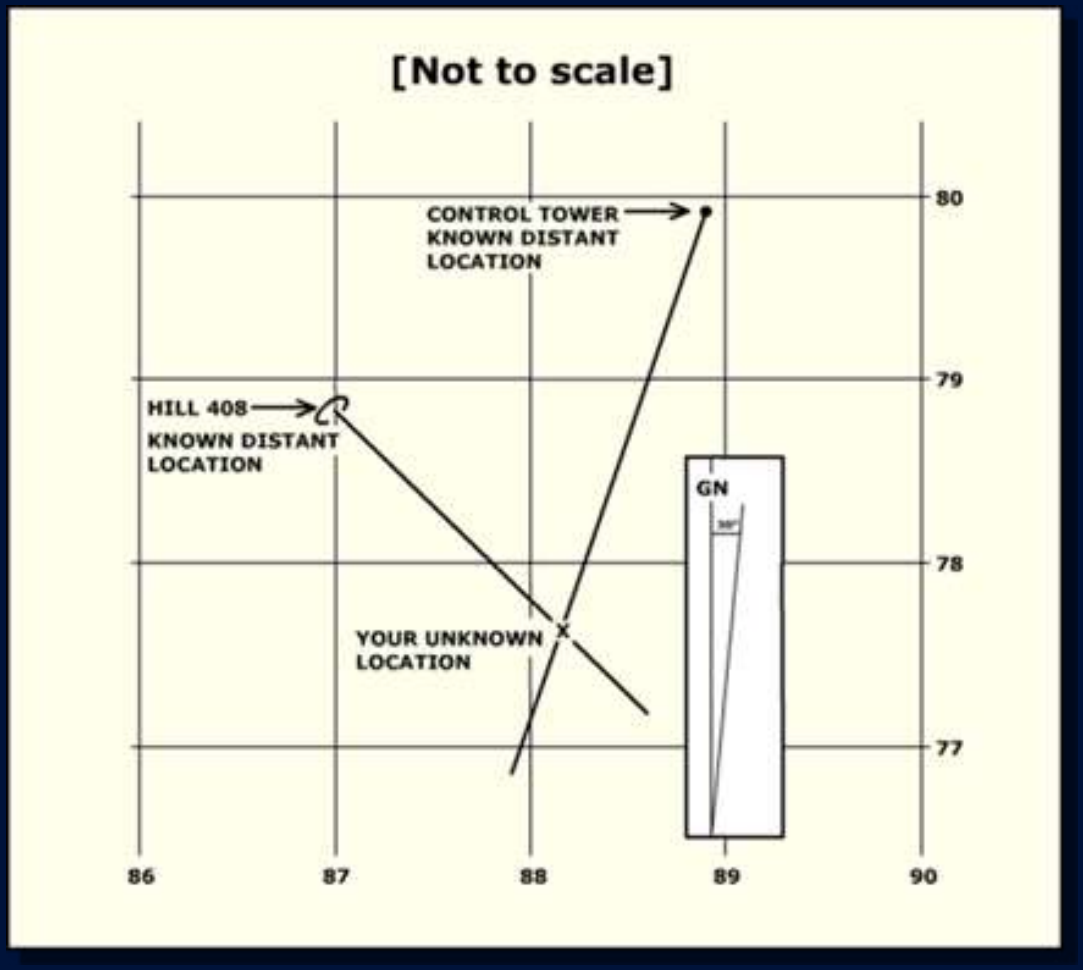
# Resection – Modified Resection

You can use a modified resection to locate your position on the map when you are at a linear feature on the ground, such as a road, canal or stream.

To do this, you need only one known location.

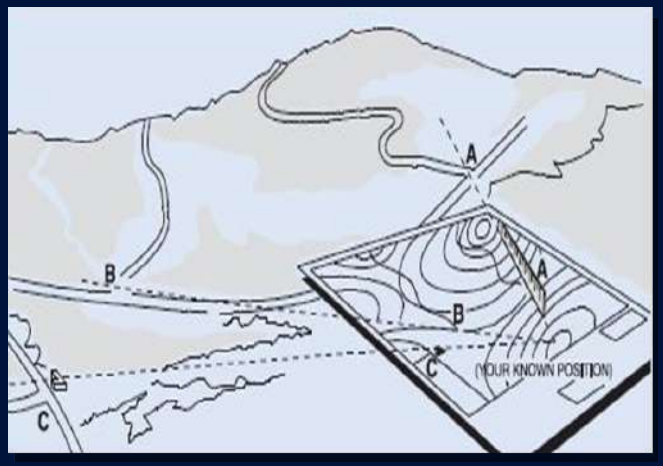
Follow the previous steps for Map and Compass method through step 7, including drawing the line on the map. The place where the drawn line crosses the linear feature is your location.

# Resection – Modified Resection



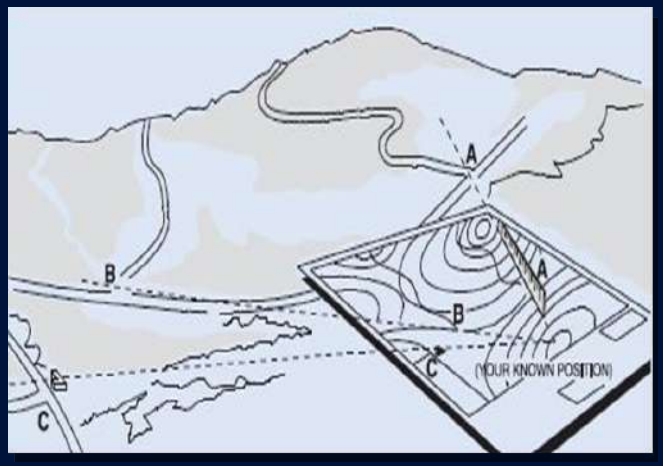
# Resection – Straightedge Method

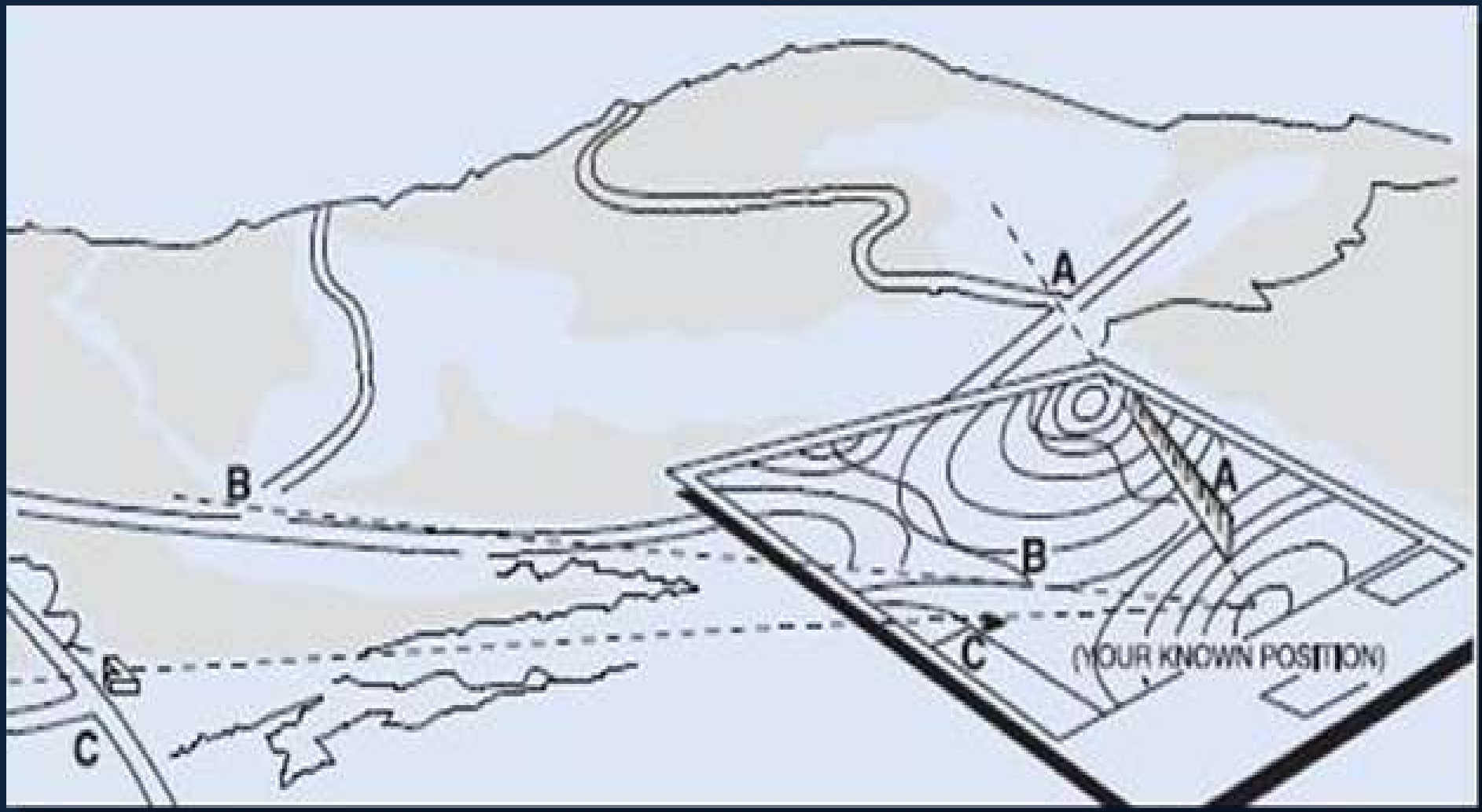
1. Orient the map (on a flat surface) to the ground by terrain association.
2. Locate at least two known distant locations or prominent features on the ground and mark them on the map (Points A, B, and C).
3. Place a straightedge on the map pointing toward one of the known points. Rotate straightedge until known point on the map is aligned with the same known point on the ground.



# Resection – Straightedge Method

4. Draw a line along the straightedge away from the known point on the ground toward your position.
5. Repeat steps 3 and 4 using the other known points (Points B and C).
6. The intersection of these lines on the map is your location.
7. Determine the six- or eight-digit grid coordinate (depending upon the desired degree of accuracy) for your location.




A
B
A
B
C
(YOUR KNOWN POSITION)
B
C

# Polar Coordinates

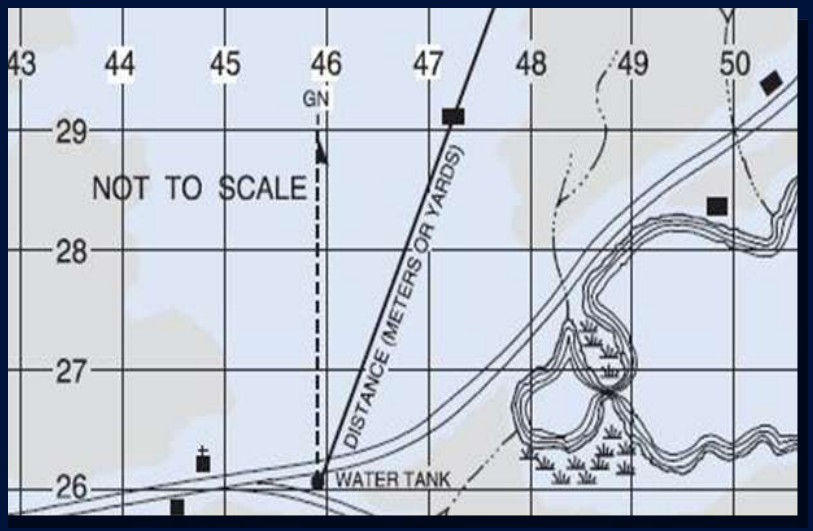
Polar coordinates are used to locate or plot an unknown point from a known location by giving a direction and a distance along the direction line.

Three elements must be present to use polar coordinates:

- A known location on the map,
- an azimuth (grid or magnetic),
- A distance (normally in meters)

There are two methods for use with polar coordinates:

- Map and compass
- Protractor

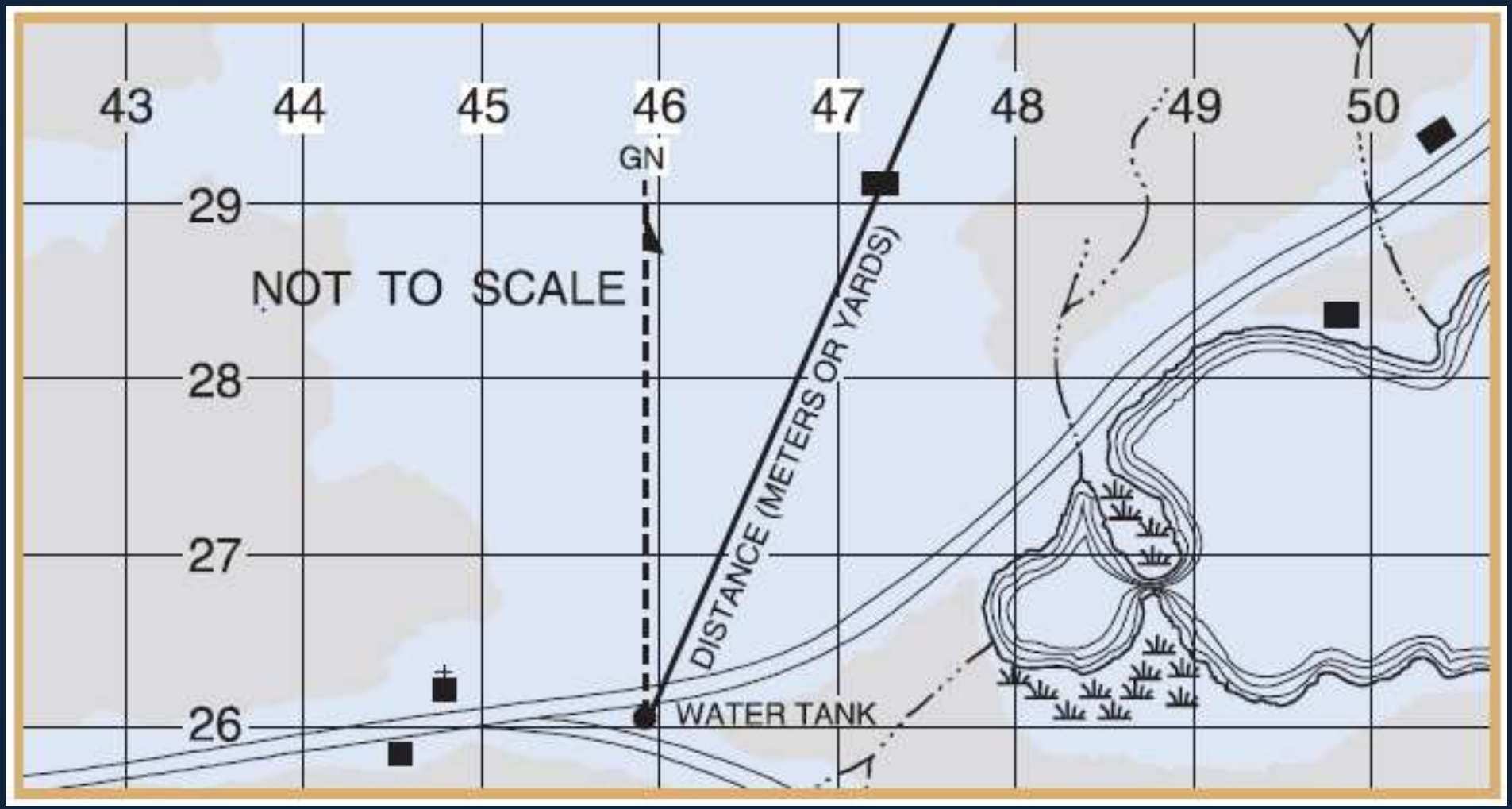


# Polar Coordinates – Map and Compass Method

1. Orient the map using a compass.
2. Determine the Grid-Magnetic Angle (G-M Angle) of the map you are using.
3. Identify the known location on the ground and mark it on the map.
4. Measure the magnetic azimuth to the unknown point from the known location using a compass.
5. Convert the magnetic azimuth to a grid azimuth.

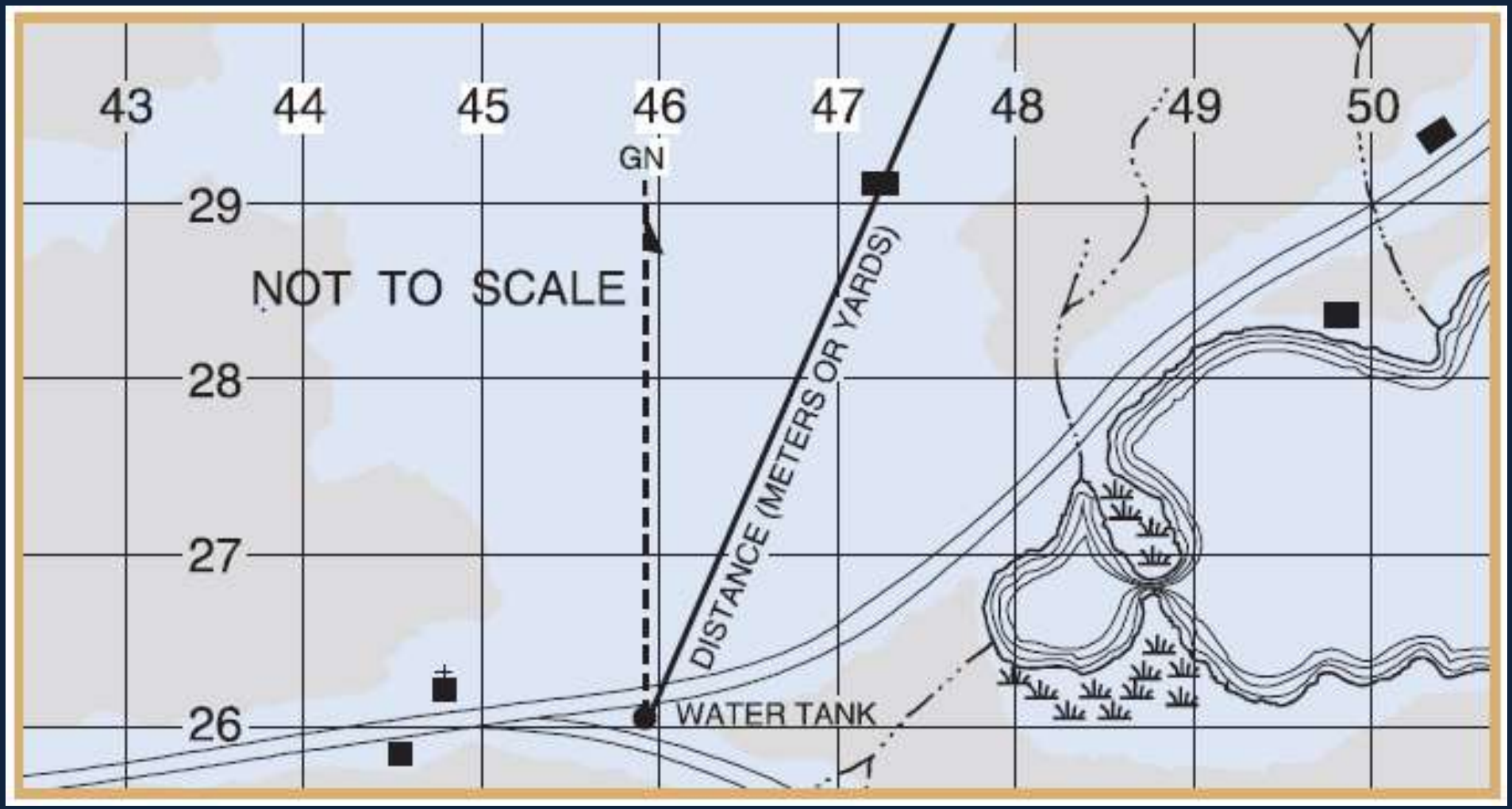
# Polar Coordinates – Map and Compass Method

6. Place a coordinate scale on the map, ensuring that the zero-degree indicator is at the top and the index point is directly over the center of mass of the point.
7. Place a tick mark at 24 degrees.
8. Draw a line on the map from the known location along this grid azimuth until it intersects.
9. Determine the distance to the unknown position. Using a straightedge and the procedure for measuring straight line distance, you determine the distance.


43
44
45
46
47
48
49
50
GN
29
28
27
26
NOT TO SCALE
DISTANCE (METERS OR YARDS)
WATER TANK

# Polar Coordinates – Protractor Method

1. Determine the location of a known point on the map to within 100 or 10 meters.
2. Measure a grid azimuth to the desired location or destination. By using your protractor, you determine the grid azimuth to be 24 degrees.
3. Determine the distance as you did in step 9 of the map and compass method.


43
44
45
46
47
48
49
50
GN
29
28
27
26
NOT TO SCALE
DISTANCE (METERS OR YARDS)
WATER TANK

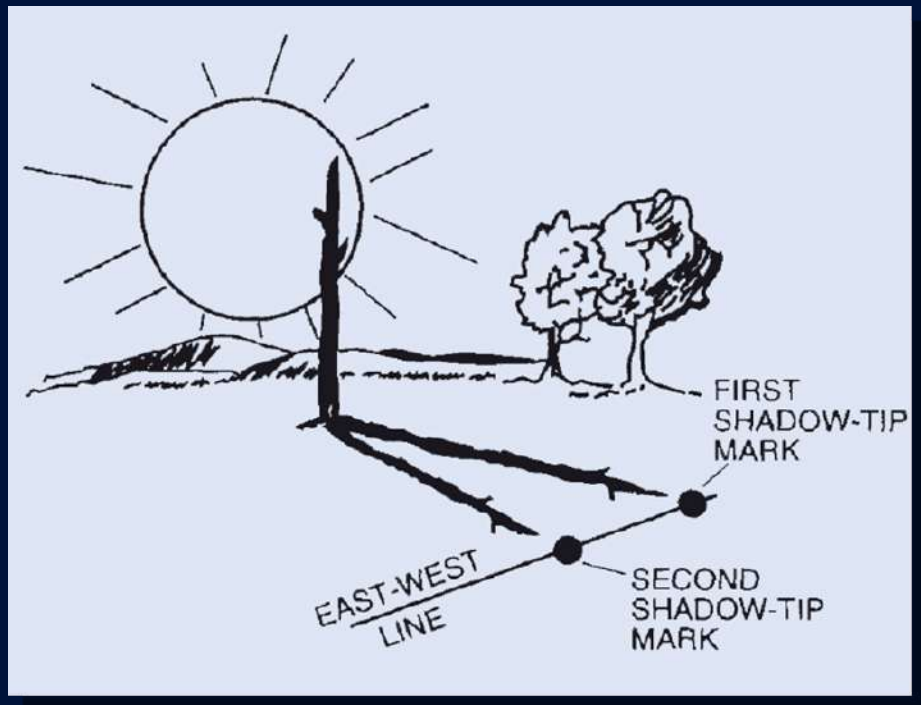
# Determine Direction Using Field-Expedient Methods

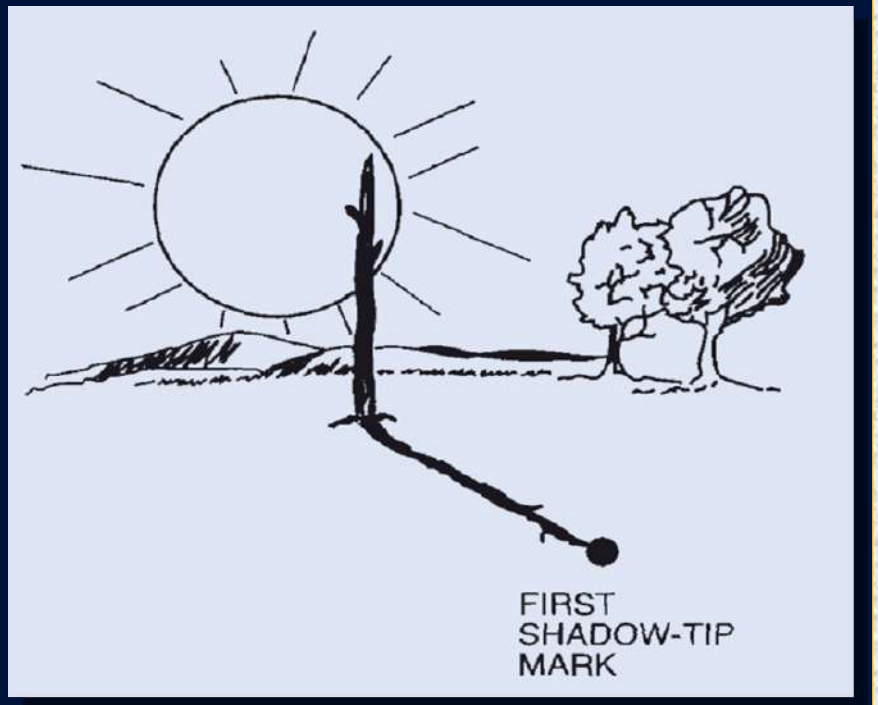
Sometimes a compass is not available and you must determine your location by using other materials and resources.

By using the sun and the stars, two methods to determine direction are the:

- Shadow-Tip Method
- Watch Method

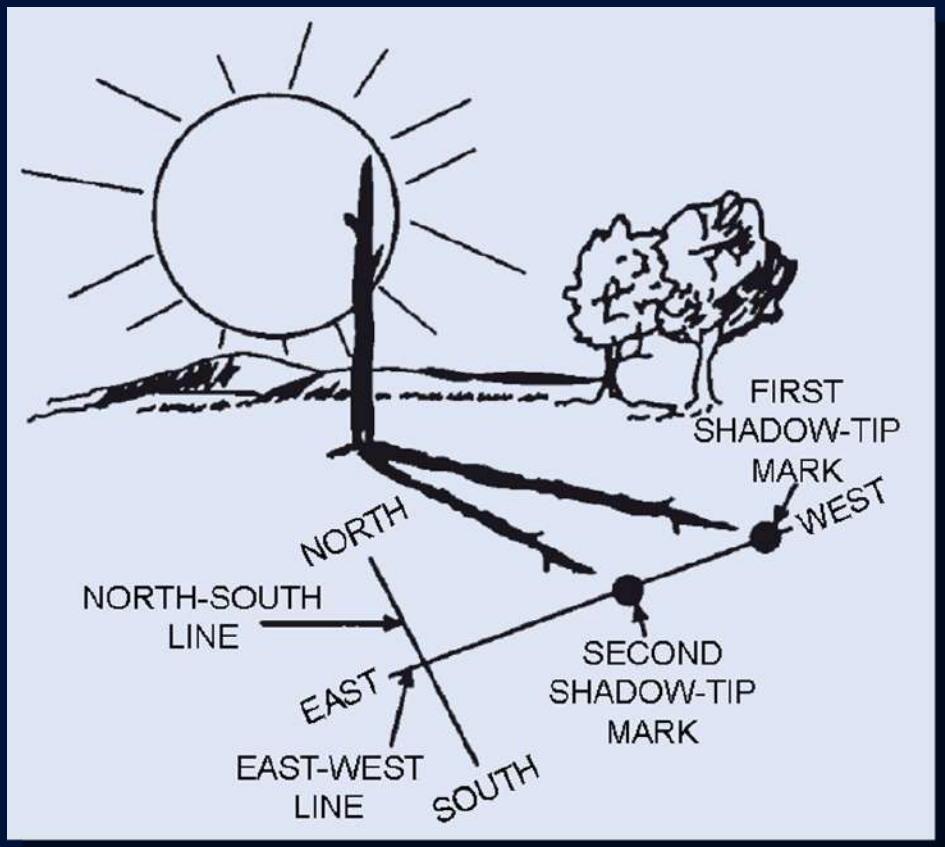
# Shadow-Tip Method




Draw a straight line through the two marks to obtain an east-west line. Extend this line past the second mark. Then determine which is the east and west end of the line.

# Shadow-Tip Method

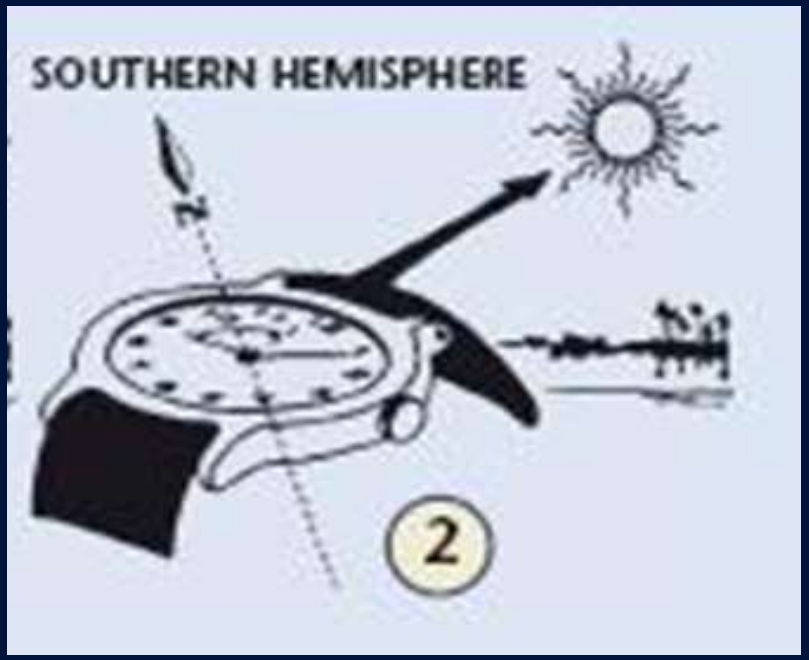


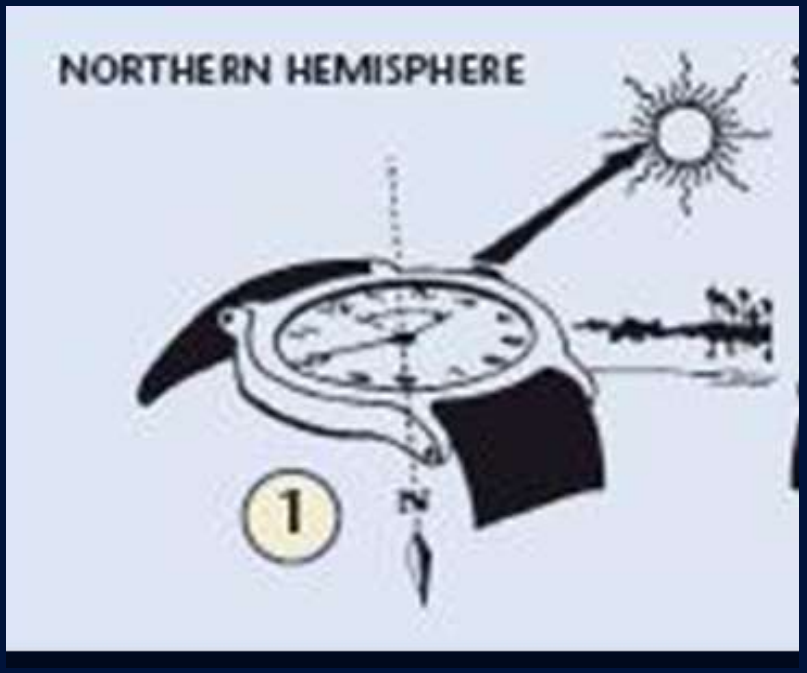

To find north and south, draw a line at a right angle to the east-west line at any point.

From this north-south line, orient the map and determine the direction.

# Watch Method

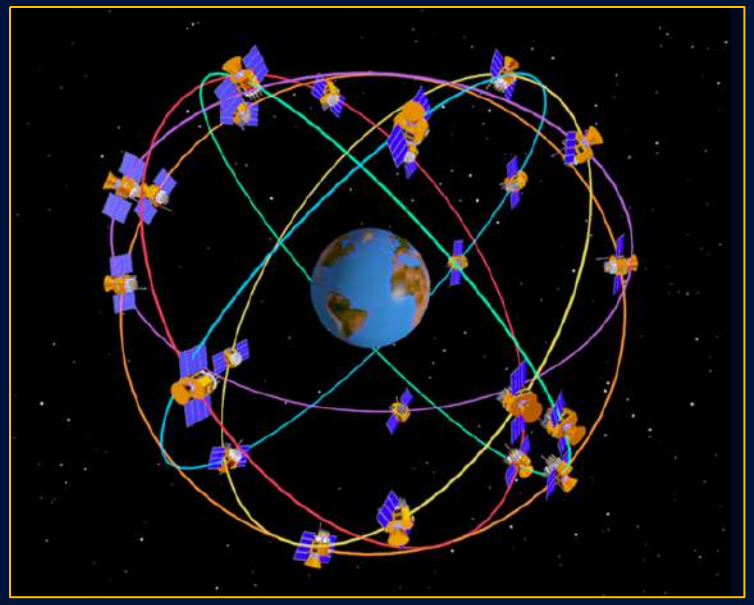
With some potential for errors especially in lower latitudes, this method can also be used to determine the approximate true north or south.



# Global Positioning System

The Global Positioning System (GPS) is a high-tech worldwide radio-navigation system formed from a network of 24 satellites and their ground stations.



GPS is the first system to pinpoint a precise location for any point on the globe, during any kind of weather.

This system utilizes these satellites to calculate positions down to a matter of meters.

# Global Positioning System

The use of advanced forms of GPS can pinpoint locations down to a centimeter. GPS is used in air navigation, mapping, pinpointing locations, and navigating routes for cars and boats.

A GPS receiver uses the travel time of radio signals to measure distance.

The satellites are closely monitored so that their exact location is always known.

# Closing Questions


CPS Lesson
Questions 7 - 8

# Review Question

Explain what the declination diagram on a map indicates.

1.

2.

3.

**(Use CPS “Pick a Student” for this question.)**

# Questions?