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MAP READING
READING TOPOGRAPHIC MAP COORDINATES

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What Are Maps?

When I began teaching high school geography several years ago, I opened the textbook and found its definition of what a map is. Let me share it with you:

> **Map-** **A graphical representation of the spherical Earth's surface drawn on a plane to a definite scale, utilizing standard symbols.**

My students would have enjoyed learning that as much as they would have wanted to go to Monday morning detention. I wanted my students to love geography, take their learning out of the classroom, and understand the many ways that the physical and human features of a place interact with one another. This geographic gobbledygook did not fit that overall vision in any way, so I didn't bother with it. I didn't even use the textbook. Maps, and the world in which my students lived- not some outdated textbook that still had a chapter about the Soviet Union were the key to my students becoming more geographically literate.

Instead, I used a much simpler definition of what a map is, and the kinds of information that it gives to people. I learned a one-word phrase from an elementary teacher that changed my teaching forever. That word is TOAD. Actually, TOAD is a cute abbreviation for the four essential features found on maps:

T Title

O Orientation

A Area

D Detail

The map's *title* tells you what the map is about. Does it represent a geographic place, or region whether that's a country, a city, a state, a neighborhood, or if you're using a kind of map called a globe, the whole world. Or the map's title might tell you about some physical or human phenomenon that takes place in a region such as military spending, literacy, or the amount of bananas grown every year.

The *orientation* of a map indicates direction to us as we read it, orienting us as to where we are. If you're drawing a map and have lots of spare time on your hands, drawing lines of latitude and longitude, which we'll learn more about later, can do this. Most maps instead, include a clever device known as a compass rose that shows at least the four cardinal directions of north, south, east, and west on the map.

All maps- even globes have represent a limited geographic *area*, and distance is determined by the scale of the map- that is its representation of actual size and distance on the flat sheet of paper in front of you.

Finally, maps include a legend or key that *details* the features you can find on the map.

If you review TOAD carefully, I'm sure you'll see as I did that you'll find all of what you need to know to develop a working knowledge about map features is in there.

Planimetric or Topographic?

Most of the maps that you and your students come into contact with such as road maps, textbook maps, and the directions to the family reunion that your Aunt mailed to you are what geographers call planimetric. *Planimetric* maps show relationships between physical and human features, but only in a very limited way. A good road map will show you the location of cities along highways, and where natural features such as rivers and lakes are. But that's about it. If you want more detailed descriptions of the terrain and the landforms found in a place, you will need to use a topographic map.

Topographic maps, the other flavor of maps used in the Map Reading competition are highly detailed representations of the natural and man-made features found in a very localized area that is usually much smaller than that of a road map. Topographic maps also show you such features as the size, shape, and elevation of landforms and the direction and gradient of stream and drain flow that you don't see in great detail on planimetric maps.

It should come as no surprise to you then that people like civil engineers, architects, and drain commissioners use topographic maps to plan the construction of places like shopping malls, highways, spillways, subdivisions, and lots of other things. Just think what would happen if you home was built on land that was prone to frequent flooding, or if your school was built on an alluvial fan- all because nobody bothered to read a topographic map or check out the land before construction began.

Topographic Maps by Other Names

Topographic maps are often called Topo maps for short. But more often, they're called *quadrangle* maps for a very obvious reason- they have four sides. Most geographers will identify specific topographic maps by their quadrangle name. For example, the Imlay City topographic map would be called the Imlay City Quadrangle. The title of a topographic map, located in the upper right and lower right corners of the map's margin give you the name of the quadrangle as well as other information about its location.

Orientation of Topographic Maps

A *neat line* borders each side of a topographic map. The neat lines of the map are in turn bordered by a white margin that contains different information about the map.

The top neat line is the northern edge of the map. If the map is oriented this way, you will be able to read the text right side up.

Read the map in a clockwise direction from the top neat line to identify the other cardinal directions. The right neat line is the eastern edge of the map. The bottom neat line is the southern edge of the map. It will be no great surprise then when I tell you that the left neat line is the western edge of the map.

You can identify other directions on the map by locating the intersections of neat lines. Read the map clockwise from the top neat line just like before. The intersection of the top and right neat lines is the northeastern corner of the map.

The intersection of the right and bottom neat lines is the southeastern corner of the map.

The intersection of the bottom and the left neat lines is the southwestern corner of the map.

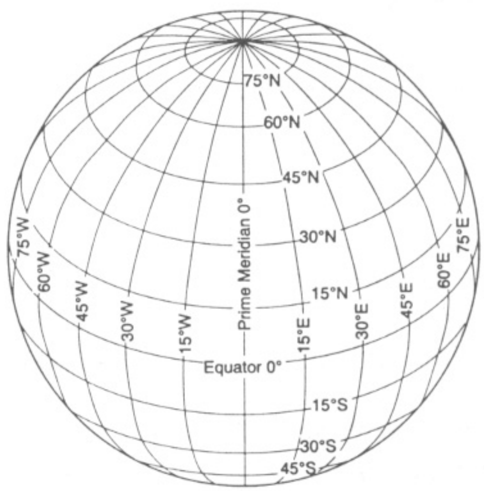
And as you probably guessed, the intersection of the left and top neat lines is the northwestern corner of the map.

Topographic Maps and the Earth's Surface

The boundaries of topographic maps are very nearly parallel to Earth's degrees of latitude and longitude. Lines of *latitude*, often called *parallels* by geographers measure locations north and south of the equator on a map or globe. Lines of latitude are *equidistant*, meaning that they are parallel to the Equator and to each other at approximately the same distance. Each degree of latitude is approximately 70 miles from the next one.

The surface of the Earth from north to south (and from south to north) is divided equally into 180° of latitude, with 90 degrees of that total north of the Equator and 90 degrees south of the Equator. All locations in North America, including the United States are north of the Equator.

The Equator, is 0° latitude, and the baseline for all other measurements of latitude. The North Pole of the Earth is measured as 90° north latitude, while the Earth's South Pole is measured as 90° south latitude. The number of degrees increases as you move further away from the Equator, and decreases as you move towards it whether you are in the northern or southern hemisphere. This is why geographers sometimes describe the tropics as a 'low' latitude region, and the Polar Regions are referred to as the 'high' latitudes.



Lines of *longitude*, also called *meridians*, measure locations east and west of the Prime Meridian on a map or globe. Lines of longitude are not equidistant because they converge at the poles of the Earth and bulge outward, as they get closer to the Equator.

The Earth's surface from east to west (and from west to east) is divided equally into 360° with 180° of that total east of the Prime Meridian and 180° west of the Prime Meridian. All locations in North America, including the United States are west of the Prime Meridian.

The Prime Meridian is 0° longitude, and the baseline for all other measurements of longitude. Lines of longitude are used to determine internationally agreed upon time zones. The International Date Line (180° longitude) is used to separate one day from the next. If you cross it from west to east on a Tuesday for example, Tuesday becomes Wednesday.

Topographic Maps and the Geographic Grid

Now that we understand how lines of latitude and longitude are used to measure directions on the surface of the Earth, let's see how topographic maps are oriented on Earth's surface.

Each *degree* of arc (circular measurement) of latitude and longitude is further subdivided into sixty smaller units called *minutes*, which are represented by a single apostrophe ('). Each minute in turn can be divided into sixty smaller units called *seconds*, which are represented by a double apostrophe ("). Look in each corner of a topographic map, and you should see measurements expressed in degrees, minutes, and seconds. These intersections of lines of latitude and longitude expressed as degrees, minutes, and seconds are geographic coordinates.

One problem faced by mapmakers since the dawn of time is how to get a great amount of detail into a map that is physically small enough for a person to read and take with them. Usually, as the area of the Earth's surface shown on a map increases, less detail and fewer objects can be seen on it. But if you decrease the amount of area shown on the map, you can show more detail in that area. When cartographers (geographers who draw maps) create topographic maps, they divide each degree of the Earth's surface in half to form 30-minute units, then in quarters to form 15-minute units, and in eighths to form 7.5-minute units.

Most of the topographic maps used in the Map Reading competition are 7.5" Series maps published by the United States Geologic Survey. The land area of a 7.5" series topographic map at a scale of 1:24,000 covers 49 to 70 square miles of Earth's surface. This is an ideal size that shows a great amount of detail and a large number of features.

Marginal Information

The *margin* of topographic maps is loaded with information about the map. Let's begin our tour of the marginal areas surrounding the map in its upper right hand corner and continue in a clockwise direction.

Upper-Right Corner: Map Title, Location and Series

The name of the quadrangle appears in the upper-right hand corner of the map in bold case. The name chosen for the quadrangle is usually that of an important feature such as a city or town located within the borders of the map.

Printed directly below the quadrangle name is the name of the state or states in which the mapped area is located.

The *Series* refers to the number of minutes in the mapped area. No other map of the same series located within the same state is given the same name.

Lower-Right Corner: The Title Block

The *Title Block* in the lower-right corner of the map includes the quadrangle and state names. The *Geographic Index Number* printed below the map name identifies the geographic position of the southeastern corner of the map-, which is also its nearest position to both the Equator and the Prime Meridian. The Geographic Index Number is also used to identify and catalog the map with the United States Geologic Survey- just like the government uses your Social Security Number to identify you, and record your name with various government agencies.

The year printed beneath the Geographic Index Number in black is the year that the map was originally printed. If the map has been photorevised (updated) since its original publication, the year of the photorevision will be printed in purple. Any new features added to the map since the original publication will also be tinted purple as well.

A *Legend* is also printed in the lower-right margin of the map that identifies the classes of roads and markers that appear in the body of the map, Depending on their classification, type of surface, and the number of their lanes, roads on topographic maps are shown in black or red. Parallel black lines in a solid or broken pattern identify other kinds of roads.

The approximate location of the quadrangle within the state it is located in is also shown to the left of the Title Block.

Bottom Neat Line Bar Scales:

Move to the left of the Title Block and directly below the center of the bottom neat line on your quadrangle, and you will see a set of three bar scales, which are used to measure distance on the map. Map scale in quadrangle maps is expressed as a fixed ratio or as direct proportional bar scales.

The fixed ratio of 1:24,000 indicates that one unit on the map- be it inches, centimeters or whatever is equal to 24,000 units of that measurement standard of actual distance. For example, if you are measuring in inches, one inch on the map equals 2,000 feet of ground distance. The fixed ratio makes it easy to use with the traditional English units of measurement that are still used in the United States (about the only place in the world that still uses them).

The bar scales on the quadrangle allow you to measure distance in miles, feet and kilometers. Note how the ‘0’ reading is at the center of a long line that represents a total distance of not one, but of two miles. A common mistake made by many students in the Map Reading competition is that they read the entire bar as a single mile, when in fact it represents two miles.

A bar scale for measuring feet is also provided below the one which measures miles. At the far left of this scale, 1,000 feet is broken down into five increments of 200 feet.

The metric bar scale is very similar to the mileage bar scale, but measures distance in kilometers. One kilometer is equal to 1,000 meters, which is about 1/6 of a mile.

Contour Interval

The fine winding brown lines that you see wiggling throughout the quadrangle are *contour lines*. Contour lines represent all connected points of the same elevation. This in and of itself however, does not tell us how steep the land is, how large a river valley might be, or whether or not there is a depression at a given location. This vertical distance between adjacent contour lines then is the difference in elevation between them whether they are close together or far apart. This distance between contour lines is the *Contour Interval* of the map, and is expressed in feet. You can find this value printed beneath the bar scales. When the contour lines are far apart, this will indicate landforms with little change in elevation. Contour lines that are close together indicate steeper landforms such as dunes or hills.

Just below the contour interval on your map, you will see the phrase *Datum is Mean Sea Level*. This might seem to be a lot of geography gobbledygook, but all it means is that all elevations on the map were taken from a baseline measurement of zero feet above sea. Who knows, we may have to revise that standard pretty soon if the greenhouse effect melts more glaciers and raises sea level.

You might also see the statement “This map complies with Map Accuracy Standards”. This just says that the people who created the map probably knew what they were doing.

Magnetic Declination

To the left of the scale, contour interval and datum information, you will see a magnetic declination diagram. *Magnetic Declination* refers to the angular difference between magnetic north (the direction that a compass points to) and geographic north (90° north latitude).

Geographic or ‘true’ north refers to what you would expect to be the North Pole. The Earth’s magnetic pole however is somewhat displaced from its geographic pole, and over time, this magnetic pole shifts its position. Sure, it’s not as cut and dry as the geographic measurement of 90° north latitude, but that’s the direction your compass will point to.

On the magnetic declination diagram shown on the quadrangle, a star represents geographic north, while the letters MN represents magnetic north. In the eastern United States, the line for magnetic declination is located just to the left of the line representing geographic north and includes a degree measurement. What this means is that you must adjust a compass that number of degrees in relation to geographic north to compensate for the angular difference between geographic and magnetic north at that location.

A final word of caution about magnetic declination. It is easy for students in the Map Reading competition to mistake the GN measurement for geographic north. The abbreviation GN does not refer to geographic north, but rather to ‘Grid North’, which is an international grid system not used in the Map Reading competition.

Lower Left Corner: The Credit Legend

The *Credit Legend* in the lower left hand corner of the quadrangle includes the following information that’s interesting to know, but not totally necessary for a beginning study of topographic maps.

Mapping Agency

The *Mapping Agency* refers to the folks who made the map for you. The name of the agency is preceded by the words “mapped, edited, and published by”. That agency is usually the United States Geological Survey.

Control

The *Control* is stated in the following line and refers to the agency or agencies which assure that the horizontal and vertical control points used to draw all of those contour lines on your map are accurate. Such agencies might include the United States Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOS/NOAA).

How Information Used to Create the Map was obtained

Found below the Control, this statement or statements disclose the methods in which information was obtained to prepare the map. In most cases, information is obtained from aerial photographs or other remote sensing technologies, and is then field checked by surveying teams clad in orange reflective vests. Other information in this section might include the years in which the aerial photos were taken, and the year in which the information was then field checked. The term ‘photogrammetric’ may be used to indicate that measurement information was obtained using remote sensing data.

If nothing else, this information should tell you that it takes a great deal of time to amass information used to create accurate maps that may be considered a reliable source of information by those who use them. You should also see the need for periodic photo revisions to keep maps up to date as human, and even many physical features can change with the passage of time.

Map Projection

The *Map Projection* refers to one of many ways of mathematically projecting a piece of the round Earth on a flat sheet of paper. Every map projection distorts the shape of the Earth in some way. That’s why when you looked at those old Mercator projection world maps used in many schools, Antarctica appears to be this huge land mass bigger than most of the continents, when in fact it si about the size of the continental United States.

Certain map projections work better than others depending on the location of the map. Conic or polyconic projections work well in mid-latitude regions such as most of the continental United States. Many topographic map projections are conic or polyconic for this reason.

Upper Left Corner: The Mapping Agency

Just in case you missed it before, the name of the mapping agency can be found in the upper left corner of the map.

Geographic Coordinates

Geographic coordinates answer the question we all ask ourselves whenever we get lost in the woods, or on our way to some place out of town. That question is- where are we?

Recall that Earth's surface is equally divided into equidistant planes of latitude located north and south of the Equator. The Equator is 0° latitude, and the lines of latitude measure north/south directions because you must cross latitude lines. Lines of longitude on the other hand measure east/west directions because you must cross them when you are traveling in either of those directions. The intersection of these lines of latitude and longitude in a given location are the geographic coordinates of that location. No two locations have the same geographic coordinates.

Reading Lines of Latitude and Longitude

When you learned how to read, you learned that it's best to read down from the top of the page, and from left to right.

When you read a topographic map to determine the geographic coordinates of features in the United States, lines of latitude are read from the bottom upward. That's because as you move further north, your distance from the Equator (0° latitude) increases, and hence the number of degrees of latitude also increases.

Likewise, longitude must be read from the right side of the map to the left side. This is because as you move further west, your distance from the Prime Meridian increases and so the number of degrees of longitude increases.

Each degree of latitude or longitude can be further subdivided into sixty smaller units of measurement called minutes. Minutes are symbolized by a single apostrophe ('). Each minute in turn can be further subdivided into sixty seconds of arc that are symbolized by a double apostrophe ("). Such precise measurements allow geographers to determine the exact location of a feature.

Reading Latitude

Locate the latitude of the bottom neat line printed near the lower right corner of the quadrangle where the right and bottom neat lines intersect. You should also see the same numbers in the lower left corner of the quadrangle where the left and bottom neat lines intersect. On the Imlay City, Michigan Quadrangle the latitude measurement is:

43° 00'

The small dash in front of the numbers indicates that it is a measurement of a horizontal line (latitude). Both of these locations are thus on the same plane of latitude.

Now read up from the bottom of the map along the right neat line until you see numbers measured in minutes (may also include seconds). On the Imlay City quadrangle, the number is 55'. This latitude measurement is read as:

43° 2' 30"

Even though the number of degrees is not printed here, you are still within the arc of 43 degrees. Look directly across the map, and you will see this same measurement of 43° 2' 30". That is because you are still on the same plane of latitude.

Now continue reading up from the bottom along the right neat line until you arrive at a measurement of 57’ 30”. This latitude is read as:

43° 5’

Again, you will see this same measurement directly across the map on the left neat line, just like you did with the previous measurement.

As you read upward to the top right corner of the map, where the top and right neat lines intersect, you will see a latitude measurement of 43° 07’ 30”. Look directly across the map to where the top and left neat lines intersect and you will see the same latitude of measurement.

In learning to read lines of latitude on a topographic map, you should have also noted the following:

- As you read latitude upwards from the bottom of the map, the number of minutes and seconds increases.
- Latitude measurements in the United States are **always** north of the Equator.
- Measurement of latitude is the same on the right and left sides of the map along the same plane.
- There are two minutes and thirty seconds between each of the measured sections we read on the map, and that there are three sections between the bottom neat line and the top neat line. 2.5’ x 2.5’ = 7.5’ hence the 7.5’ Series of topographic maps.

Reading Longitude

Locate the longitude reading of 83° 00’ printed near the lower right corner of the quadrangle where the right and bottom neat lines intersect. You will also see this measurement where the top and right neat lines intersect.

From this location, move your finger to the left along the bottom neat line until you reach the longitude measurement of 2’ 30”. This measurement is read as 83° 2’ 30”. Look on the top neat line directly across from this measurement and you should see the same number of minutes. Continue moving your finger to the left along the bottom neat line and you should see the longitude measurement 5’. This measurement is read as 83° 5’. You will also see this measurement directly across the map at the top neat line. As you read to the lower left corner of the map where the left and bottom neat lines intersect, you should see the longitude measurement 83° 07’ 30”. You will also see this measurement of longitude where the top and left neat lines intersect.

In learning to read lines of longitude on a topographic map, you should have noted the following:

- As you read longitude from right to left, the number of minutes and seconds increases.
- Longitude measurements in the United States are west of the Prime Meridian.
- Measurement of longitude is the same on the top and bottom sides of the map along the same plane.
- There are two minutes and thirty seconds between each of the measured sections we read on the map, and there are three sections between the right neat line and the left neat line. 2.5’ x 2.5’ = 7.5’ hence the 7.5’ Series of topographic maps.

Now let’s put latitude and longitude coordinates together so that we can read and write geographic coordinates.

Neat Line Coordinates

Locate the latitude reading 44° 52' 30" near the lower right corner of the Imlay City Quadrangle, where the right and bottom neat lines intersect. Then locate the longitude reading 85° 52' 30" just below the latitude reading. The point at which these two lines meet are the southeast neat line coordinates. The geographic coordinates of this location are written as follows:

43° 00'N
83° 00'W

Note that the latitude coordinates are written first, and are followed by the abbreviation N for north. That's because this location, like all other locations in the United States is north of the Equator. Longitude coordinates are followed by the abbreviation W, which stands for west. That's because this location, as well as all others in the United States is west of the Prime Meridian.

Proceed along the bottom neat line to the left. The southwest neat line coordinates of this quadrangle are as follows:

43° 00'N
83° 07' 30"W

Note that the latitude measurement is the same for both the southeast and southwest coordinates, and that the longitude measurements are 7.5 minutes apart.

Now look at the top right corner of the map, where the right and top neat lines intersect. The northeast neat line coordinates of the map are written as follows:

43° 07' 30"N
83° 00' W

Note that the latitude measurement of the northeast and southeast neat lines are 7.5 minutes apart, and that the longitude measurement of the northeast and southeast neat line coordinates are the same.

Proceed along the top neat line to the left. The northwest neat line coordinates of the Imlay City Quadrangle are written as follows:

43° 07' 30"N
83° 07' 30"W

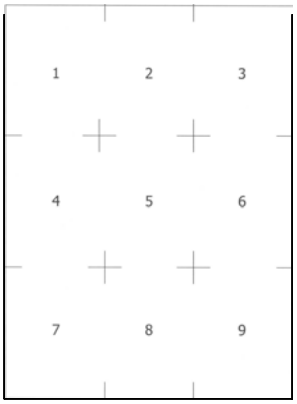
Note that the latitude measurement of the northwest and northeast neat lines is the same, and that longitude measurements are 7.5 minutes apart.

By reading the neat line coordinates of a topographic map, it is possible to understand the dimensions of the map. Now let's learn how to further subdivide the map into smaller sections yet.

The Nine Mental Sectors

Topographic maps can be further subdivided into nine smaller sections using the 2.5-minute sections you just learned about. These sections are collectively known as the *nine mental sectors.*

The nine mental sectors on a 7.5 series topographic map are located as shown in the table below:



The Nine Mental Sectors

To locate each section on the map, let's begin by locating the crosshairs, which may be used to divide the map into sectors.

Begin, by moving your finger up from the bottom neat line upwards along the right neat line. When you get to the 2' 30" latitude tic mark, move your finger directly across the map until you reach the 2' 30" longitude tic mark along the bottom neat line. You should see a set of two crossed lines that look like an oversized addition sign. Those are the bottom right *crosshairs*. The coordinates of these crosshairs on the map are written as follows:

43°2' 30"N
83°2' 30"W

Continue moving your finger to the left. You should see the bottom left crosshairs as you come to the 57'30" longitude tic mark. These coordinates are written as follows:

43°2' 30"N
83°5' W

Now move your finger upward from this location to find the top left cross hairs as you come to the 57'30" latitude tic mark. The coordinates for the top left crosshairs are written as follows:

43°5' N
83°5' W

Move along this line back to the right and you will find the top right crosshairs when you come to the 55' longitude tic mark. The coordinates for the top right crosshairs are written as follows:

43°5' N
83°2' 30" W

Knowledge of how topographic maps are arranged and oriented, and the types of information they provide will help you to prepare students for competition and to use topographic maps as a powerful teaching tool to help students understand more about the world in which they live. Now, let's determine the geographic coordinates of features that do not fall directly on those boundaries.

Determining Exact Geographic Coordinates

In a 7.5' Series Quadrangle, we have learned that the distance of each of the nine mental sectors is 2.5° (7.5 / 3) or 150 seconds (2.5 x 60). If you were to measure in millimeters from the bottom neat line to the Sector boundary lying directly above and parallel to it, the distance would be 192 millimeters. This is useful information for calculating latitude.

Calculating longitude works in much the same way except that you measure in millimeters from the right neat line or the nearest Sector boundary to the Sector boundary directly to the left and parallel to it. This distance is not the same for all topographic maps because the Earth tends to bulge outward the closer you get to the equator. For the Imlay City Quadrangle, this distance is 141 millimeters. Try measuring the map sectors to see for yourself, and then let's try to determine the geographic coordinates of a topographic map feature on the Imlay City Quadrangle.

Look for the Clarks Corner School in Sector 9. To determine the geographic coordinates of the main building shown on the map carefully follow the steps given below.

To Determine Latitude

1. Measure the distance in millimeters (mm) from the bottom neat line to where the flagpole joins the main building.

   That measurement should be 125mm.

2. Divide that measurement (125mm) by 192- the distance in mm from the bottom sector boundary to the top sector boundary.

   Your answer should be .6510416
3. Multiply your answer by 150- this, remember, is the number of seconds in a 2.5' Sector.

   Your answer if you've been with me so far should be 97.65624
   This is the number of seconds that the building is away from the bottom sector boundary.

4. Now, let's convert our seconds to minutes. We can round this answer to 98 seconds if I remember what my second grade math teacher taught me, and if we divide this number of seconds by 60- as you know the number of seconds in one minute, that gives us the following answer:

   1 minute 38 seconds (01' 38")

5. Now, let's add 01' 38" to the value of the bottom Sector boundary- which in this case is the bottom neat line of the Imlay City Quadrangle. If the bottom neat line measures 43°00' N and we add an additional 01'38", then our latitude measurement for this feature will be:

   43°01'38"N

Remember, when measuring latitude to determine exact geographic coordinates, measure upward from the bottom Sector boundary to the feature that you wish to measure. Divide that measurement by the distance in millimeters from the bottom Sector boundary to the Sector boundary directly above and parallel to it. Multiply your answer by 150- the number of seconds in a 2.5' Sector and convert this answer to minutes. Finish by adding the minutes and remaining seconds to the bottom Sector boundary.

To Determine Longitude

6. Measure the distance in millimeters (mm) from the right Neat Line.

   That measurement should be 114mm.

7. Divide that measurement (114mm) by 141- the distance in mm from the right Neat Line boundary to the left Sector boundary.

   Your answer should be .8085106

8. Multiply your answer by 150- this, remember, is the number of seconds in a 2.5' Sector.

   Your answer if you've been with me so far should be 121.27659

   This is the number of seconds that the main building is away from the bottom sector boundary.

9. Now, let's convert our seconds to minutes. We can round this answer to 121 seconds rounding our answer as before, and dividing the number of seconds by 60, that gives us the following answer:

   121 seconds (121")

10. Now, let's add 121" to the value of the right Neat Line boundary. If the right Neat Line boundary measures 83°00' W and we add an additional 121", then our longitude measurement for this feature will be:

    83°02'01" W

The exact geographic coordinates of the main building of the Clarks Corner School in Sector 9 of the Imlay City Quadrangle can now be written as:

43°01'38"N
83°02'01"W

Remember, when measuring longitude to determine exact geographic coordinates, measure from the right Sector boundary to the feature that you wish to measure. Always divide that measurement by the distance in millimeters from the right Sector boundary to the left Sector boundary directly parallel to it. This measurement differs between topographic maps because of the Earth's tendency to bulge at the equator, so it's probably a good idea to measure the distance for each map you use. Multiply your answer by 150- the number of seconds in a 2.5' Sector and convert this answer to minutes. Finish by adding the minutes and remaining seconds to the right Sector boundary.

Conclusion

Whether you're teaching an Earth Science or Geography class or preparing students for Science Olympiad competition, the concept of location is all important because in order to understand the spatial relationship of physical and cultural features to one another, you must first know their location. A knowledge of how to determine exact geographic coordinates will make learning more relevant for students as they 'go local, then global' to increase their knowledge and awareness of the world in which they live.