

Coach Latitude and Longitude Calculations

Coach files are a series of short lessons, each for a Road Scholar topic. Most started out as responses to questions from coaches. They are rough notes- maybe refined, maybe not. Questions and answers are from various events. You will be seeing Mapscans (screen grabs) from various USGS maps and some from AAA Road Maps. It's always better to have the whole map, so I will include the name and date of the USGS Topo map that the Mapscans come from. You can download the entire map free from USGS.gov.

Introduction:

You should have already worked through two other Coach files- Latitude and Longitude, and Map Sectors. This file will combine understandings to show you how to calculate the exact latitude and longitude for any given point on a USGS 7.5 minute map.

Review:

Latitude lines run around the earth parallel to the Equator and show your location in degrees North or South. Numerical values run from 0° at the equator to 90° at the poles. USGS topo maps cover all areas in the United States, including possessions like the Virgin Islands, but are always at North latitudes.

Longitude lines run around the earth perpendicular to the equator and show your position in degrees East or West of the Prime Meridian. Number values run 0° to 180° West or East. All longitude lines converge at the North and South Poles. USGS topo maps will always have West latitudes.

Angle measurements are expressed in degrees, minutes, and seconds. You must be very careful when doing math with degrees--60" equals 1' and 60' equals 1°

On topo maps, latitude lines and longitude lines form the Map Sector Reference Grid (grids are also called graticules). Number values are shown on the map corners and edges in shortened form. Those numbers, with careful measurements, let you determine the exact coordinates for any spot on the map.

Latitude and Longitude on Road Maps

With drivers increasingly using GPS -based navigation programs, many Road maps now include lat/long markings. AAA Maps have lat/long tick marks for whole degrees along the neat lines.

*** Enlarged AAA Mapscans- Marginal Latitude and Longitude Markings***

(Expressed in decimal degrees, with West longitude showing as -96°)

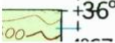
Latitude	Longitude
	

Map Sectors- based on USGS Questa, NM 1995

Several Mapscans and diagrams below are from the USGS Questa, NM 1995 7.5 minute map. This map was used in the event [Zombie Bedtime Rhymes](#), posted on www.soinc.org under B Resources for Road Scholar.

You already know that 7.5 minute maps, the most common in Road Scholar, are divided into a 9-sector grid. So far, we have left out the latitude and longitude calculations, but now they will be added to the Map Sectors.

To start, look at the four corners of the **USGS Questa, NM 1995 1:24,000 7.5 min map**.

Northwest corner $105^{\circ} 37' 30''$ $36^{\circ} 45'$ 	Northeast corner $105^{\circ} 30'$ $36^{\circ} 45'$ 
Southwest corner $36^{\circ} 37' 30''$ $105^{\circ} 37' 30''$ 	Southeast corner $36^{\circ} 37' 30''$ $105^{\circ} 30'$ 

The Southeast Corner has a latitude of $36^{\circ} 37' 30''$ North (all US latitudes are North), going up to $36^{\circ} 45' 00''$ North in the Northeast corner. That's a difference of $0^{\circ} 7' 30''$ of latitude.

Same thing for longitude- it goes from $105^{\circ} 30'$ West up to $105^{\circ} 37' 30''$ West. (All longitudes in the US are West). That's a difference of $0^{\circ} 7' 30''$ of longitude, as you would expect for a 7 1/2 minute map. The diagram below shows Map Sectors on the Questa map, along with the lat/long values at sector boundaries.

(This example is from USGS Questa, NM 1995). latitude is shown on right side - increases South to North. Longitude is shown across top *in italics* - increases East to West. Numbers in parenthesis do not actually show on the real map.

$105^{\circ} 37' 30'' (W)$	$(105^{\circ}) 35' (00'' W)$	$(105^{\circ}) 32' 30'' (W)$	$105^{\circ} 30' (00'' W)$	
Northwest 1	North 2	Northeast 3		$36^{\circ} 45' (00'' N)$
West 4 "downtown Questa"	Central 5	East 6		$(36^{\circ}) 42' 30'' (N)$
Southwest 7	South 8	Southeast 9		$(36^{\circ}) 40' (00'' N)$
				$36^{\circ} 37' 30'' (N)$

On the East neat line, the Sector boundaries are labeled every $2' 30''$ in shortened form- the number in parentheses are assumed and the number shown plainly are printed on the map. Longitude shows across the Northern Neat Line.

Problem # 1: (Using USGS Questa, NM 1995) **What are the Latitude and Longitude at the Southeastern corner of the map? Express you answer in degrees, minute, and seconds. Don't forget N, S, E, or W! Lat= $36^{\circ} 37' 30''$ North Long= $105^{\circ} 30' 00''$ West**

No math involved, just reading from the map. Notice the answer for longitude includes seconds. They were not shown on the mp but assumed. The question requires them for a complete answer.

Problem # 2: What is the longitude at the Western boundary (neat line) of the map?

105 ° 37' 30" W. Again, just reading from the map.

Using marked Sector Reference lines to find Latitude or Longitude:

Sometimes you can just read the values directly from the map. In the diagram of Map Sectors with lat/long above, see Sector W4 with "downtown Questa" label. You can see a graticule intersection (+) marked in the Northeast corner of the sector.



Problem # 3: What are the latitude and longitude at the graticule Intersection? Express your answers in degrees, minutes, and seconds. Don't forget N, S, E, or W.

latitude = 36° 42' 30" N longitude= 105° 35' 00" W

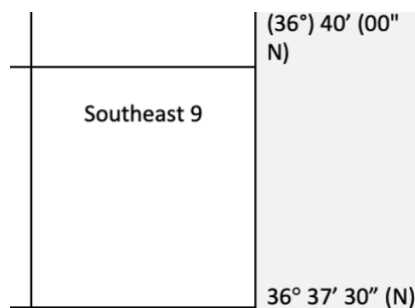
Lat/long are read by looking across the map to then eat lines

Using Map Sectors to Find the Latitude and Longitude of Features

Determining the lat/long of a point right on a Sector boundary is just a matter of reading the lat/long label. Easy! What about a feature that is not on a line? You must do some careful measurement within a millimeter- and some math. It's not difficult but you must be careful in keeping track of degrees, minute, and seconds.

The basic idea is simple. You already know that any map sector is 2' 30" South to North.

Assume you have a point in the center of a sector:



You know the Southern boundary of SE9 has a latitude of 36° 37' 30" N.

You know the Northern boundary of SE9 has a latitude of 36° 40' 00" N (a 2' 30" increase).

So, a point halfway from South to North would have a latitude of 1" 15" above the South, or lat= 36° 38' 45" N

To get the latitude for any given point, you must make a few careful (within 1 mm) measurements.

Measurements and Math to Find Latitude or Longitude of a "Target" Point:

1. From the neat lines, read and record the latitude at the South boundary of the Sector.
2. From the neat lines, read and record the latitude at the North boundary of the Sector.
3. You know the distance from South to North, in degrees/minutes/seconds is 2' 30", or 150 "
4. To the nearest mm, measure the distance from the South boundary to your target.
5. To the nearest mm, measure the distance from the South boundary the North Boundary
6. The math involves a proportion:
$$\text{mm from south to target} / \text{mm from south to north} = \text{seconds south to target} / 150 \text{ seconds}$$
7. This will give you the number of seconds North of the Southern boundary.
8. If there are more than 60 seconds, convert to minutes and seconds.
9. Add this to the known latitude at the southern boundary and you have the latitude of the target point.
All this sounds like a long series of steps, but once you are familiar with the process is only a few minutes, and you get a bunch of points in an event. Longitude works exactly the same way.

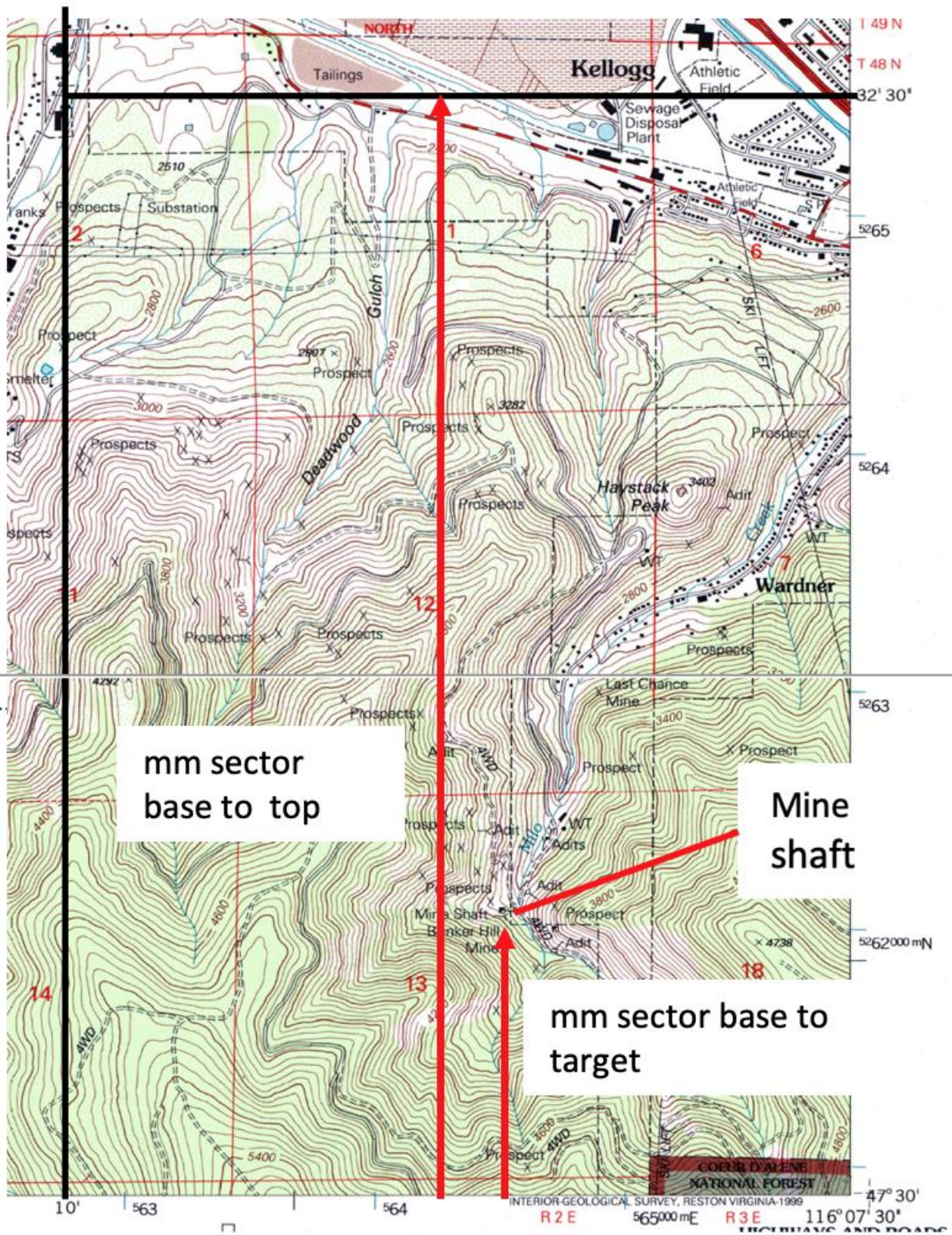
Problems: Using USGS Kellogg West, ID 1996

These problems are from the 2022 nation Event- "*We All Talk About Bruno*". This event was run online via Scilympiad. Any map distances shown here are taken from the actual hard copy USGS map; they may be different on your computer screen. This Mapscan shows the SW9 Map Sector, close to actual size. Sector boundaries have been modified in heavy black and distances to measure are shown in red.

Problem #4: What is the latitude at the Bunker Hill Mine Shaft? (Express your answer in degrees, minutes, seconds. Use correct format.)

latitude= 47° 30' 39" North

Many event scorers allow a + / - range of 3" for full credit, with closeness to the ideal value being a tie breaker. This is to allow some error in measurements. In this on-line event measurements were given to teams.



Here are the measurements on the original hard copy map you need for the computation:

These measurements were provided to teams in the event; being on-line does not permit the accurate measurements to be made. There is no way to control how large students see an image in Scilympiad.

latitude at South boundary of Sector SE 9	47° 30' 00" N
latitude at North boundary of Sector SE 9	47° 32' 30 ' N
map distance from South Sector boundary to mine	50 mm (provided)
map distance from South Sector boundary to North	192 mm (provided)

Math to Find Latitude: Steps in Sequence

Map sectors are always 2' 30" (that's 150 ") S-N and E-W

	map sector	SE9
1	South Sector border lat	47° 30' 00" North
2	North Sector border lat	47 32' 30 ' North
3	mm south to target	50 mm (provided)
4	mm south to north	192 mm (provided)
5	latitude difference south to north	2' 30" = 150"
6	formula	mm south to target / mm south to north = seconds to target / seconds south to north 50 / 192 = ? / 150" =
7	result= seconds from south to target	39.06 "
8	convert to minutes and seconds: Add seconds to base deg/min/sec to base	47° 30' 00" North + 39"
9	Add deg/min/sec to base target latitude=	47° 30' 39" North

Longitude is done the same way. Always measure and work from South the North for latitude, and East to West for Longitude. This way you will be adding numbers rather than subtracting.

Problem # 5: What is the longitude at the Bunker Hill Mine? (Express in degrees, minutes, seconds)

116° 08 ' 36.4" West

Google Earth gives 116° 08' 40.35" West to what might be the original mine shaft --it's hard to tell)

Note: The table below shows measurements as made on the actual hard copy map. You may use some or all of them.

longitude at East boundary of Sector SE 9	116° 07' 30 " West
longitude at West boundary of Sector SE 9	47 32' 30 ' N
map distance from East Sector boundary to mine	58 mm (provided)
map distance from East to West boundary of Sector SE9	131 mm (provided)

Math to find longitude: steps in sequence**Map sectors are always 2' 30" (that's 150 ") S-N and E-W**

whole map East neat line longitude	116° 07' 30 " West
map sector	SE9
East sector border longitude	116° 07' 30 " West
West Sector border longitude	116° 10' 30" West
distance (mm) East border to target	58 mm
distance (mm)East border to West border	131 mm
formula	mm west to target /mm east to west = seconds to target x 150 seconds
result= seconds from East to target convert to minutes and seconds	66.4" = 1 ' 6.4"
Add seconds to East border deg/min/sec to base	116° 07' 30 " West + 1 ' 6.4"
target longitude	116 ° 08' 36.4" West

Google Earth gives 116° 08' 40.35" to what might be the mineshaft, but it is not clear in the image.

To get USGS topo maps online:

www.usgs.gov The United States Geologic Survey. USGS no longer prints maps, but you can do free downloads of most USGS topo maps. If you have a large monitor, you can show downloaded maps actual size on your screen. This allows you to make measurements and calculations. You can thus do practice events without the hard topo map. How cool is that?

The USGS site changes constantly but this worked as of October 2024:

Example using Questa, NM 1:24000 map dated 1995 (needed for Zombie Bedtime Rhymes Event, posted on soinc.org)

usgs.gov → products → topographic maps → get topo maps → historical topo map collection → (see menu) search by map name → Enter "Questa" in search box → click "24K" below search box → Slide date bar to about 1980 → Results should show: Questa, NM 1995" → pick "↓GEOPDF 17 MB" from menu. Download may take a while.

On your own computer: by adjusting "view" to 100% you will have the same map used in competitions. Save any maps as, for example. "USGS Questa NM 1995" and all your downloaded maps will be together. You can make measurements right on your screen but note that "actual size" on your screen is probably different than the same setting on another screen. Try adjusting your screen so that the black UTM grid shows as 42mm squares. You cannot print a whole map on a standard printer, but you can screen grab one map sector at a time and print it on an 8.5" x 11" sheet of paper.

For questions contact the writer at:

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