

Introduction

Grid systems allow you to locate features on a map. Systems covering small areas can be shown on a flat map easily, but for large areas there is a problem: the Earth is not flat--no matter what grandpa says. It is roundish. So, maps, along with map grid systems, get distorted. Globes do not have this problem, but it's hard to fold up a globe and carry it with you.

Maps and Grids

The most convenient way to find points on a map of the Earth is with a grid of vertical longitude lines and horizontal latitude lines. Grid problems arise because the map is flat and the Earth is round. Latitude lines running east-west are no problem, but vertical north-south longitude lines converge as they approach the poles. The distortion over small distances is manageable, but a USGS Topo map from higher latitudes is narrower than one from lower latitudes because of the "longitude squeeze". Remember that the USGS maps show a 7' 30" x 7' 30" area of latitude and longitude, not a given area of square miles. (For the rest of this document, "latitude and longitude" will be written as lat/long)

Mercator projection, developed by the Flemish cartographer Gerardus Mercator in 1570, show lat/long lines as an even square grid. This works well, but large area Mercator maps are very distorted near the North and South Poles because they do not show the convergence of longitude meridians.

The Universal Transverse Mercator (UTM) system partly solves the "longitude squeeze" problem by just ignoring all areas north of 84° N and South of 80°S. Except for Antarctica, no land areas are excluded from the UTM system.

Basics

The **Universal Transverse Mercator System (UTM)** is modern grid system used to locate features on the Earth's surface. Instead of East/West longitude and North/South latitude, UTM uses only two directions: "Northings" and "Easting".

UTM--The good

Latitude and longitude use angular measurements in degrees, minutes, and seconds. Lat/long "grid boxes" such as Map Sectors vary in size. Distances between different points of lat/long do not easily convert from angles into feet or meters on the ground. The UTM grid is completely metric and gives coordinates directly in meters, thus making locations and distances much easier to deal with.

UTM--The bad

UTM coordinates use very large scary numbers, like 10T 0624301 E, 10T 4859317 N. Although all modern USGS maps show the UTM grids, they do not all show it the same way, and it can be hard to find.

UTM--The beautiful

UTM grid boxes are always 1,000 meters x 1,000 meters. UTM math is base ten, not base 60 as in degrees, minutes, and seconds. That makes UTM very consistent and

computer/calculator friendly. For Road Scholar problems, you can figure an exact location in a few minutes. You do not have to convert seconds to minutes or degrees.

UTM Grids are based on Grid North (The GN on USGS declination diagrams), not on magnetic north. There is no adjustment needed for magnetic declination.

The Overall UTM Grid

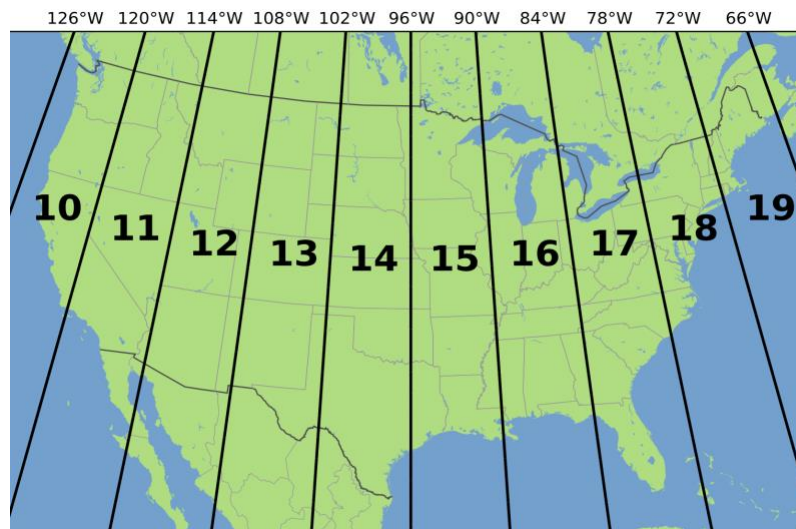
UTM divides the Earth into 60 zones of 6° of longitude (360° total). Zones start at the International Date Line (180° E or 180° W, in the Middle of the Pacific Ocean) and are numbered going eastward only, not east and west. Various parts of the US, from Alaska to the US Virgin Islands, are found in UTM zones 2 through 20.

Northings are the vertical grid and are designated by letters. Letters start at the south pole and work northwards. The 48 contiguous U.S. states are all in zones R through T.

UTM in Road Scholar

At first glance UTM is all big scary numbers. However, its application to a specific USGS topo map easier than lat/long problems once you overcome your number shock. The UTM zone is included in marginal information on USGS topo maps:

The Universal Transverse Mercator Grid Zones in the United States



The "lower 48" US states are all in UTM Zones 10 to 19.

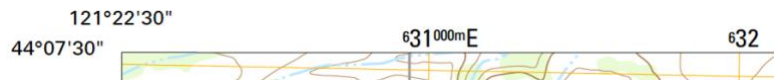
Each UTM Easting Zone is 6° of Longitude wide.

Note that the zone lines do not converge as longitude lines do.

On some USGS maps, the UTM grid shows as a black grid covering the map like this. The 1 km square grid boxes are always 42 x 42 mm on a 1:24,000 map.



On other USGS maps, the UTM grid is only shown by tick marks along the map neat lines(edges). The markings may be black, blue, or tan.



Problem # 1: using USGS Rock Island, WA 2003

What is the UTM Easting value at the Abnormal Brain Bank at the northeast corner of the Brain Building?

1. Find the UTM Zone:

The UTM zone is in a block of marginal information in lower left corner:

Produced by the United States Geological Survey

North American Datum of 1983 (NAD83)

World Geodetic System of 1984 (WGS84). Projection and

1 000-meter grid: Universal Transverse Mercator, **Zone 10T**

10 000-foot ticks: Washington Coordinate System of 1983 (south zone)

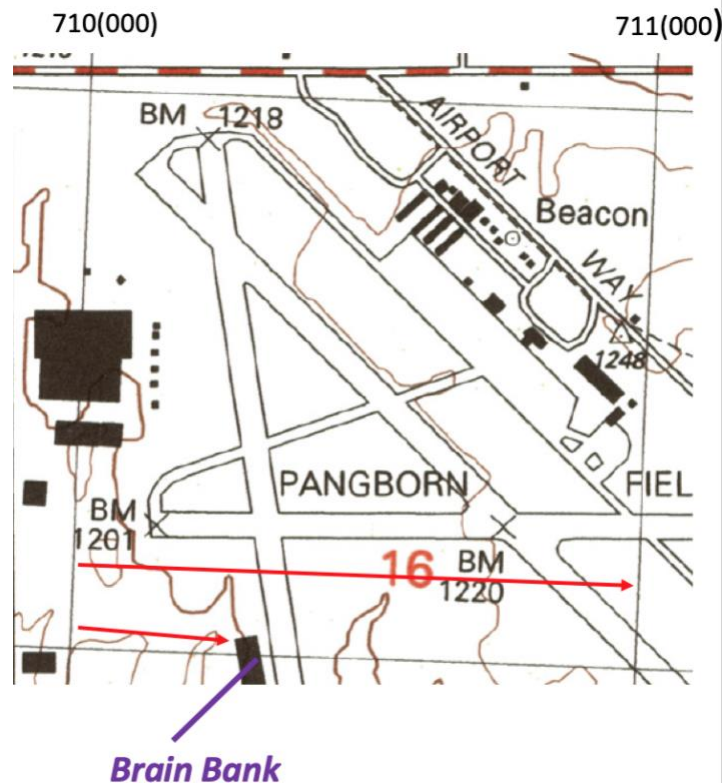
On 7.5-minute quadrangle maps, the UTM Easting and Northing grid lines are marked at intervals of 1,000 meters. The 1,000-meter value of the ticks is abbreviated for every tick or grid line. The full meter value is shown for ticks nearest the southeast and northwest corners of the map. See below; **7 08 000mE** is near the Northwest corner of this map and **7 09** is the next tick to the East.



Note the 709 marking (709000), which assumes the (000) for the thousand meters. Too many numbers make the map hard to read, so it is common to leave stuff out and assume you understand. latitude and longitude markings are also abbreviated.

2. Locate the Target Point: In the actual event, the story helps students locate things for questions: (from Zombie Bedtime Rhymes, posted on soinc.org)

At the airport, Uncle Mortimer shows us a series of buildings that store airplanes, apples, and brains. The brains are kept refrigerated and are grouped according to how smart they are. "Just watch out for the Abnormal Brain Bank" says Mortimer. Take careful note of its location, but make sure you do not disturb any of the abnormal brains--they are already disturbed"



Notice that the UTM grid lines are not perfectly North-South on the map. The map is set on "True Geographic North", but UTM uses Grid North. See magnetic declination diagrams.

3. Measurements and Math

Measure and set up a proportion just like for latitude/longitude.

Easting: Start with measuring east from the vertical Easting grid line west of the target.

Northing: start as in latitude with measuring north from the horizontal Northing grid line south of the target.

For both, measure the distance between the grid lines. Since values of UTM units do not change as do longitude distances, UTM boxes are always the same size: 42 mm on a 1:24,000 map. In measuring for Easting, you always work to the east, just the opposite of longitude where you always measure to the west in the western hemisphere.

On the enlarged Mapscan above, the Easting measurement is 25 mm east of the 710,000 grid. The distance between the 710,000 grid and the 711,000 grid is 75 mm on my enlarged view (42 mm on the actual hard copy map). You may get something different. By definition this is a 1,000 meter distance.

Easting proportion is: $25 \text{ mm} / 75 \text{ mm} = x / 1000 \text{ m} = 333 \text{ meters}$.

That is the distance, in meters, from the western grid line to the target Brain Bank.

To get the UTM, add the 333 meters to the value of the Western grid line value of 710,000 shown on the map.

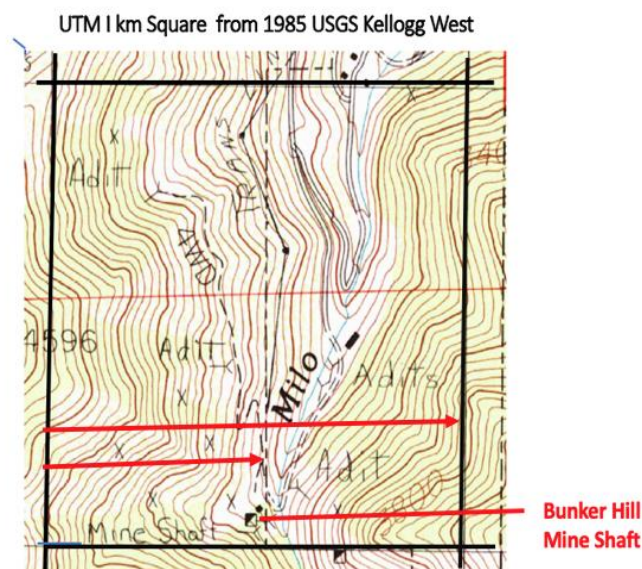
In the grid below: Measurements were made on the enlarged Mapscan. If using the actual USGS map, numbers will be different but answer will be close.

To find UTM Easting:	
UTM Zone (from marginal information)	Zone 10
Target-	Brain bank building
West to East base line map distance =	75 mm
West base line to target map distance	22mm
Western base line value =	710,000
Eastern base line value=	711,000
Math: map distance to target/ West-East grid map distance x 1000=	$22 / 75 = .333 \times 1000 = 333\text{m}$
Easting value: West base + math answer	Zone 10 710333 mE (range 710233-710433)

Problem # 2: using USGS Kellogg West, ID 1996

What is the UTM Easting value at the Bunker Hill Mine Shaft? Express your answer in the correct format. 564512 mE

This was an on-line Scilympiad event, so measurements were given and teams had to do calculations. (Note: measurements used here are from original hard copy map, as used in the event. Everything is bigger in this enlarged scan so you can see labels ,etc. Teams in the actual event did not get all these labels.)

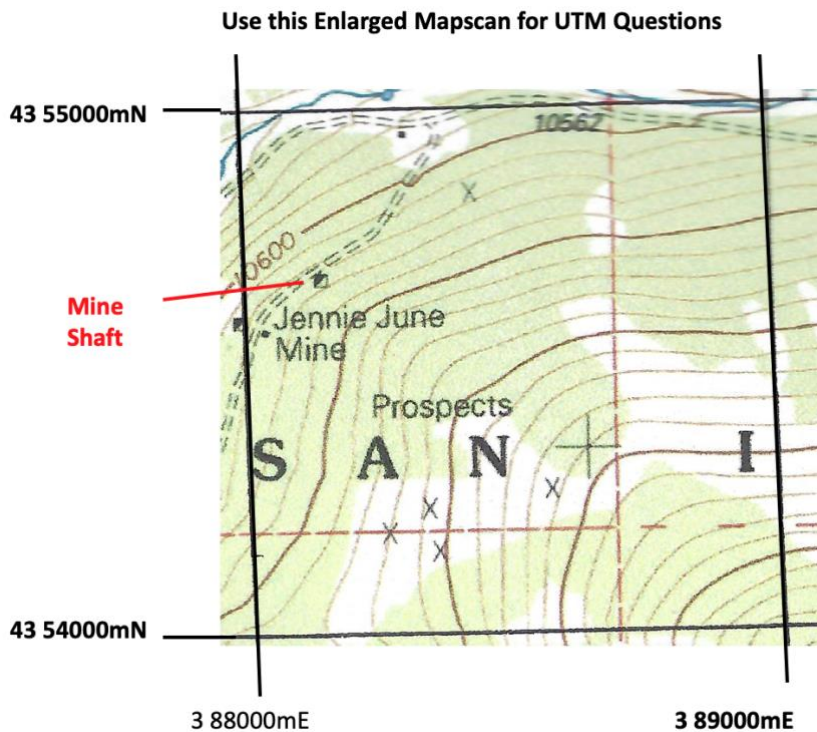


To find UTM Easting:	
UTM Zone (from marginal information)	Zone 11 (given)
Target-	Bunker Hill Mine Shaft (given)
West to East base line map distance = 42 mm	42 mm (given)
West base line to target map distance	21.5 mm(given)
Western base line value =	564000 m E(given)
Math- map distance to target/ West-East map distance= $21.5/42 \times 1000=$	512
Easting value: West base + target= 564000 + 512	564512 mE

Story- Orpheus and Euridice- looking for Euridice at the bottom of the Jennie June Mine

USGS Leadville North, CO 1994

(Note: UTM grid is not distorted; UTM does not use true North-South compass directions)



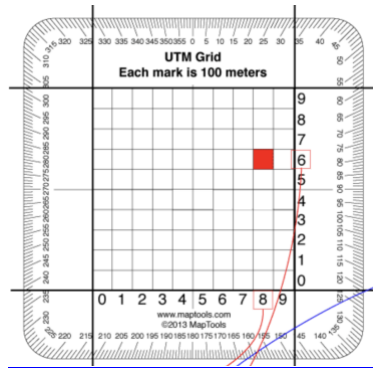
Problem# 3: Using the Universal Transverse Mercator system, what is the UTM Easting for the entrance to the Jennie June mineshaft? The zone is not needed for this problem.

388150 mE (range 388110- 190)

To find UTM Easting:	
For this 1000 x 1000 "grid box": UTM Zone from marginal information	13
Target-	Jennie June mine
West base line value	388000mE
East base line value	389000mE
West to East base line map distance =	70mm (42 mm on hard copy map)
West base line to target map distance	10 mm (42 mm on hard copy map)
Math- map distance to target/ West-East map distance=	10/70= .1428== 143 m
Easting value: West base + target=	388143 mE (Maptools says 388190)

Using Map Aids to Solve UTM Problems

Maptools.com sells a number of map aids. Map overlays can save you time and give accurate results that are close to what we get with paper and rulers. They are a very fast way of getting results. There are overlays for lat/long, UTM, etc. See <https://www.maptools.com/>

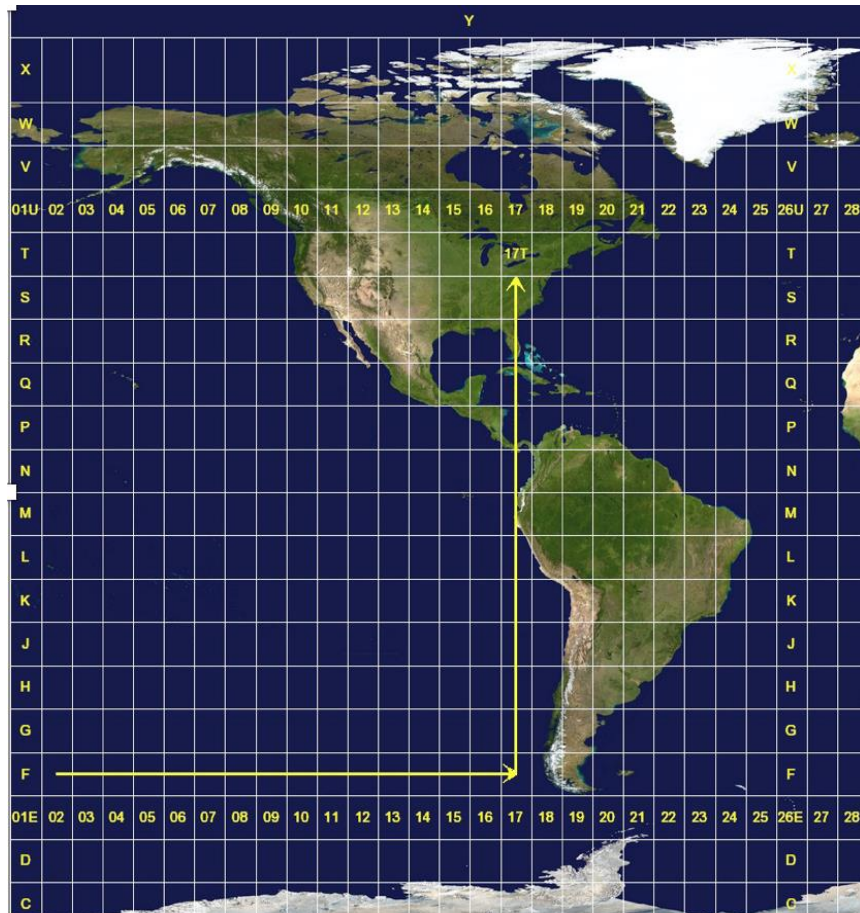


Map overlay grids will work well with original USGS maps, but many events must now be done with Mapscans of the original maps. Mapscans may not be the exact same size as the original map, so grids may be misleading.

Maptools also has several good tutorial videos, including finding UTM, using their overlays. Note that videos show you how to find yourself on a map when you are out in the wilderness. It's not the same as using them in a Road event, but the basic techniques are the same. You are better off measuring and calculating--that's what we do- but the overlays are a great way of checking to avoid "way off" answers.

Never show up at a Road Scholar event with a brand- new map tool. It will only cause confusion. Make sure you learn how to use it ahead of time!

Universal Transverse Mercator Grid -Easting and Northing Zones in the Americas



To Get USGS Topo Maps Online:

www.usgs.gov Is the website for The United States Geologic Survey. USGS no longer makes routine paper prints of topo maps. You can order custom printed maps, but you can download most USGS topo maps for free. If you have a large monitor, you can display 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 (a Road Scholar resource event on soinc.org)

Steps: 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. Downloading 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 measures as 42 mm 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 actual size on an 8.5" x 11" sheet of paper.

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For questions contact Brendan at: ctsciencedirector@gmail.com