Coach Compasses, Azimuths, and Bearings 12 16 2024

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 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 get the maps free online from USGS.gov. (See procedure at end)

Maps are usually drawn so that North is "up". Meridians of longitude are vertical, and parallels of latitude are horizontal.

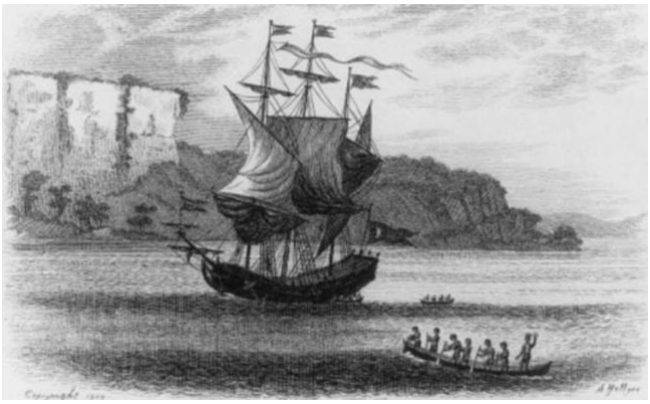
How can you tell which way is North?

When people traveled on land, they could find their way based on various landmarks - rivers, mountains, etc. Sailors close to land could do the same thing. However, sailors traveling out of sight of land had no landmarks! To tell where they were and where they had to go, they relied on the positions of the sun and stars.

European sailors knew that the sun was always to their south at noon with shadows always pointing north. At night, the North Star (Polaris) is always directly north. The sun rises from the east, although its exact rising point varies with the season. Same for sunset in the west. Between careful observations of the sun and Polaris, sailors could get an accurate picture of North, South, East and West and their latitude during good weather. Everything was different for navigators in the southern hemisphere.

Compasses came into use about 1100 in China and about 1600 in Europe. A compass shows north on cloudy days or even at night. But as Sailors learned to use the compass, they realized it did not usually agree totally with shadows, and they trusted the shadows more--they had been using the sun, stars, and shadows and sun for hundreds of years. In the ship's logbook, captains always recorded how many degrees away from "sun shadow/Polaris north" the compass read. The difference is Compass Variation or Magnetic Declination.

Excerpt from Henry Hudson's logbook, September 1609, in New York Harbor: (original spelling)
" ... We steered away West- North- West, by our varyed Compasse, which made a West way.... The Compasse varyed 10 degrees from the North to the West."



Magnetic Declination

Compasses point to magnetic north, not true or geographic north. The difference between the two varies by the year and your location. The difference is Compass Variation or Declination. In the United States declination may be 0° or almost 30° East or West of true north.

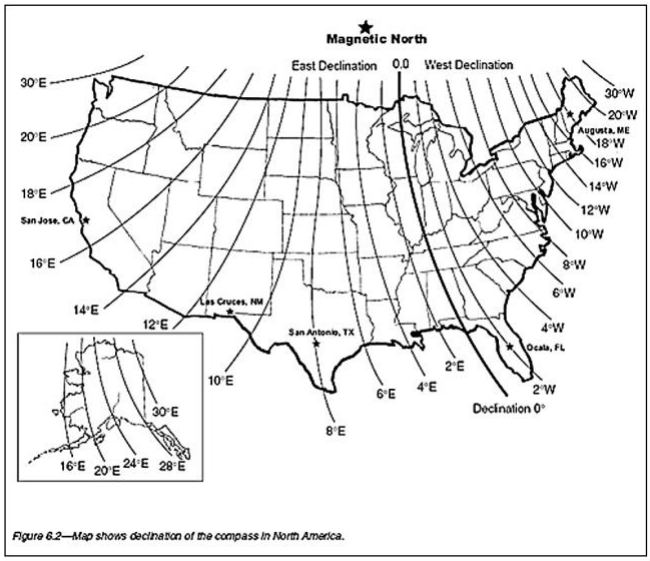
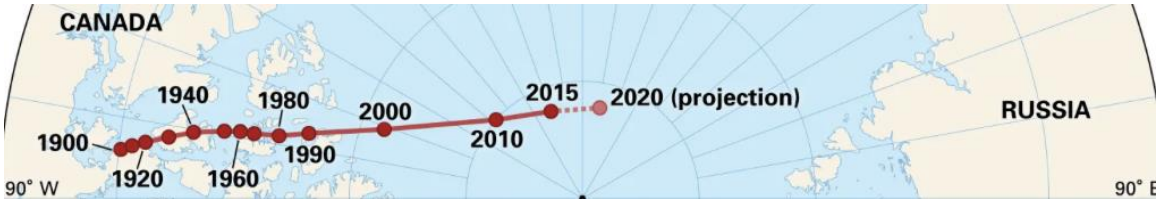


Figure 6.2—Map shows declination of the compass in North America.

Shifting Magnetic North

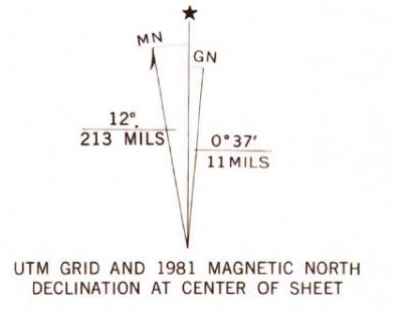
Magnetic north continues to shift. During the 20th century, magnetic north shifted north an average of 10 kilometers per year. More recently, magnetic north has been shifting about 40 kilometers per year.



Magnetic Declination on USGS Topo Maps

Every USGS Topo map shows three types of North: True or Geographic North (★ for North Star), Magnetic North (MN), and Grid North (GN). You can ignore Grid North for Road Scholar.

From USGS Jersey City, NJ 1967: Same place as Henry Hudson but 358 years later-



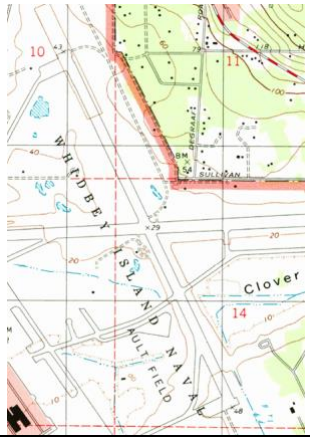
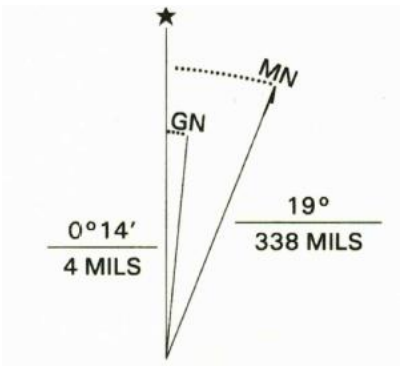
The declination, or difference between True north and MN, is 12° West of True Geographic North. You can ignore the MILS for Road Scholar.

Problem # 1: In the center of the Jersey City Map, how far away from true North, and in what direction, will a compass point? 12° West of North

On the declination diagram, the star shows Polaris, or true north. In this case MN is 12° west. That's close to Hudson's estimate of 10° West of North- especially allowing for 358 years of magnetic pole wandering.

Problems involving Declination

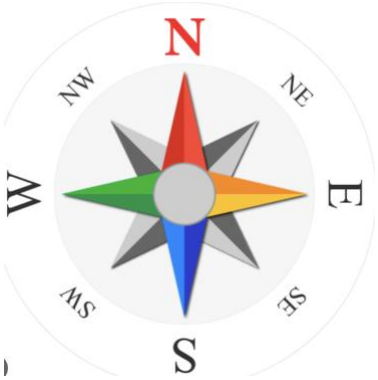
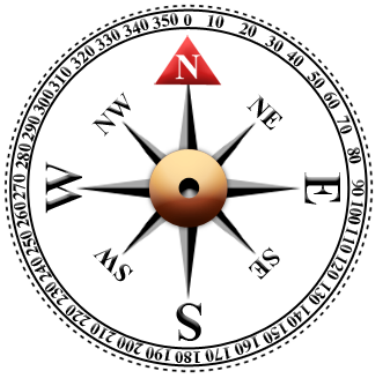
USGS Oak Harbor, WA 1998: *Story- Aircraft approaching a runway. As we near Whidbey Island Naval Air Station from the Northwest, the air controller tells our pilot how to approach the runway.*

Mapscan Whidbey Island Naval Air Station	***Magnetic Declination***
	

Problem #2 : If the pilot is going to allow for magnetic declination in using her compass, she must check the map. What is the magnetic declination at the center of the map area? Express your answer as degrees and direction from true North. **19° East of North**, reading from the map's declination diagram. Airport runways are a common source of declination or azimuth questions because they are easy to find, nice, straight lines. Actual runways always have the azimuth painted on both ends in a shortened form.

Azimuths

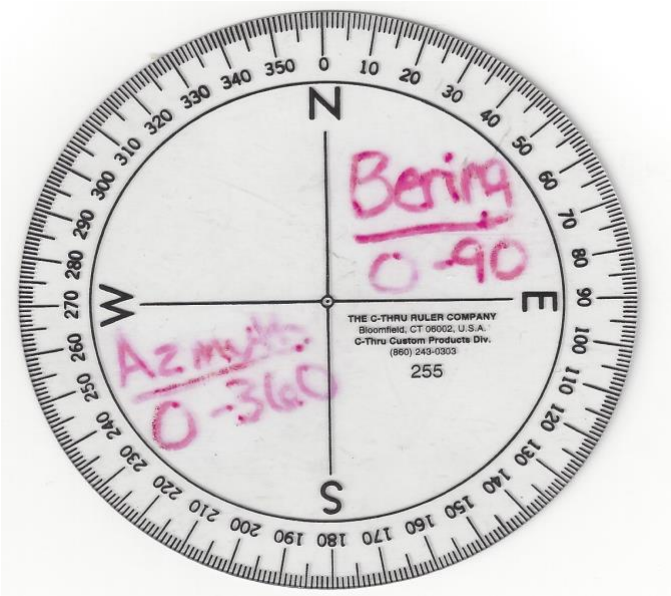
Azimuths and bearings are both ways of expressing the compass direction from you to another place. Azimuths are more common today and are all numerical; bearings are an older way of saying the same thing and always use a combination of compass points numbers. Azimuths are expressed as a degree value from 0° to 359° (360° is the same as 0°).

Compass Rose With Directions	**Compass Rose With Direction and Azimuths**
	
N, S, E, W are the most basic, or cardinal, directions	**Azimuths run clockwise from 0° to 359 °. 360° is the same as 0°, so it does not show.**
Intermediate points are NE, SE, SW, NW	**Intermediate azimuth values can be given as decimal degrees, example 35.7°, etc.**

Measuring Azimuths and Bearings on a Map

To measure azimuths on a map you need a protractor. Full circle protractors are best. The starting point for Azimuth is wherever you are, or whatever point on the map is designated. That is the center of the compass or protractor. The azimuth is the direction to another specific point. In a Road event, the hardest part of measuring an Azimuth is making sure that 0° degrees on your protractor is aligned with North on the map and held steady while you make your degree reading. You can accurately measure angles on Mapscans in Scilympiad Events. Although the size of images will vary from one computer screen to another, the angles will hold true. The azimuth from the target point back to you will be opposite.

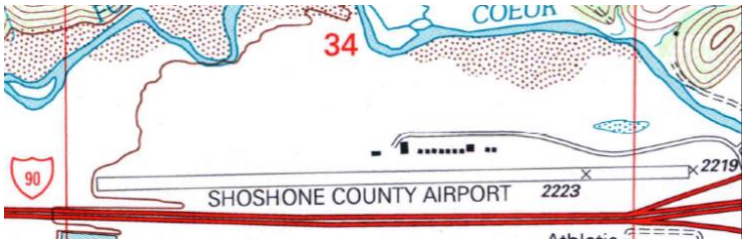
Circular Protractor *(Thanks to the kids who left this nice protractor behind at an event!)*



Problem # 3 : Suppose you are standing directly in the center of the compass and walk due East. What is your azimuth? 90° (Note there is no N, E, S, or W.)

Problem # 4: Suppose you are standing directly at the 90° mark and walk due West. What is your azimuth? 270°

From USGS Kellogg West, ID 1996:



Problem # 5 :The pilot tells us we are approaching Shoshone County Airport from the West. What Azimuth should she use to line up with the runway?"

88° (range 84- 92) (Google Earth = 88.59) Place a piece of blank paper on the runway. Find a reference like a map border (neat line) and use it to line up North on your protractor, then read the runway Azimuth.

Problem # 6: See Oak Harbor, WA1998 above:
What Azimuth must the pilot use as she approaches the runway? Remember, she is headed Southeast on her approach. 155º (range 152 to 158) not counting declination; this question did not ask about it. Aircraft take off and land facing into the wind. Because of this, runways ordinarily have two azimuths so air traffic controllers can guide pilots depending on which way the wind is blowing. Actual runways have the approach azimuth painted on both ends in a shortened form. If approaching this runway heading Southeast, the azimuth is 155°; if approaching headed Northwest, it would be 335°.

If a question calls for you to measure an azimuth and allow for declination:
A West declination is added to the measured value. If you were in New York Harbor with a declination of 12° West were steering a course of 183°. the magnetic course would be **195°**

An East declination is subtracted from the measured value: in Oak Harbor above, the magnetic azimuth is 155°- 12° = **143°**

It may help to remember an old saying: "West is best (add), East is least (subtract)"
Electronic devices like i-Phones and GPS units figure directions on satellite positions rather than magnetic compass needles, so you do not have to compensate for declination.

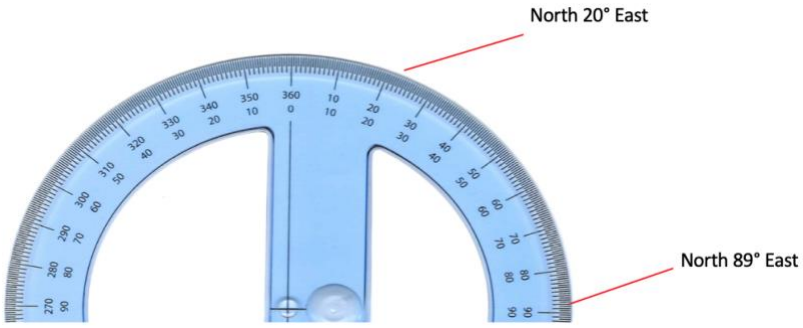
Compass Bearings

Azimuths and bearings are both ways of expressing compass direction from you to another place. A compass bearing is an older way of saying the same thing as an azimuth, but always use a combination of compass points and numbers. Azimuths are used for airplane navigation and commercial shipping. Compass Bearings are used in property surveys in the eastern US, and often in traditional sailboat navigation.

Compass Bearings are expressed in two parts:
1. Are you going further North or further South?
2. How far away from exactly North or South?

Examples: assume you are in the center of the circular protractor below:
1. **Bearing North**: For an Azimuth of 20°:
   a) you are going further North than South, so the first part is **North.**
   b) you are not going exactly north; you are going **20 °to the East of North**.
   The compass bearing for this becomes **North 20° East**

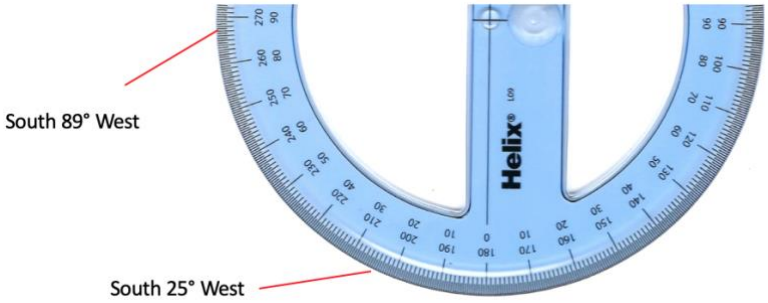
2. If you repeat this for an azimuth of 89°, the compass bearing will be **North 89° East.**



Bearing North

3. **Bearing South**

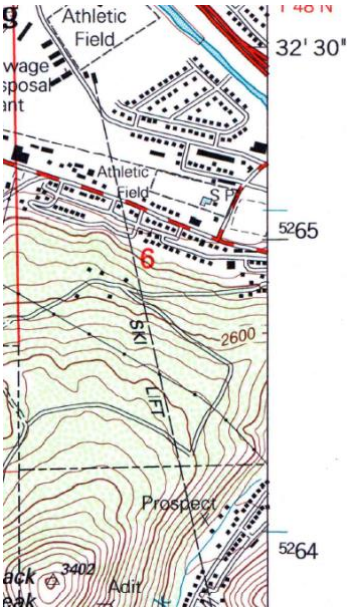
If you want to follow an azimuth of 91°, things change. You are no longer going mostly north; you are going mostly south. An azimuth of 91° becomes a bearing of **South 89° East**



Problem # 7: What is the compass bearing for an Azimuth of 269°? South 89 °West

Problem # 8: What is the compass bearing for an Azimuth of 205°? South 25° West

Reading a compass bearing on topo map- From USGS Kellogg West, ID 1996:



Problem # 9: What is the Azimuth of the ski lift from the Ski Lift Base House towards the Southeast?
167° (Range 164° - 170°) The Eastern neat line provides a N-S line for measurement of the Azimuth. Google Earth has this as 167.3°.

Problem # 10: What is the old-fashioned compass bearing of the ski lift from the Ski Lift Base House towards the Southeast?
South 13° East (Range South 10- 16 East)
This problem is from a Pandemic Event run on Scilympiad. Since Scilympiad shows up on your computer screen in all different sizes, you cannot do direct measuring of distances. However, changing the image size does not affect angles and you can measure angles with good accuracy. This problem was set up so that students could use the neat line map edge for a North-South Reference, so it is easy to align the protractor.

The following problems are from actually from a college class exam for aspiring teachers:

Assume that you have just graduated from college, the job market in teaching is terrible, your loans are due, and you have decided to become a pirate to make ends meet.

You go to Wall Street, where all the famous pirates hang out. You take lessons to talk like a pirate. You do so well that Captain Jack Sparrow, the most famous pirate of them all, agrees to teach you how to steer his ship.

"Here be yer compass", sez he. "Steer as I tells ye and we'll get me treasure for sure!"

"Ye must sail on an Azimuth of 220° for two days and ye will reach the US Treasury. Ye can grab all the money in broad daylight!

Problem # "Draw yer azimuth on the compass or ye will end up a substitute teacher instead of a pirate!! "

Problem # 11: "Now tell me what compass bearing ye must steer to bring it back!"
You answer: "**Captain Sparrow, me Azimuth (that's me course in degrees) on the way back will be 40°** "

Problem # 12: "Real pirates use compass bearings. What's yer bearing on the way back?
Your answer: **"Aye, Captain. Me bearing is North 40°East! Argh"**

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 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 actual size on an 8.5" x 11" sheet of paper.