Land Navigation IV
Map and Compass

Unit 12, Land Navigation IV. Map and Compass.
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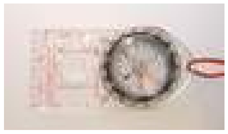
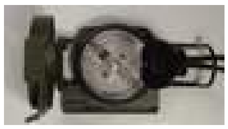
Compasses

Lets look at compasses – many different sorts, with advantages and disadvantages of each.

Compasses

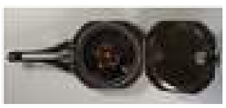


- Orienteering/Baseplate
  - Good backup



- Lensatic
  - Can't set declination

- Orienteering/Baseplate & Mirror



- Pocket Transit
  - Too expensive – more than needed.

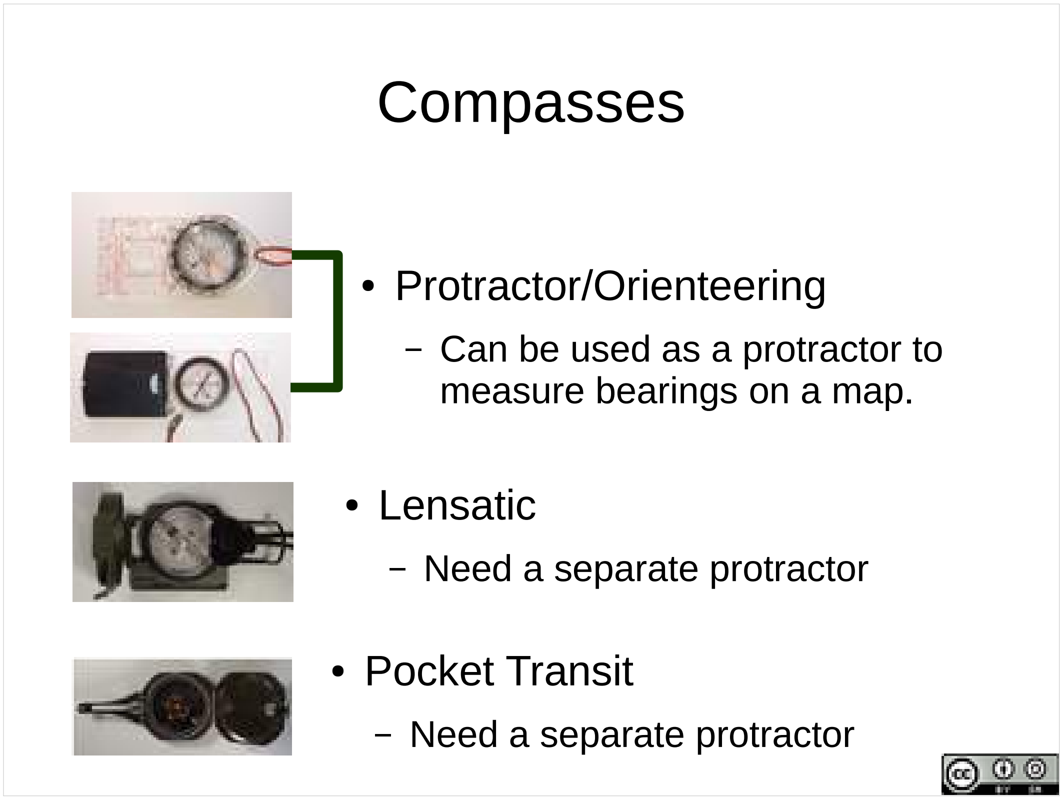
Four typical styles:

Baseplate/Orienteering – good for basic navigation, make a nice backup, hard to be accurate enough with them for accurate grid navigation.

Lensatic, accurate navigation, can’t set the declination.

Baseplate/Orienteering with mirror –accurate navigation, can set declination.

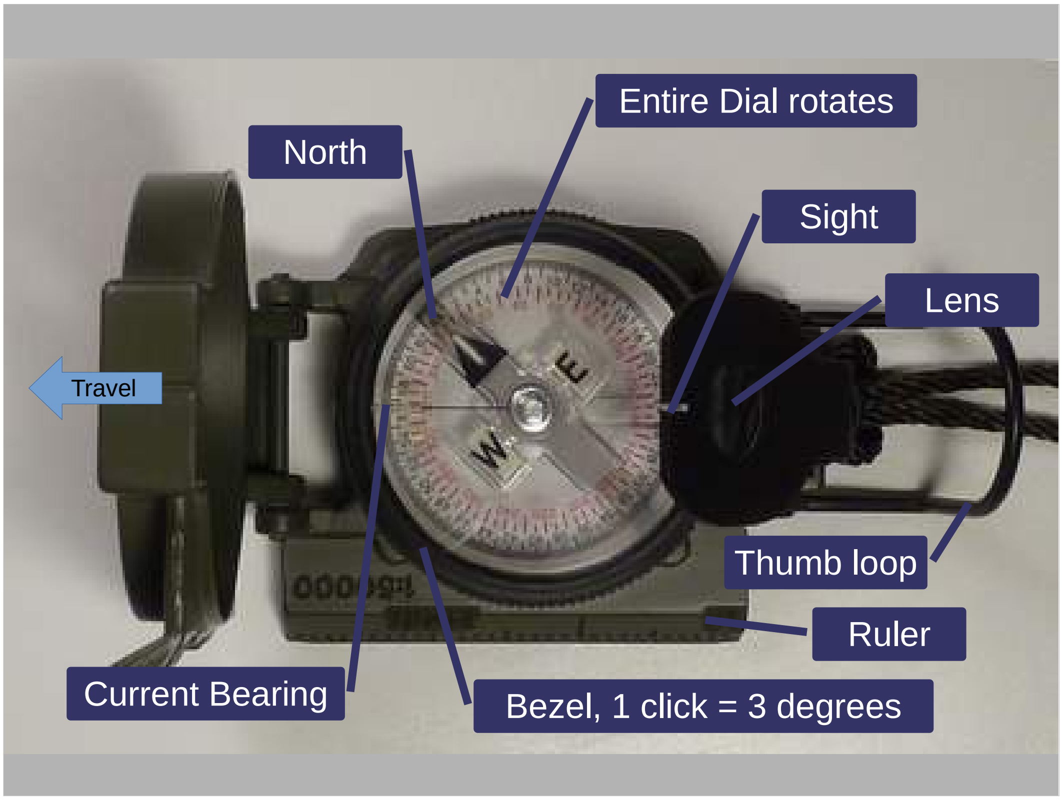
Geologist’s pocket transit – overkill.



Orienteering compasses can also be used as a protractor to measure angles and bearings on a map.

Lensatic Compass

Let’s look at the Lensatic compass.

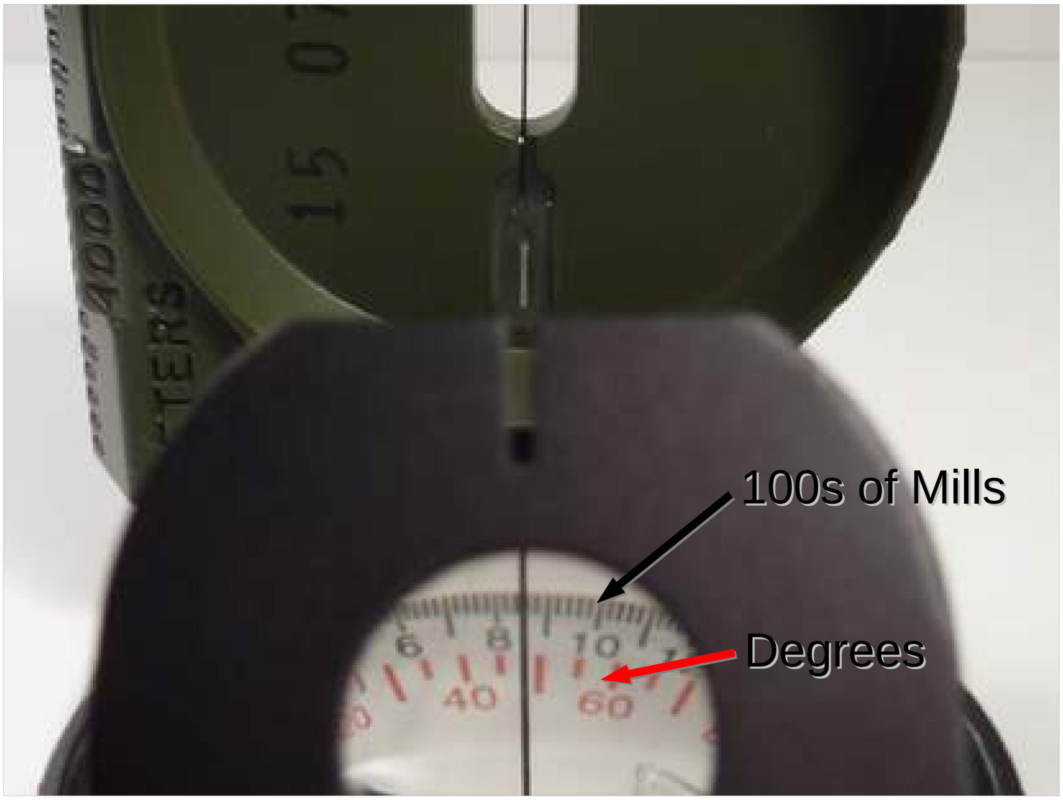


Parts of a lensatic compass

Cover and lens with sight fold up.

Entire dial with the numbers swings free and rotates, with N and 0 always pointing north..

For most accurate navigation, fold the cover and magnifier part way open, and hold up to your eye.



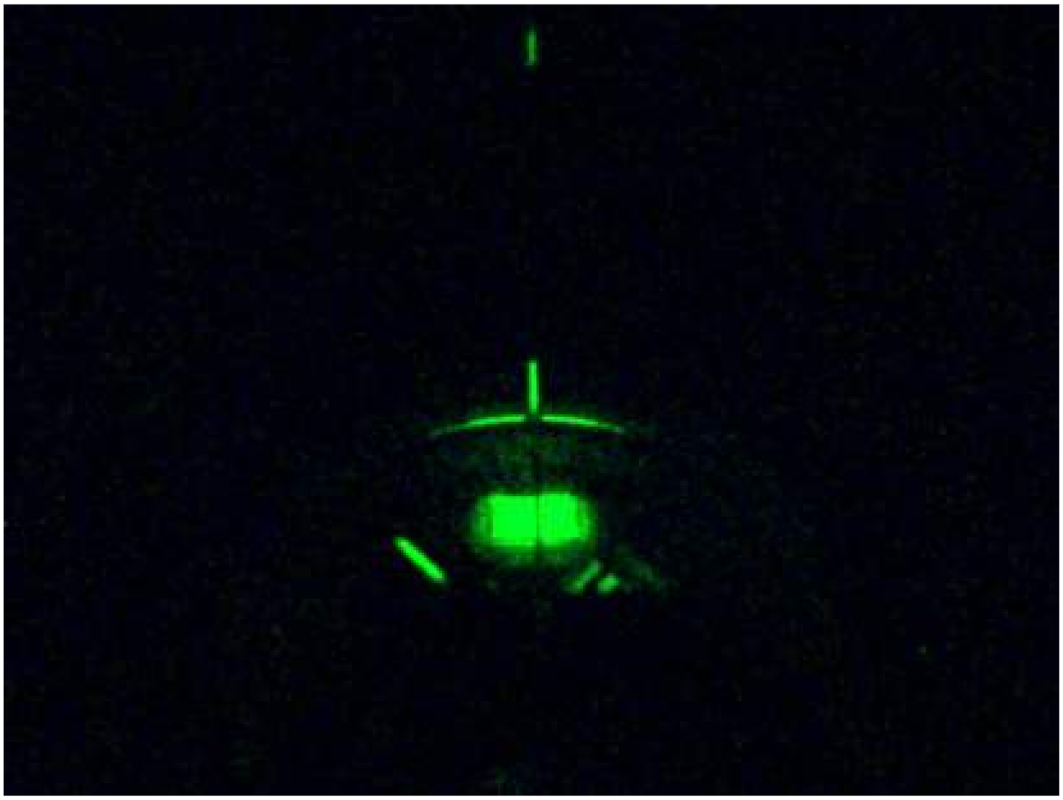
Lens lets you read the bearing on the numbered disk while you sight on a distant object.

Disk has angles marked in degrees and mills (rather, hundreds of mills). There are 6400 mills to 360 degrees, one mill is 1 meter at 1 km.

(one degree is 17.8 mills, so one degree error is about 18 meters in 1 km. 5 degrees error is about 90 meters in 1 km).

The bezel with it's line can rotate, so you need to be careful that it is lined up with the sights before reading the bearing.

Here North is off of to the left, and we are looking on a bearing of about 48 degrees.



Tritium night sights on a lensatic compass.

Let you sight at night.

Outer bezel ring clicks, one click for 3 degrees. This lets you read bearings by feel when you don't have enough light to read the numbers. Sight on target, line on bezel straight on bearing, then turn and count clicks until the line is lined up with the illuminated north arrow – multiply clicks by 3 = degrees.

Angles

- Mill
  - **one mill is 1 meter at 1 km**
  - There are 6400 mills to 360 degrees
- Degree
  - one degree is 17.8 mills
  - **one degree error is about 18 meters in 1 km**
  - 5 degrees error is about 90 meters in 1 km

Mills are useful for thinking about precision of navigation.

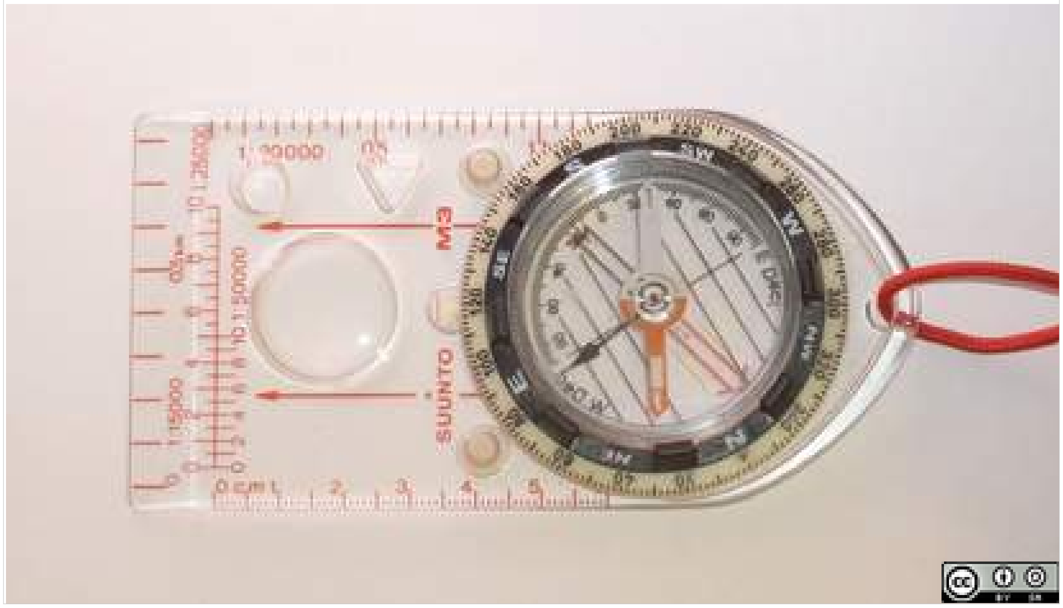
One mill is one meter at one kilometer.

About 18 mills to one degree. Thus one degree difference is about 18 meters difference at 1 km of travel.

One bezel click on a lensatic compass is 3 degrees, a navigation error of one click means over a 50 meter error in location when traveling one km.

5 Degrees error is about 90 meters in 1km, about 30 meters in 500 meters. A grid line 500 meters long with a 5 degree error in navigation will end up about 30 meters off – if your grid spacing is 100 meters, that's one third of your grid spacing...

Baseplate/Orienteering Compass



Both a compass and a protractor for reading bearings on a map.

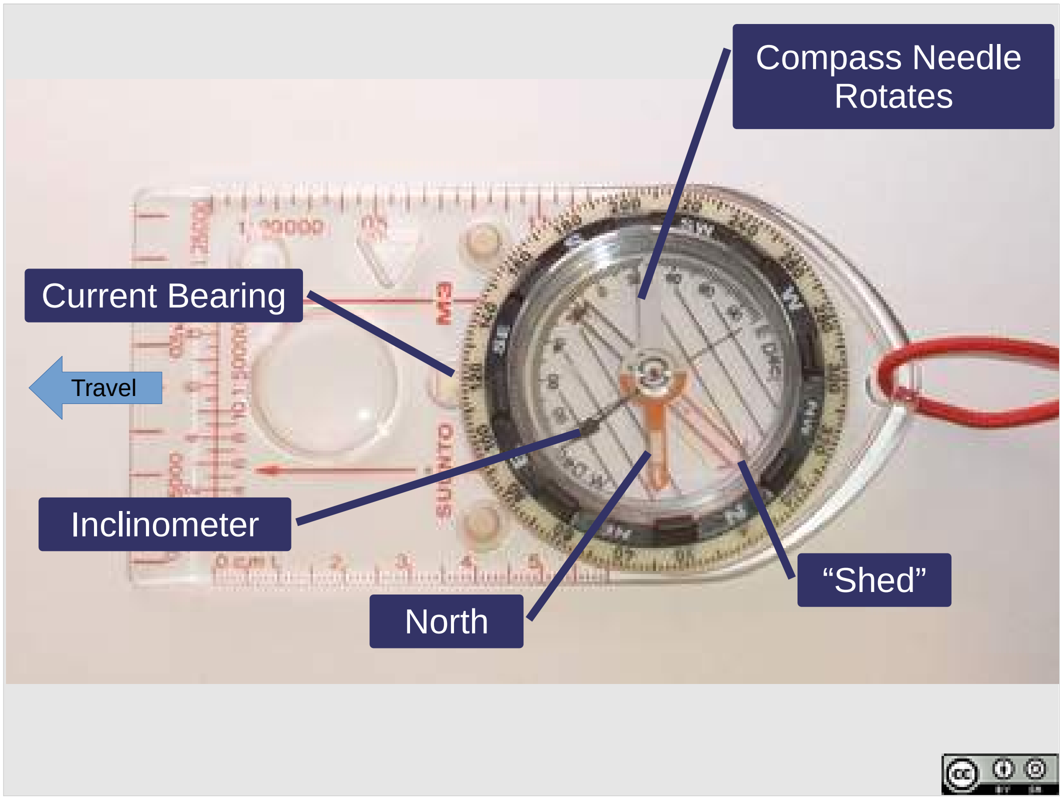
May have adjustable declination.

Good for general land navigation.

Doesn’t have sights, so difficult to use accurately enough for gridding in SAR.

Needle swings free.

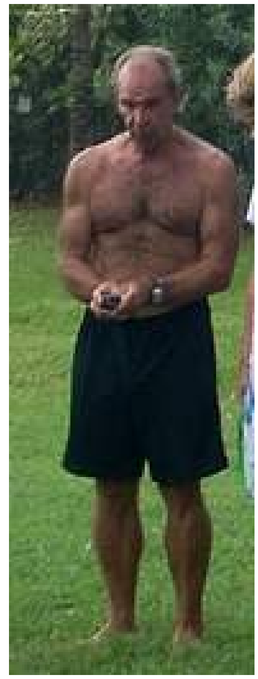
Numbers are on a separate dial you can rotate.



Parts of a baseplate compass.

Holding a baseplate compass

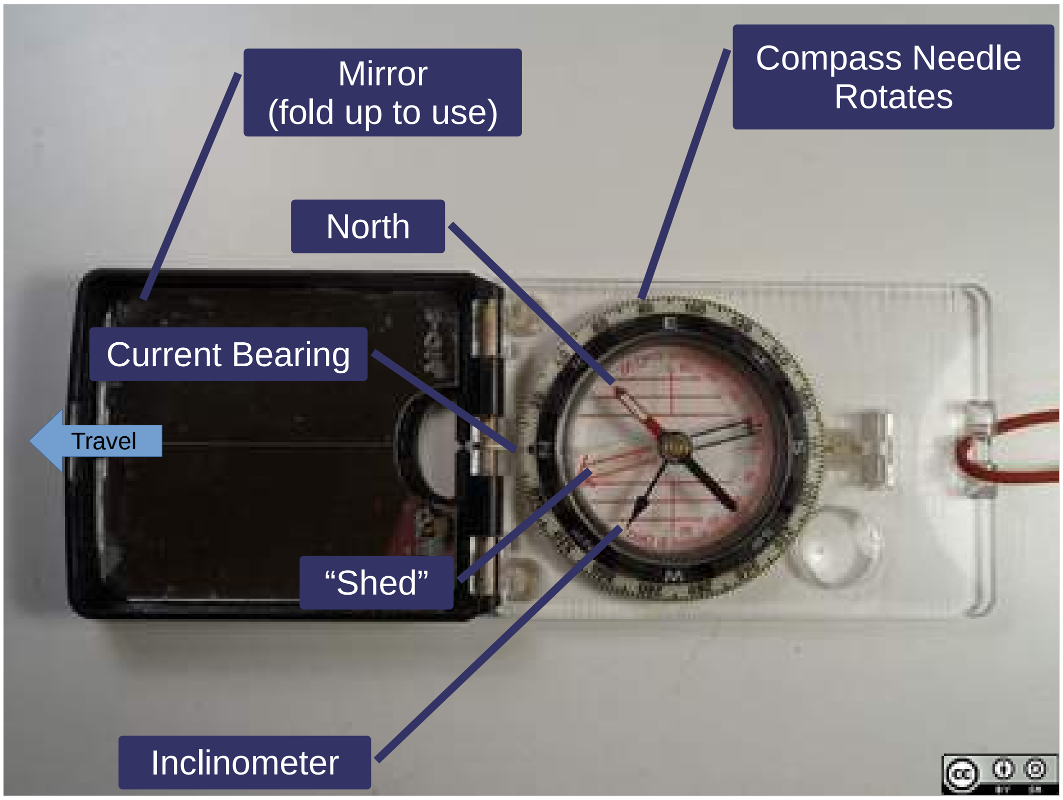
- Shoulders square to target.
- Hold at waist level.
- Look straight ahead at target.
- Look down at compass, adjust and read bearing.
- Navigating on a bearing: Move, looking at compass and target until you are square to the target.



Navigating accurately with a baseplate compass requires standing square to the direction you want to travel, holding the compass at waist level, and looking back and forth between your target and the compass.

This is a dive instructor in the USVI demonstrating how to navigate with a dive compass – same posture is used for any compass that doesn't have sights that you have to look down at to see the compass needle.

You can also use a lensatic compass or a baseplate compass with needle this way, just less accurately than using their sights.



Parts of a baseplate compass with mirror (laid flat for use as a protractor on a map).

Most designs – mirror goes in the direction of travel.

Fold part way closed and look in the mirror, you are looking in the direction of travel.

Another design of mirrored base plate compass with the mirror folded up for navigation.

“Shed” is a black circle to contain a red N on the compass needle in this design.

Compasses get fancier and more expensive.

Geologist’s picket transit getting to be overkill for SAR.
Accurate, easy to use, durable, heavy, expensive.

To hold a baseplate compass with a mirror:

Fold the mirror part way closed.

Hold the baseplate between thumbs and forefingers, at eye level.

Sight on your target, look in the mirror to see the compass needle (and the shed).

Turn right and left to make sure that the compass needle swings freely.

Align the line down the mirror with the pivot point of the compass needle.

Rotate the dial to put the north arrow in the shed, and read your bearing.

Holding a compass

- Baseplate
  - Waist level
- Lensatic
  - To eye
  - Waist level (folded flat)
- Mirror
  - Eye level, away from face
  - Waist level (folded flat)

Reviewing: Any of the compasses can be used held at waist level looking straight down. Reasonable for travel, but not accurate navigation for SAR.

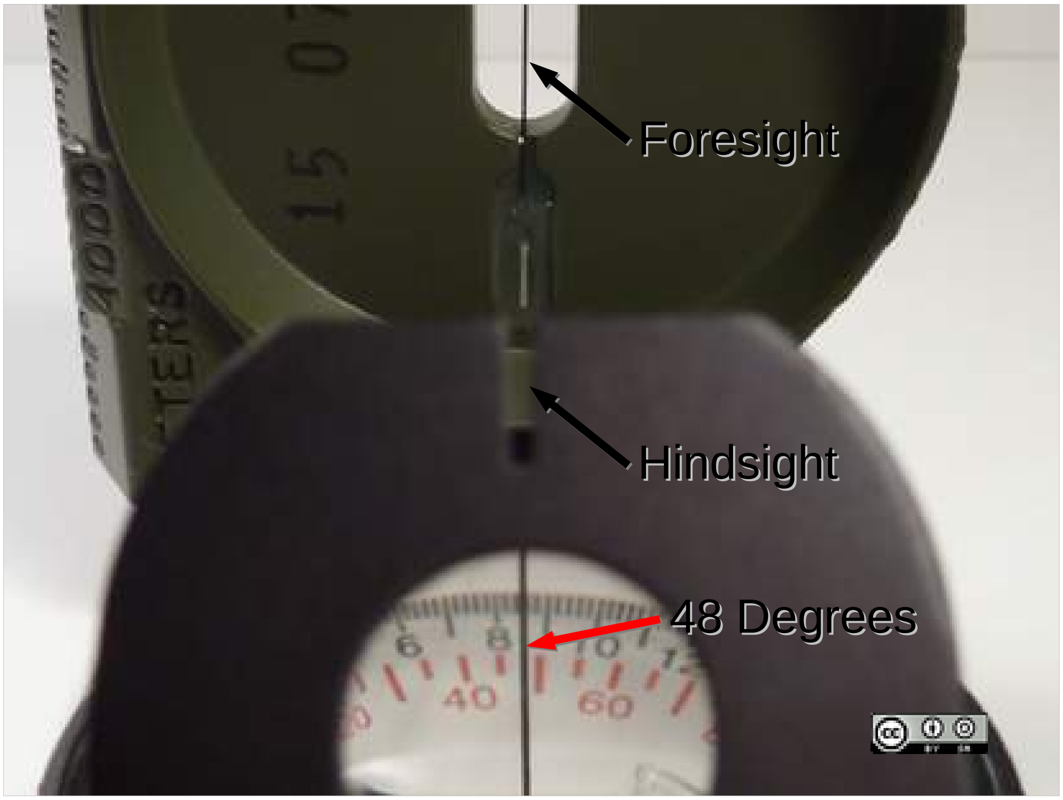
Lensatic compass, hold up to your eye.

Mirrored base plate compass, hold flat at eye level away from your face.

Be careful of where you hold your compass – magnetic objects will affect it, metal objects can affect it. In some areas, there is local natural magnetic variation, particularly in areas where there are iron ore deposits (e.g. Michigan).

Sighting and shooting a bearing

How to shoot a bearing (or travel on a bearing)

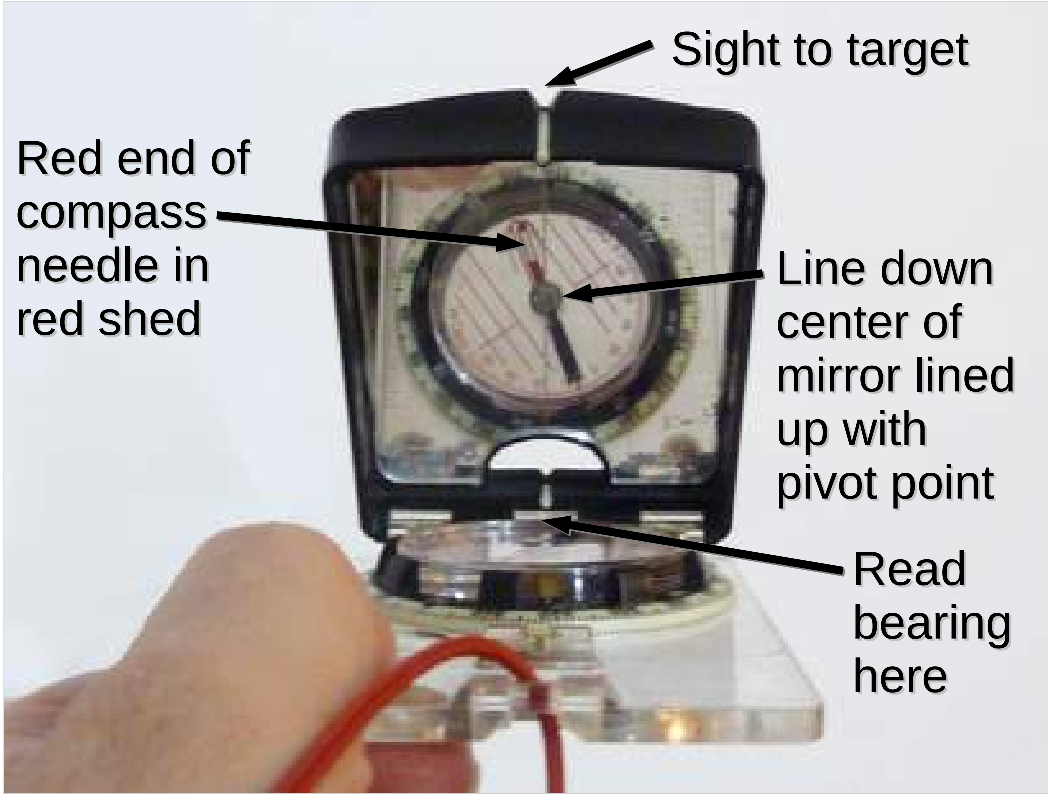


With a lensatic compass, line up the foresight, the hindsight and the thing you want to navigate towards.

Then look through the magnifier and read off the bearing.

Given a bearing, turn your head and the compass and look through the magnifier until the compass is pointing on your bearing.

Then look up and see what the hindsight and foresight are pointing at.



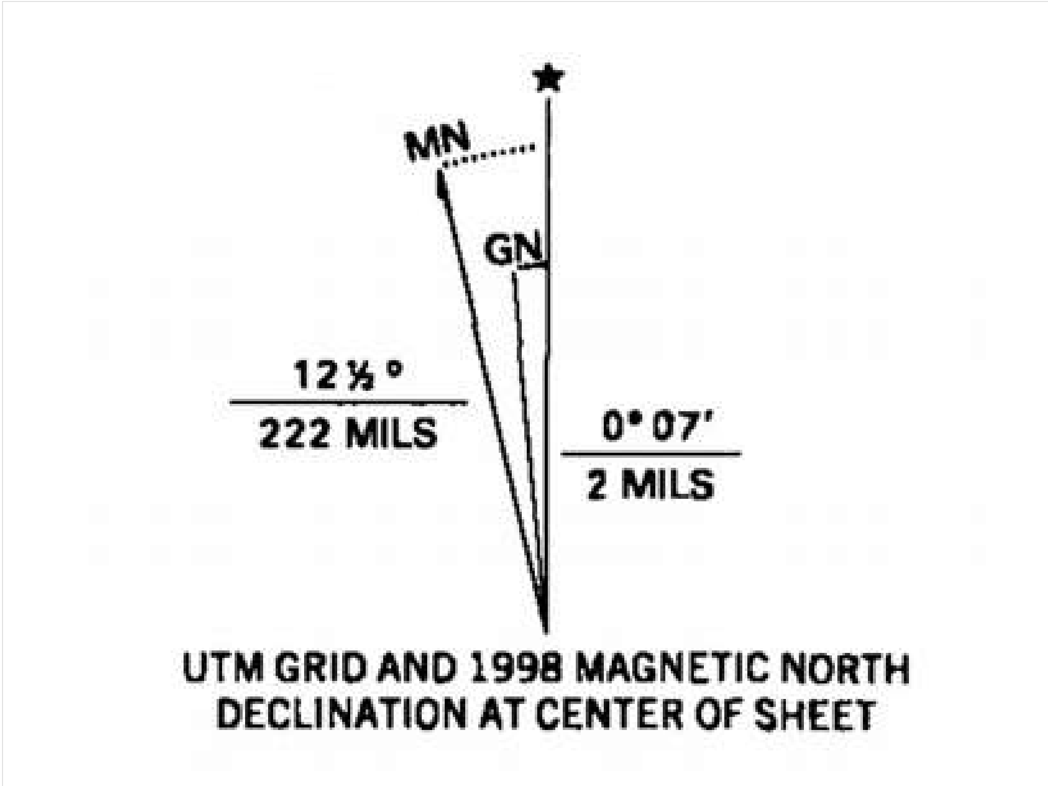
With a mirrored base plate compass, hold level (move side to side to make sure the needle swings free), line up the line down the middle of the mirror with the pivot point of the compass needle.

Sight on the thing you want to navigate towards (sighting here on either the top or bottom sight).

Rotate the dial to put the red end of the compass needle in the red shed.

Make sure that everything is level.

Now look at the direction of travel end of the dial and read off the bearing.



How do you account for declination?

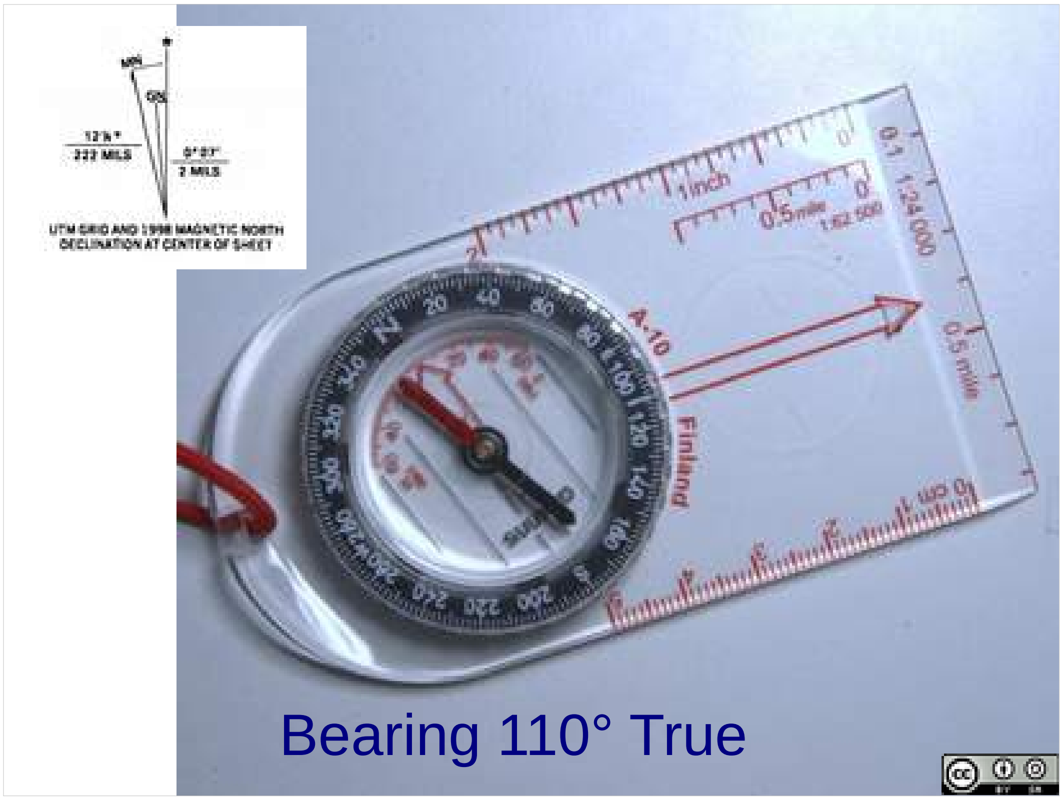
Declination & Adjustable Compasses

- Ignore it (OK if near agonic line)
- Do math (Correct for declination)
  - Everyone in the field works with magnetic north
  - People at base do the math, communicate magnetic.
- **Set declination on compass**
  - **Everyone works with true north**
- Mark magnetic north lines on map
  - Everyone works with magnetic north

With an adjustable compass, these are our choices:

Some base plate compasses aren't actually adjustable for declination, but have a declination scale on either side of the red orienting box (shed). Here the north end of the compass needle is in the red shed.

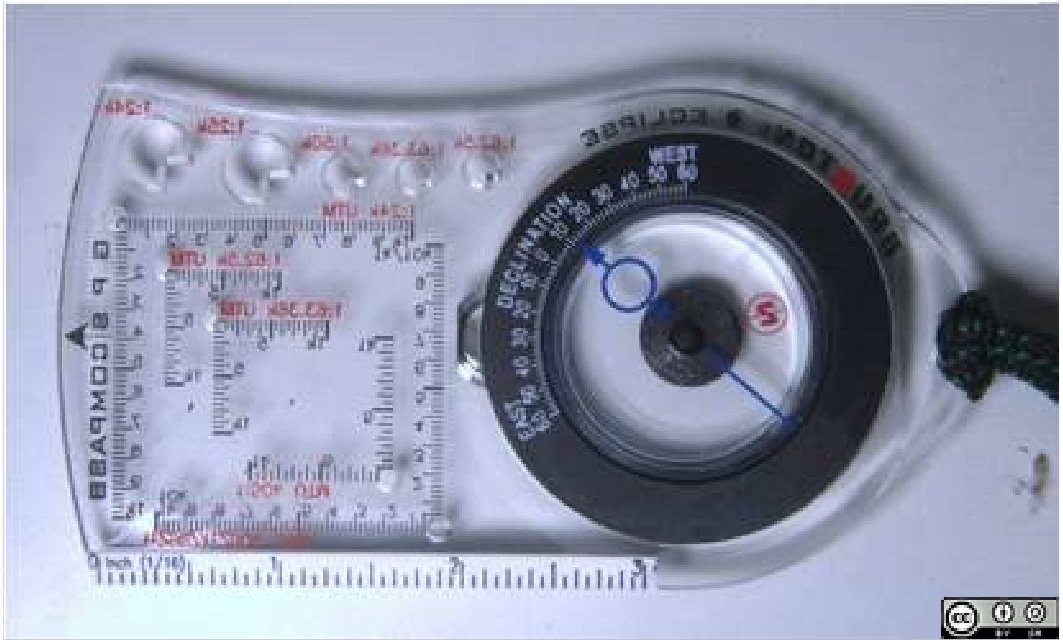
The bearing (at the direction of travel end of the dial) is 110 degrees, thus 110 magnetic.



Here we don't have the red compass needle lined up with the shed, we have it line up at the 15 degree west of north angle next to the shed.

Bearing at the travel end of the dial is 110 degrees, but we've accounted for the declination, so this is 110 true.

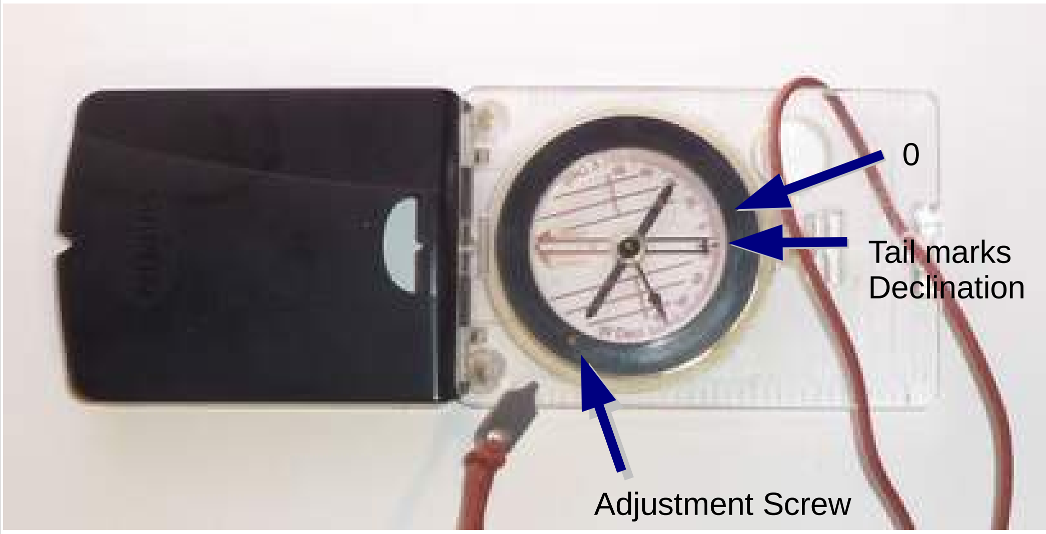
Declination Adjustment



Declination may be adjustable, rotating a pointer on the orienting box against a declination scale. Here, the declination scale is printed on the bottom of the bezel, and the N arrow on the orienting box/circle points to the declination.

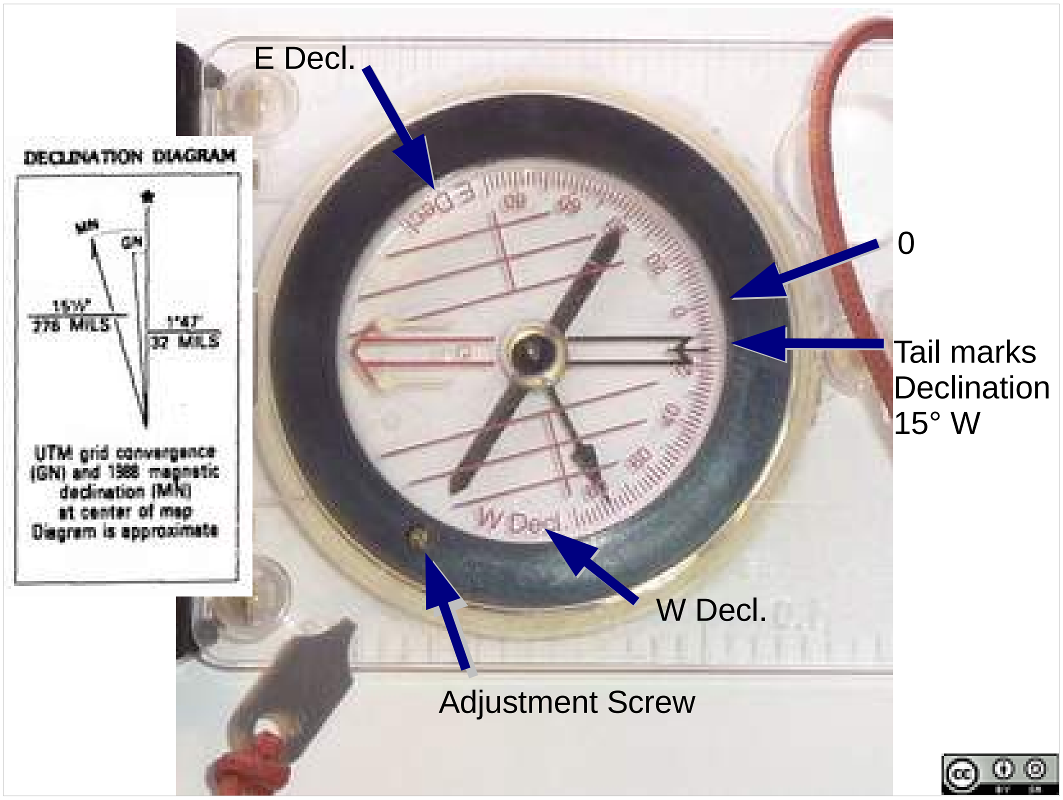
Adjustment is a friction fit in some compasses (press the capsule with the compass needle in it between thumb and forefinger and twist the bezel)

Declination Adjustment



Mechanical adjustment screw in other compasses.

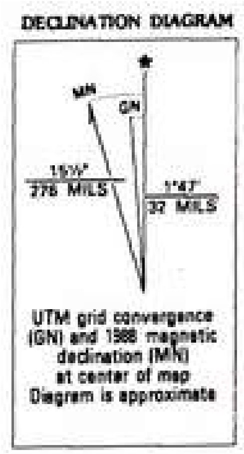
Here the tail of the orienting box (the black end of the shed) points to a declination scale marked in degrees E and W declination.



Closer view, screwdriver on the lanyard is used to adjust the declination.

Compass here set to a 15 degree west declination.

Sanity check



Is magnetic north west of true north?

With a 15 degree declination dialed into this compass, does it say that the same thing as the declination diagram?

Does the declination diagram say that magnetic north is west of true north?

Does the compass agree?

What bearing is this compass set for?

What if you can't set the declination? (as when using a lensatic compass)

Two choices – do math, or put a magnetic north grid on the map.

Declination & **Lensatic** Compasses

- Ignore it (OK if near agonic line)
- Do math (Correct for declination)
  - Everyone in the field works with magnetic north
  - People at base do the math
- ~~Set declination on compass~~
  - ~~Everyone works with true north~~
- Mark magnetic north lines on map
  - Everyone works with magnetic north

Here are the choices – everything but setting the declination on the compass.

Do Math

- **Map to compass – West, Add**
  - Bearing measured on map: 45 degrees (true)
  - Declination 15 degrees west
  - Map to compass: 45 + 15 = 60 degrees (magnetic)

- **Map to compass – West, Add**
- Compass to map – West, Subtract
- Map to compass – East, Subtract
- Compass to map – East, Add

To convert between magnetic and true:

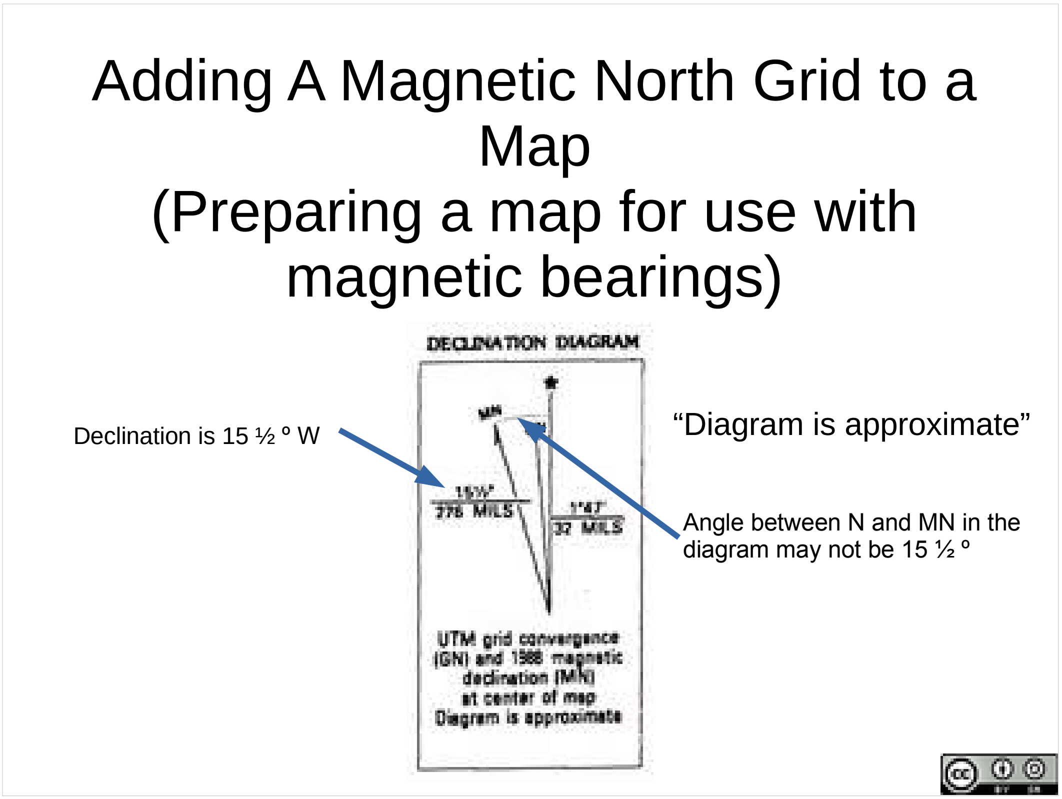
Remember: Map to compass: West, add.

Magnetic-True Conversion Handout.

Who does the math?

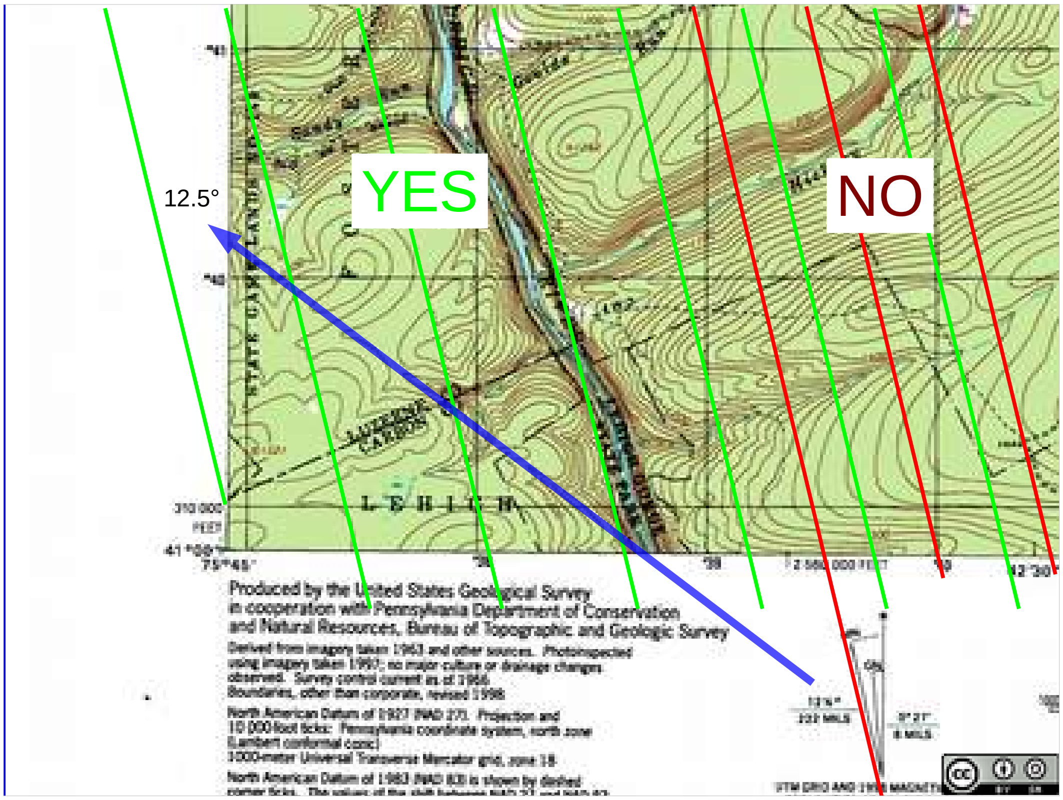
- Everyone who is moving bearings to/from a map.
  - Do math to convert between magnetic and true bearings and plots on map.
- Everyone in field works with magnetic bearings
- Radio transmissions are magnetic bearings.

Most effective way to work when compasses can’t be adjusted for declination is to put all communications in magnetic north, conversion only happens when someone needs to work with a map.



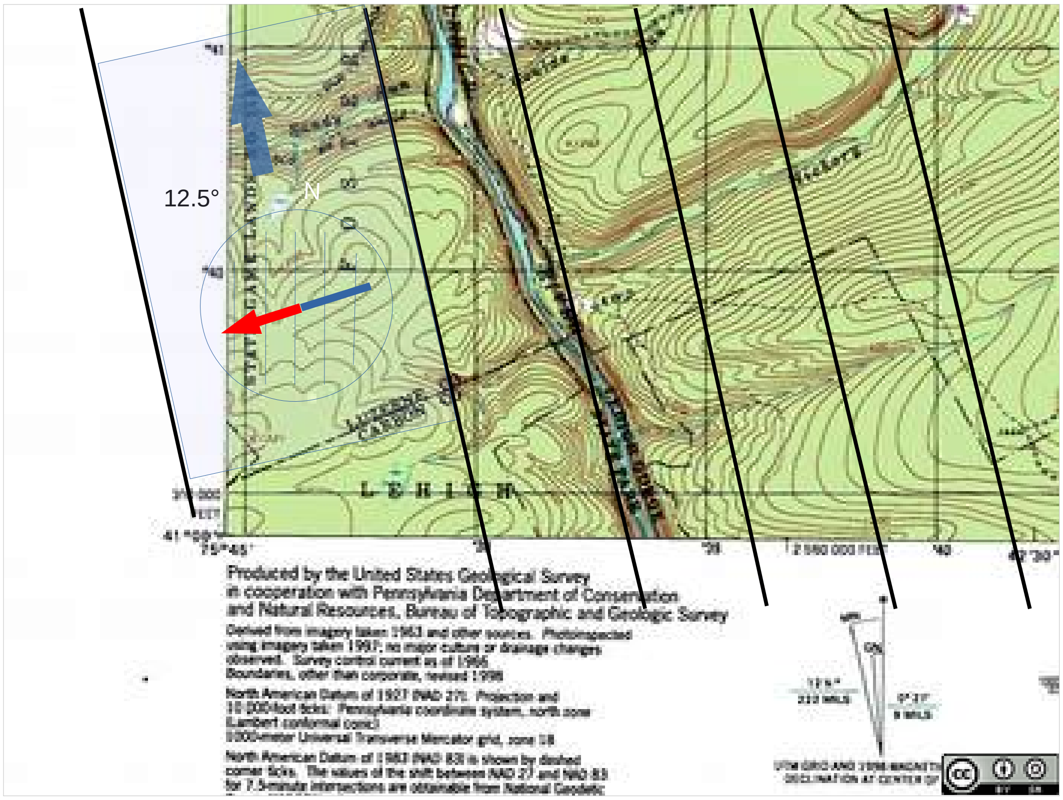
You can also mark up a map with magnetic north-south lines, and read magnetic north directly off the map.

Look at the declination diagram on the edge of the map, find out the declination angle.



Now using a protractor from the edge of the map, measure that angle, and draw lines on the map running magnetic North-South.

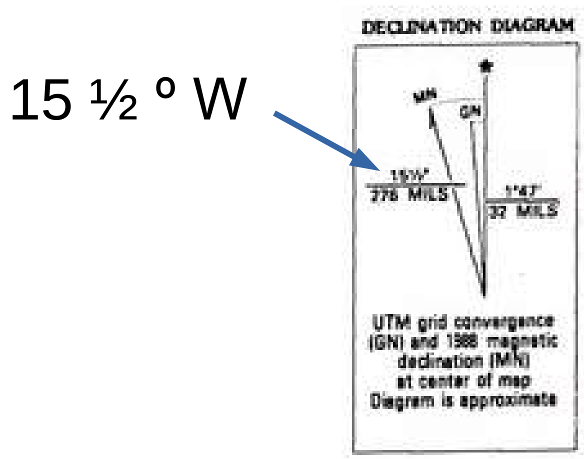
Don’t start by extending the magnetic north line on the declination diagram, it may not be accurate. Always measure the number of degrees of declination.



You can use your compass as a protractor to start the lines – set the dial to the number of degrees of declination, line up the lines on the base of the dial with the edge of the map, sanity check that the edge of the compass is lined up with the magnetic north line on the declination diagram, and draw a line down the edge of the compass.

Now you can use a ruler to draw multiple parallel magnetic North-South lines on the map.

What happens if you don’t account for declination?



Here, the declination is 15.5 degrees west of north.

If you travel 500 meters on a bearing in this area without accounting for declination, how far will you be off?

Recall: about 18mil per degree, one mill 1 m at 1km.

5 degrees, about 90 meters at 1km, 15 degrees, about 270 meters at 1 km, 15 degrees, about 130 meters at 500m.

What if you dial in the declination, but put in 15E instead of 15W? About 270 meters error at 500 meters traveled...

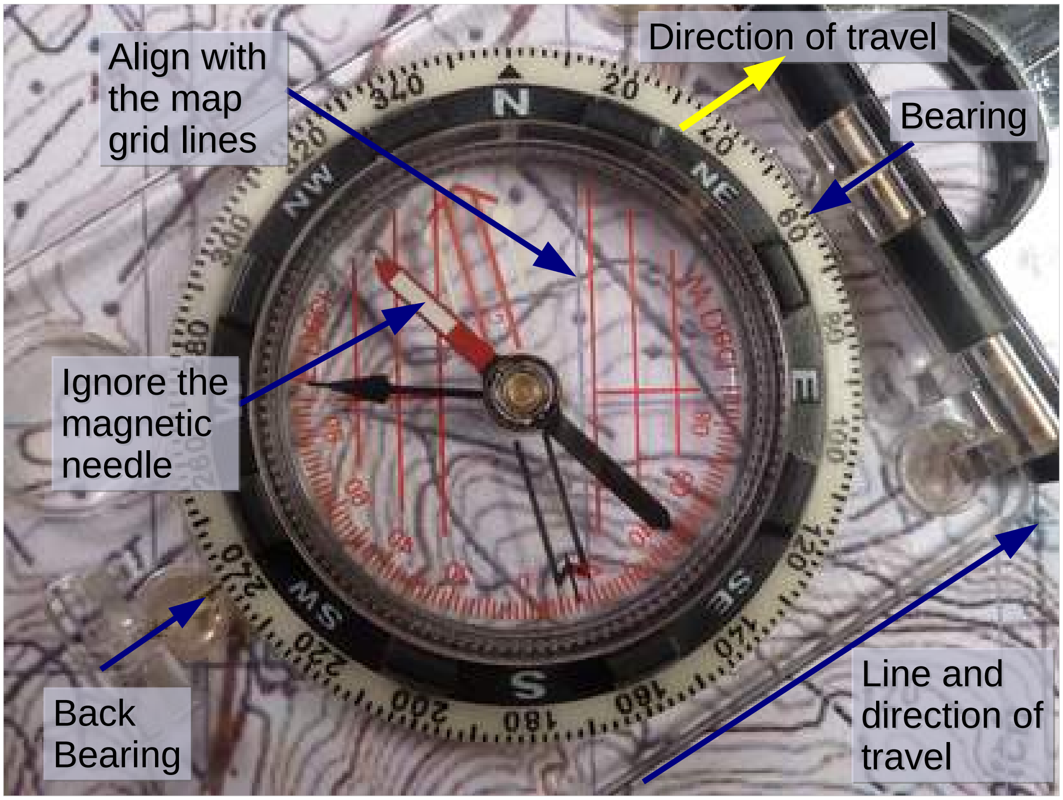
Measuring bearings on a map.

You can use your baseplate compass as a protractor to measure bearings from one point to another on a map.

Draw a line on the map connecting two points you want to travel between.

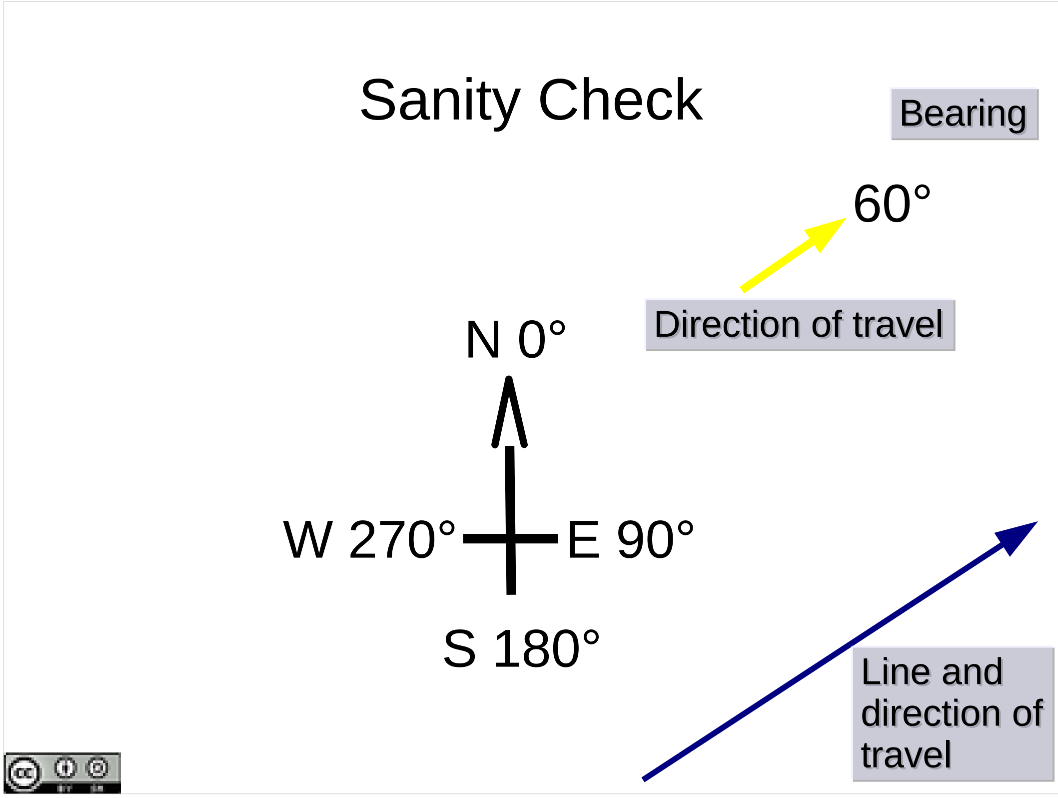
Lay the compass on the map, edge of the compass along your line, the mirror (or direction of travel arrow) of the compass pointed in the direction you want to travel.

Ignore the magnetic needle on the compass – you are going to use the compass as a protractor.



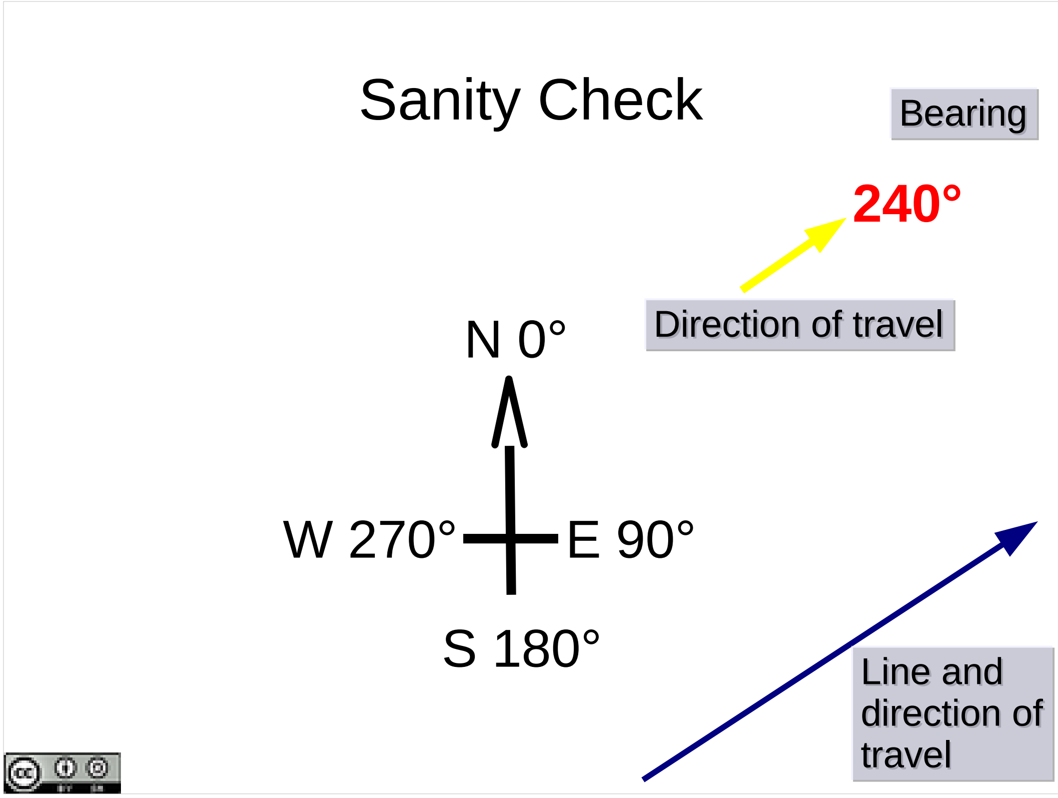
Rotate the compass bezel until the lines in the back of the dial line up with the north-south grid lines on the map.

Read your bearing off the compass – at the compass/direction of travel end.



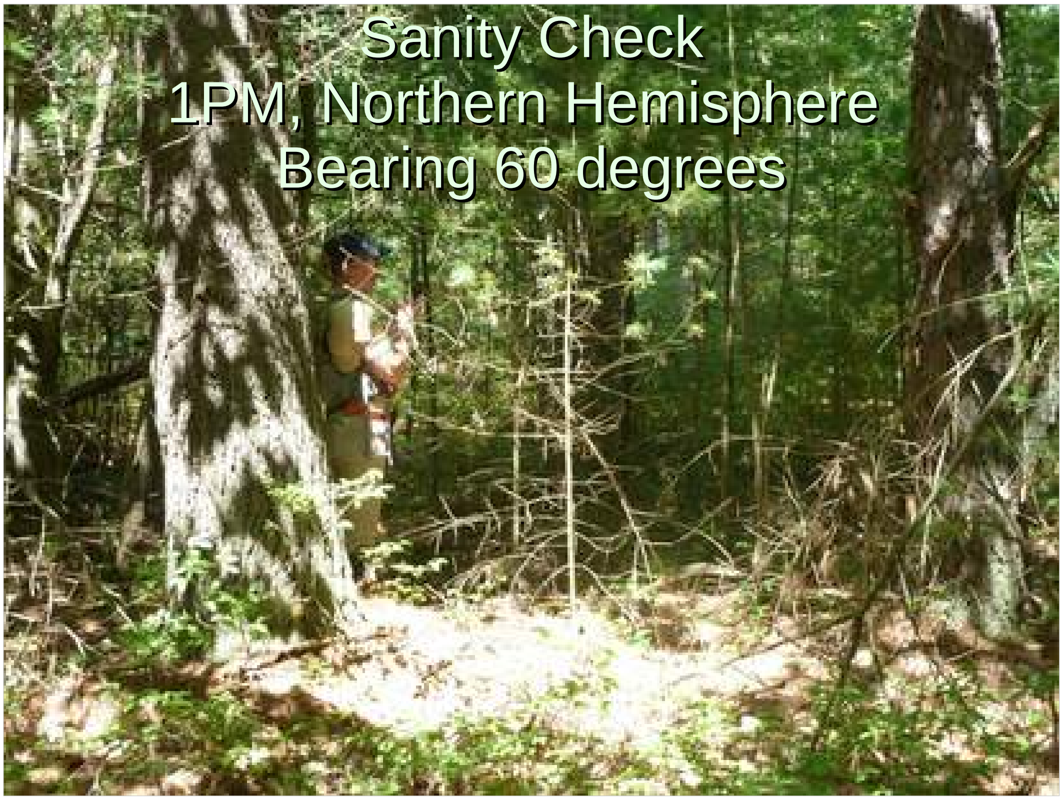
Now sanity check your results.

North is 0 degrees – E is 90 degrees. Your direction of travel on the map is to the NE.   60 degrees is between 0 and 90 degrees, so your bearing seems sane.



What happened here?

If you read the back bearing by mistake, your sanity check will flag that 240 degrees is not between 0 and 90.



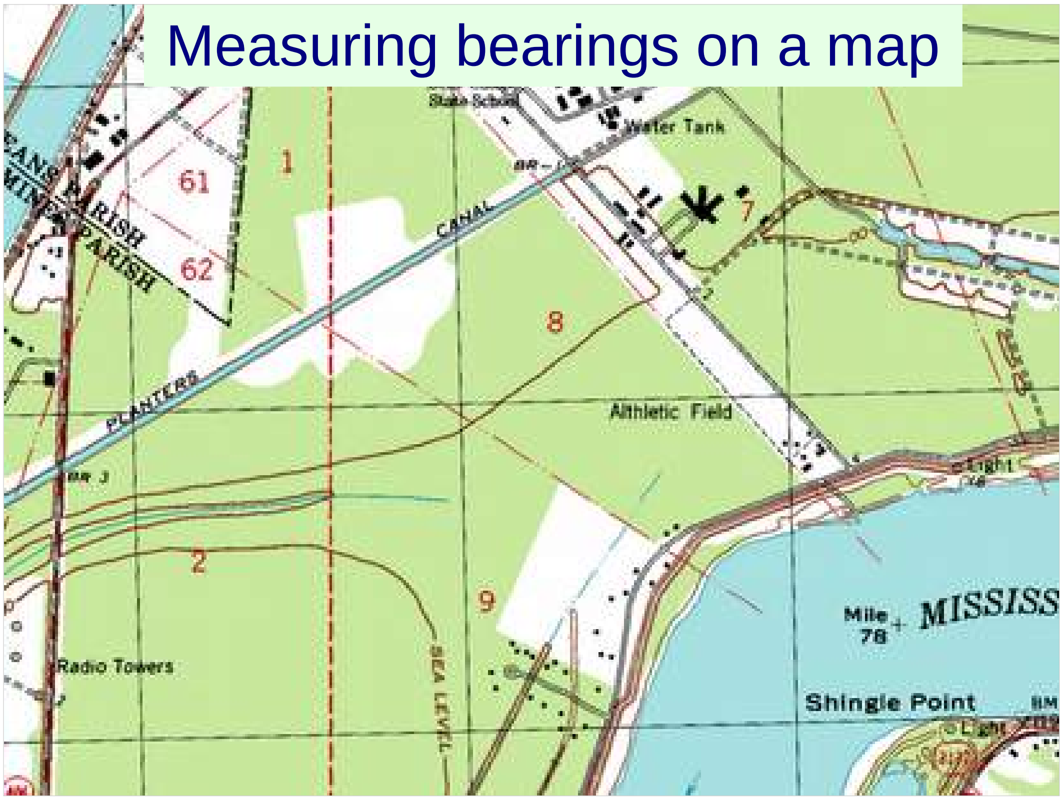
It is 13:00 in the northern hemisphere. The searcher is traveling on a bearing of 60 degrees true.

Sanity check: is she traveling in the right direction?

What can we see that tells us this?

(the sun is approximately south, she's standing at an angle of somewhere around 60 degrees off the shadow the tree is casting on her).

Measuring bearings on a map



Practical Evolution (1) Determine Bearings on map.

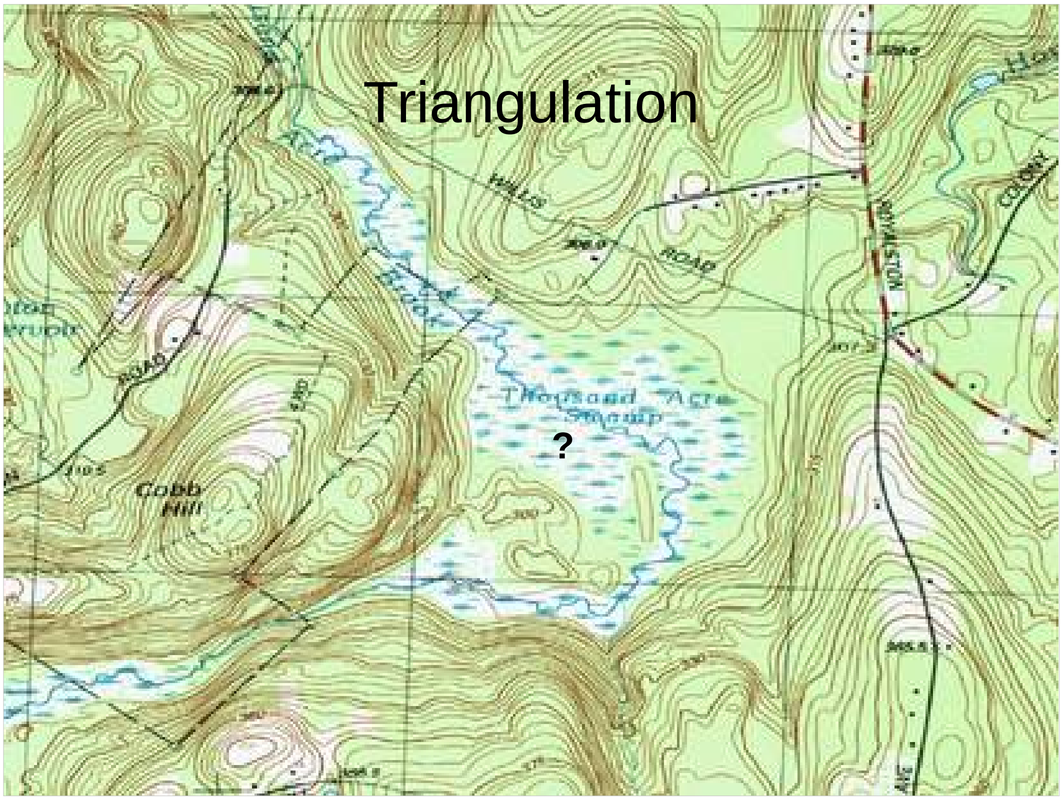
On USNG Training map:

Set declination (1 degree east).

Measure bearing(relative to true north): light on Shingle Point to the water tank near Planters canal.

Measue the back bearing (from the water tank to the light).

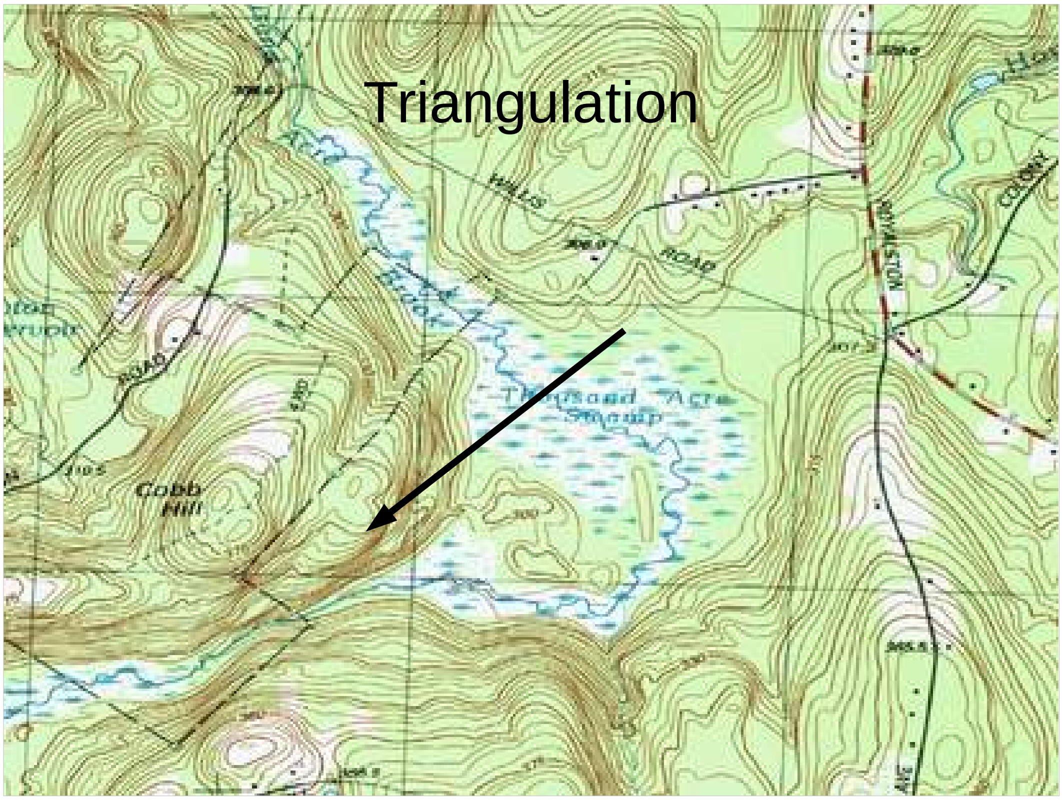
Repeat with the bearing from BR 3 where the road crosses Planters Canal to light 18 on the north bank of the Mississippi river.



I’m in the one thousand acre swamp.

Where in the swamp am I?

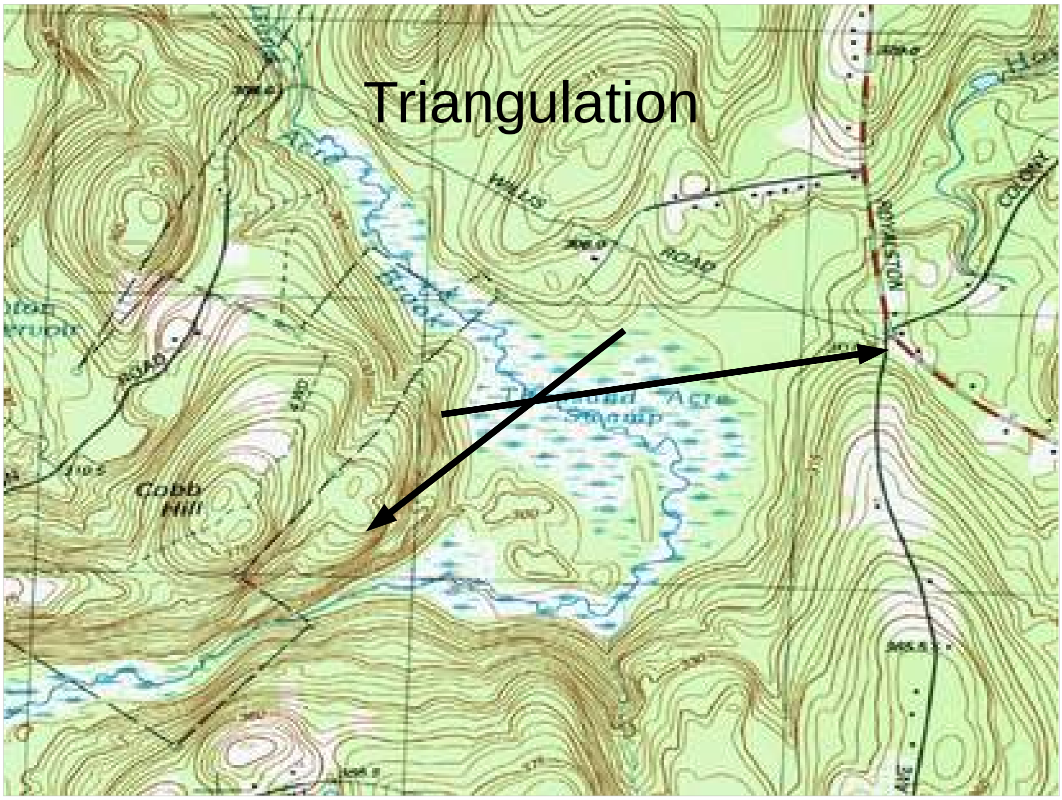
Triangulation



Pick a landmark, shoot a bearing to the landmark.

Here, 245 degrees to what you think is the top of the steep drop off on the SE corner of Cobb Hill.

Draw a line on the map passing through where you think you are and the landmark. You are somewhere on the line.

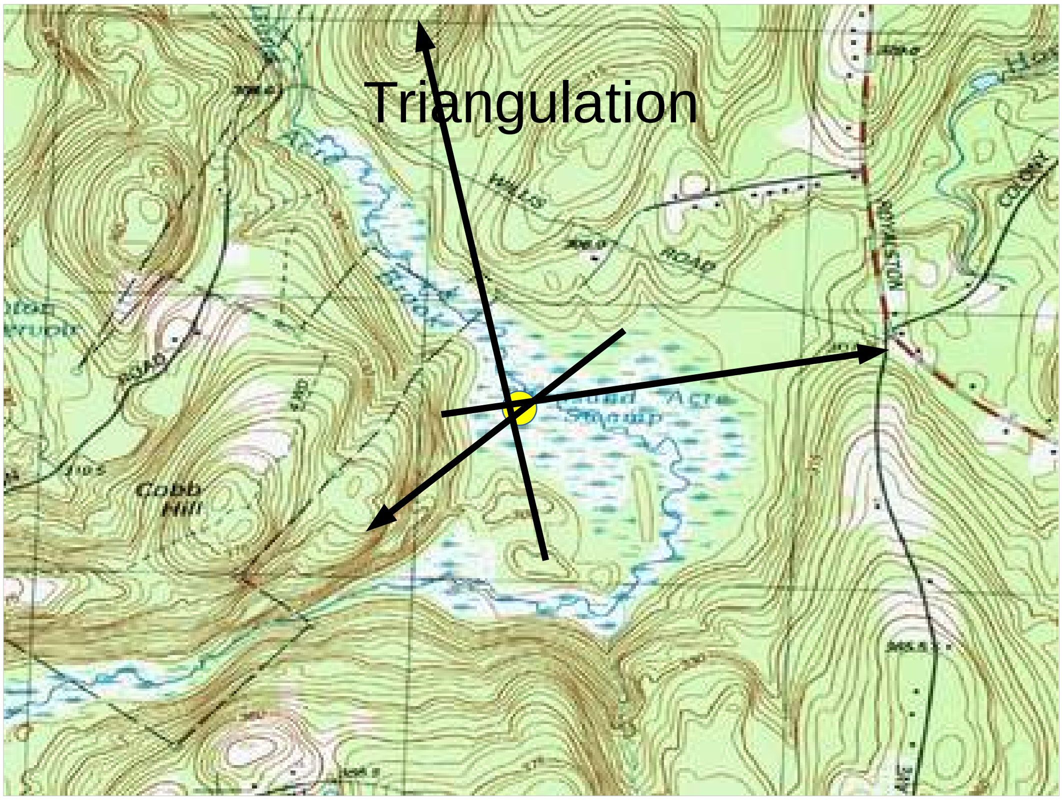


Repeat with a second landmark.

Here 80 degrees to the northernmost edge of the hill to the south east of the swamp.

Draw another line. You are approximately where the two lines cross.

Triangulation



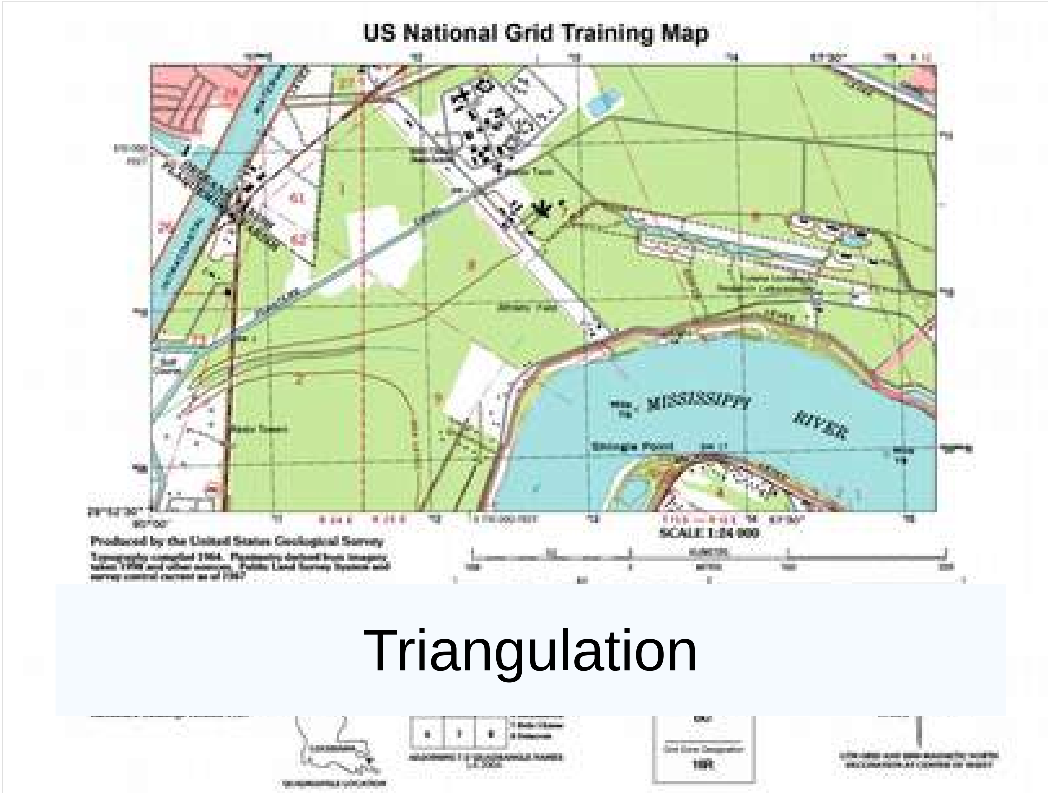
Add a third line.

Here 350 degrees to the steep sided hill North of the swamp.

You are where the three lines cross.

You can describe a location with three bearings two three landmarks.

Most accurate if the three landmarks are very specific (e.g. a Church steeple), and if the three landmarks are widely separated (about 120 degrees apart).



Exercise (2) Triangulation

With landmarks, like triangulation – locate your position on the map, then rotate the map so that about 3 landmarks that you can see are off in the same directions on the map as they are around you.

By compass: Put the map on a flat surface, align compass with side of map, dial N onto the direction of travel, adjust for the correct declination, rotate the compass until the magnetic needle is in the shed.

Don’t do this on a car hood or some other metal surface (including concrete with rebar). Why not?

Go outside and do practical evolutions 3-7
(3) Orient Map to North with a compass.
(4) Orient Map to North by landmarks.
(5) Shoot Bearing, (6) Shoot bearing and plot on map.
(7) Triangulate location.