Online Surveying FE 208
Lecture 6

The Compass and Compass Theory

Learning Objectives for this Lecture

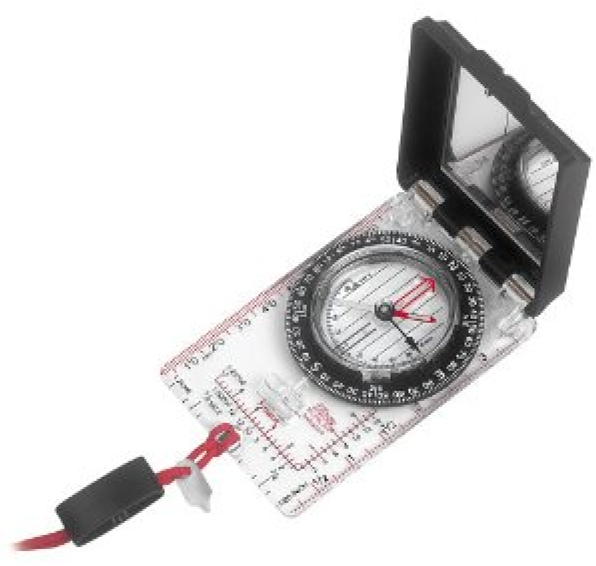
1. **Know the three main types of compasses foresters might use**
2. **Know the differences and accuracies of the three compass types**
3. **Be able to explain compass theory**
4. **Be able to explain the magnetic poles**
5. **Know the key points about the magnetic poles**
6. **Be able to explain magnetic declination**
7. **Know the main sources of variation in declination**
8. **Be able to explain local attraction**
9. **Know the procedure to recognize and correct for local attraction**
10. **Be able to do the three types of conversion problems**

Uses for the compass in modern surveying

- Blunder check against modern instruments
- Reconnaissance work
- Maintaining line
- Low order survey

Types of compasses for surveying

- Hand or pocket compass
  - Rough estimates
  - Good to $\pm$ 2 degrees



- Surveyors or Staff compass
    - Reasonable accuracy
    - Leveled in two directions over the point
    - Easy to use in steep terrain
    - Good to ± 30’

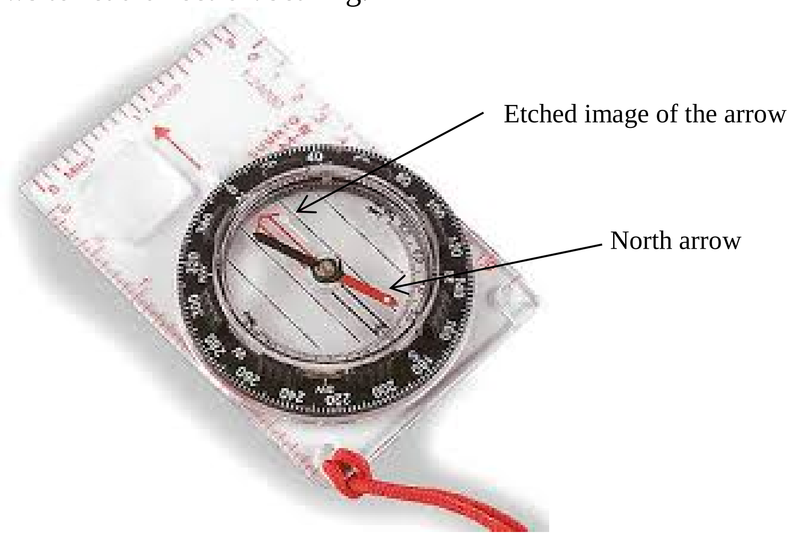
- Transit or total station
    - Leveled by use of a tripod
    - Sighting by cross-hairs
    - Good to 10” to 1”

Using the Hand Compass

It is important to hold the compass in both hands and make sure the center of the compass is pointed directly above the survey point. You can use the built-in mirror to look “down” through the compass to see that point and the center of the compass are lined up. In addition, the compass should be nearly level.

By holding the compass this way, you can use your fingers to easily turn the calibrated dial and line up the arrows to read direction/bearing.



The correct bearing is obtained by turning the calibrated dial until the north arrow (red arrow) is lined up inside the etched image of the arrow.

Using the Staff Compass

Method of Taking a Magnetic Bearing. The surveyor's compass is set up (and leveled) at same point on the line whose bearing is desired. The needle is let down onto the pivot, and the compass sights pointed approximately along the line. While looking through the two sights the surveyor turns the compass-box so that they point exactly at a lining pole or other object marking a point on the line. The glass should be tapped lightly over the end of the needle to be sure that the latter is free to move. If it appears to cling to the glass this may be due to the glass being electrified, which condition can be removed at once by placing the moistened finger on the glass. The position of the end of the needle is then read on the circle and recorded.

Since the needle stands still and the box turns under it, the letters E and W on the box must be reversed from their natural position so that the direct reading of the needle will give not only the angle but also the proper quadrant.

When the north point of the compass-box is toward the point whose bearing is desired, read the north end of the needle. When the south point of the box is toward the point, read the south end of the needle. If a bearing of the line is taken looking in the opposite direction, it is called the “reverse bearing”. Reverse bearings should be taken to check for error. The following illustration demonstrates the proper method of taking a magnetic bearing.

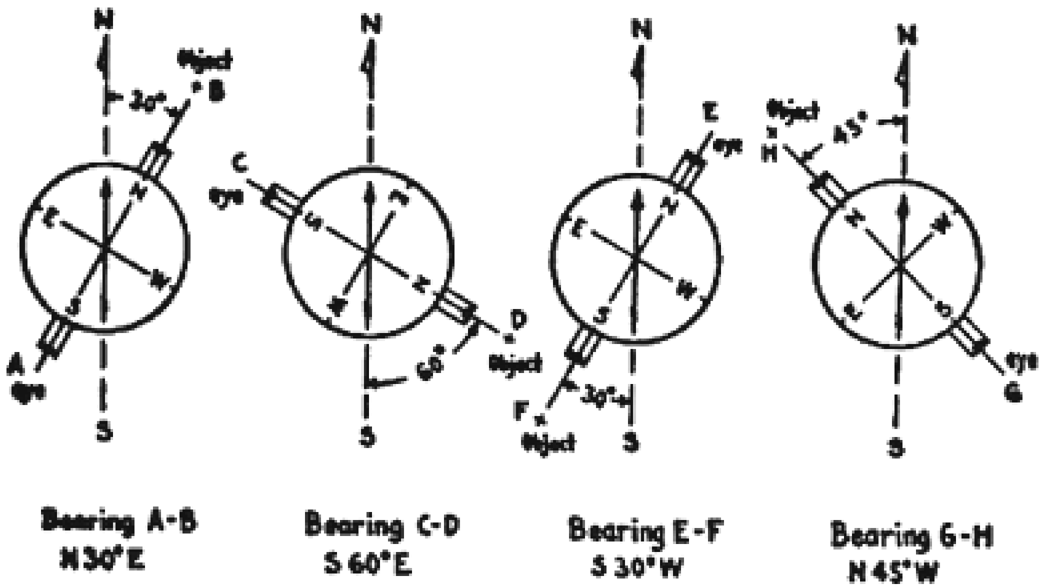


Illustration: Method of Reading Bearings

Compass Theory

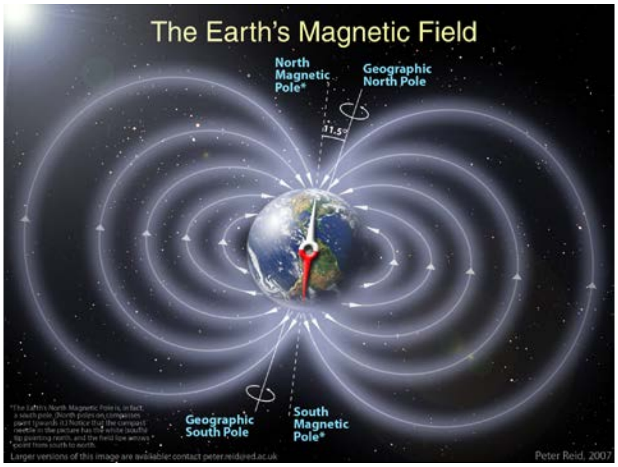
The compass consists of a magnetized needle that swings on a pivot at the center of the needle. The needle aligns itself with the Earth’s magnetic field and points to magnetic north in the northern hemisphere. ***It is very important to know that the magnetic poles are in constant movement.***

The compass needle will “dip” downwards towards the magnetic force in the area. To offset this, the needle is weighted down on the opposite end by a small coil if wire to keep the needle “floating”. The pocket compass does not have the weight but instead is floating in liquid.

The transit and total station do not have a magnetized needle but rely on compass position calculated from known compass bearings and angles turned.

The Magnetic Poles

The **North Magnetic Pole** is the point on the surface of Earth's Northern Hemisphere at which the planet's magnetic field points vertically downwards. Its southern hemisphere counterpart is the South Magnetic Pole. Since the Earth's magnetic field is not exactly symmetrical, the North and South Magnetic Poles are not antipodal: i.e., a line drawn from one to the other does not pass through the geometric center of the Earth.



Points to remember

- The north and south magnetic poles move constantly
- The north magnetic pole is considerably south of the true north pole defined by the Earth's horizontal axis.
- The magnetic forces of the Earth will pull the compass needle into a parallel position with the forces.
- Therefore, there is a true meridian which passes through the north pole and a magnetic meridian which passes through the magnetic field in the direction of the magnetic north pole.
- Daily variation amounts to less than $1/10^{th}$ of a degree.

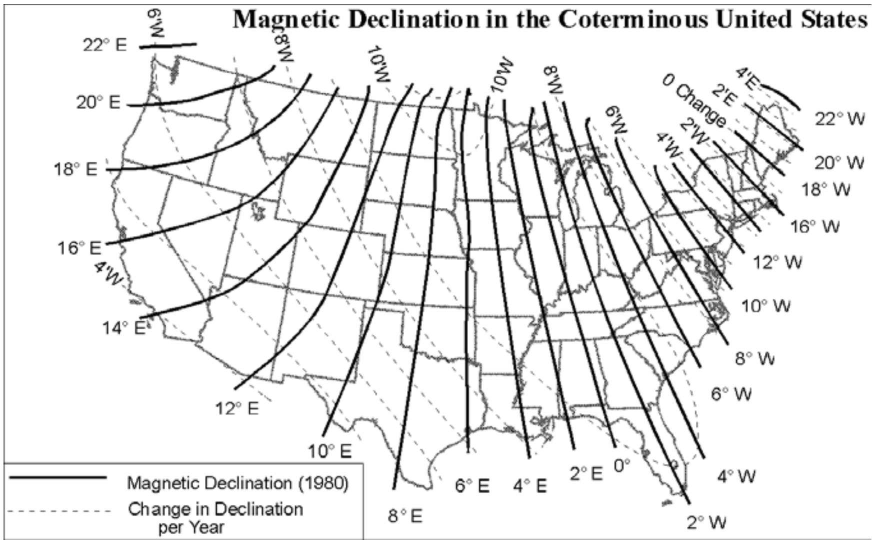
Magnetic declination

Magnetic declination is the horizontal angle from the true meridian to the magnetic meridian. Navigators call this angle the ***variation of the compass***

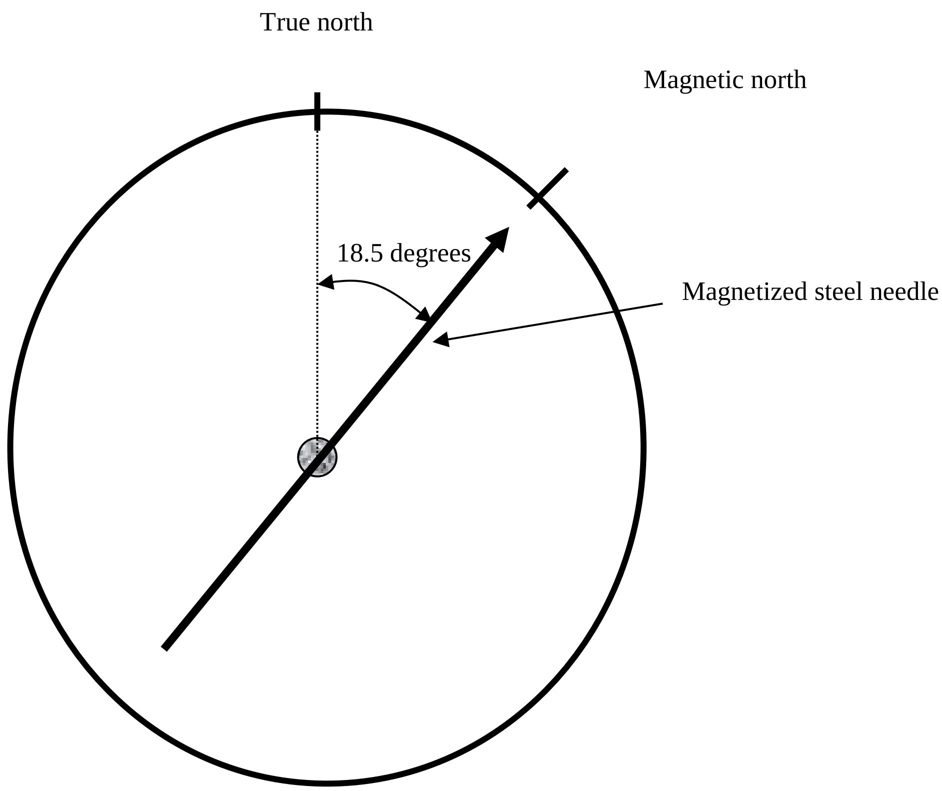
Because the magnetic poles are constantly changing, the magnetic declination is also constantly changing. In general, the daily change is so small that it can be effectively ignored, but over time it should be checked and compasses readjusted.

Long term declination is shown on charts called ***Isogonic Maps***

Below is an isogonic map from 1980 for the U.S. The line at 0 degrees is called the ***agonic line***



For the Corvallis, Oregon area, note that the declination in 1980 was approximately 19 degrees east (18.5 degrees). In 2013, the declination has shifted to approximately 16 degrees, roughly where it was in 1980 for the San Francisco Bay area.
This is how that would have looked on a compass. Note that the needle is pointing to magnetic north, about 18.5 degrees to the east.



For current approximations of the declination shift, you can go to the web page:

http://magnetic-declination.com/

Corvallis area is at 15^0 46’ E at the present (Spring 2013)

Variations in Declination

The changes in magnetic variation over time can be broken down into 4 categories. Of these, secular variation is the most important to consider

- Secular
- Daily
- Annual
- Irregular

Secular variation

Variation occurring over long periods of time

Most important variation because of its magnitude. Long term predictions are difficult because no mathematical formula has been found to address this change

Daily variation

Well within the variability of the compass readings themselves.

Annual variation

Again well within the variability of the compass

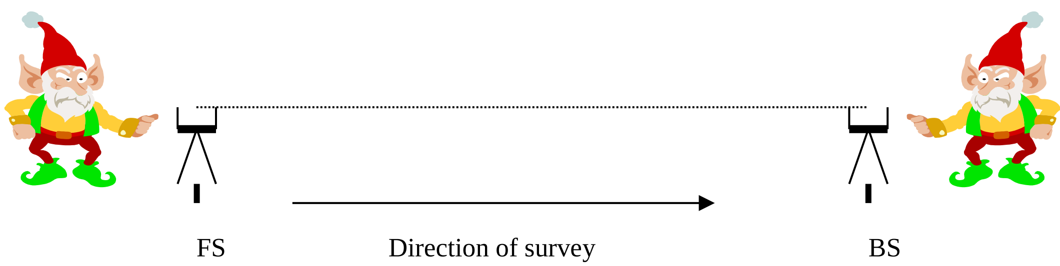
Irregular variation

Unpredictable variation caused by storms or magnetic interference

Local attraction

When working in the field, you need to always be aware of magnetic field anomalies called ***local attraction***. Local attraction affects the magnetic field through metallic objects and direct current electricity. Often in forest environments, local attraction can be found when passing through areas of geologic iron deposits as one example.

Local attraction can be checked for by taking forward and back bearings. If the bearings do not agree within some reasonable limit, then local attraction is at work.

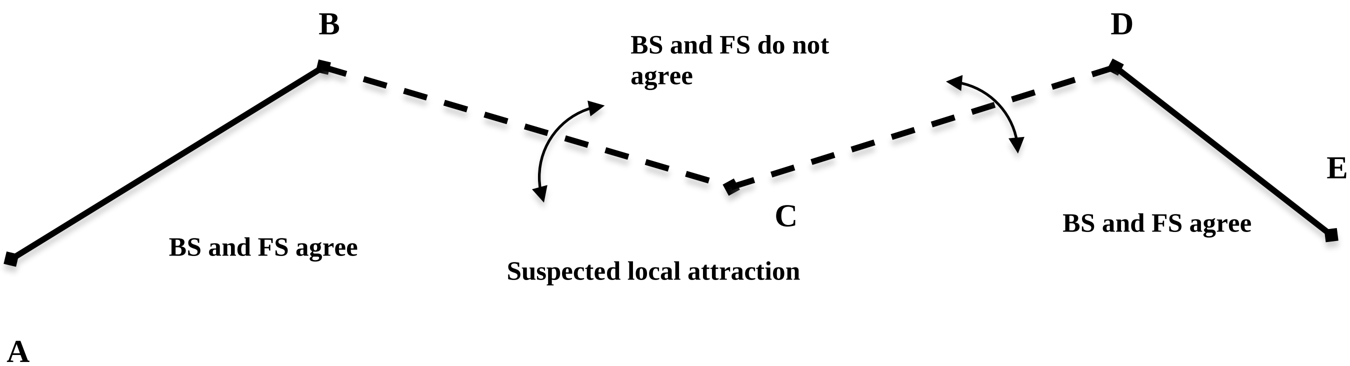


Compass adjustments for local attraction

The primary concern for variation in local attraction is the correctness of the record bearing for the survey.

Local attraction will cause an equal amount of error to all compass readings taken at the same point

Local attraction is recognized and calculated by sighting to a distant point and then backsighting to the point suspected of having local attraction. In the example below, we know that the compass has not been affected at points B and D since the back and fore sights agree. Therefore, since local attraction is at play, the compass reading from B to C is assumed and the reading from C to D is noted as the reverse reading of D to C (back sight).



Conversion problems

Typical problems in land surveying require the conversion of bearings from a different time period to the present or the other way around.

Three situations arise for conversion of compass directions:

1. Conversion of true bearings to magnetic bearings
2. Conversion of magnetic bearings to true bearings
3. Conversion of magnetic bearings for different declinations

Conversion of true bearings to magnetic bearings

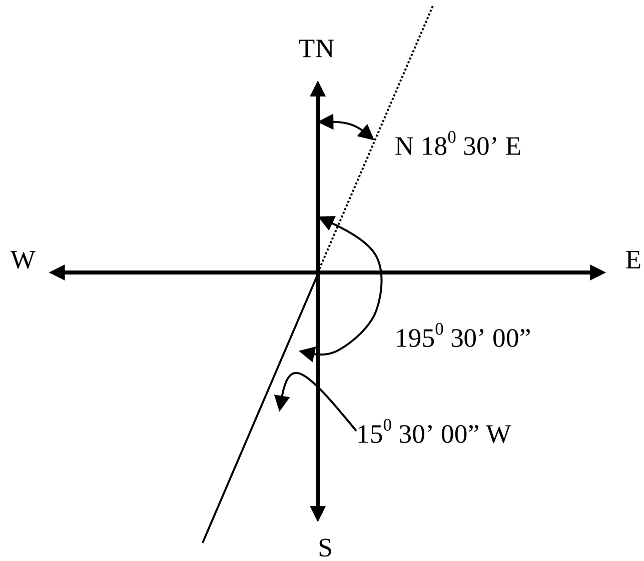
Remember, the line is true to true north. ***Don't move the line! Only move the declination!***

<u>Problem 1</u>

The true bearing of a line from an original 1868 survey is recorded as S 15^0 30' 00" W. The magnetic declination was 18^0 10' E. The magnetic declination now (1999) is 18^0 30' E. What are the past and present day magnetic bearings for the line?

Solution

Draw a sketch



1868 magnetic bearing	= 18^0 10' E - S 15^0 30' 00" W
	= S 2^0 40' 00" E
1999 magnetic bearing	= S 15^0 30' 00" W - 18^0 30' E
	= S 3^0 00' 00" E

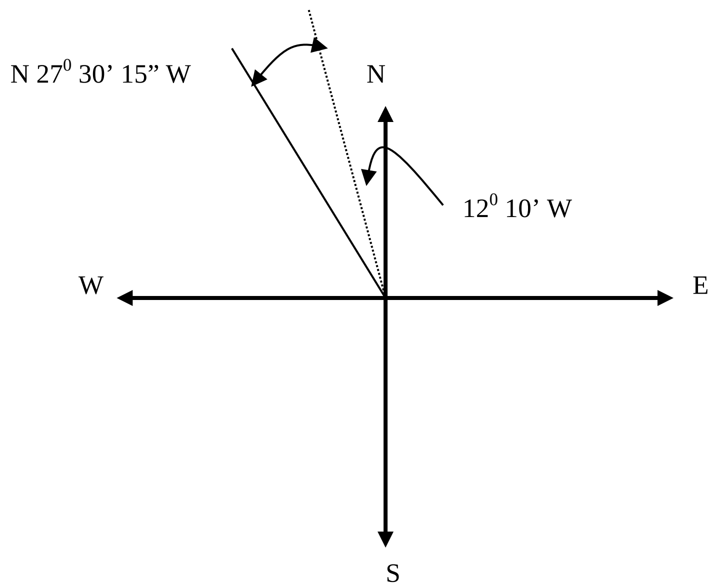
Conversion of magnetic bearings to true bearings

Problem 2

The true bearing of a line is required for a property line retracement. The original 1885 survey record bearing for the line is N 27^0 30' 15" W. The magnetic declination was 12^0 10' W. What is the true bearing of the line?

Solution

Draw a sketch



The property line lies N 27^0 30' 15" W of the magnetic declination
True bearing = N 27^0 30' 15" W + N 12^0 10' W
True bearing = N 39^0 40' 15" W

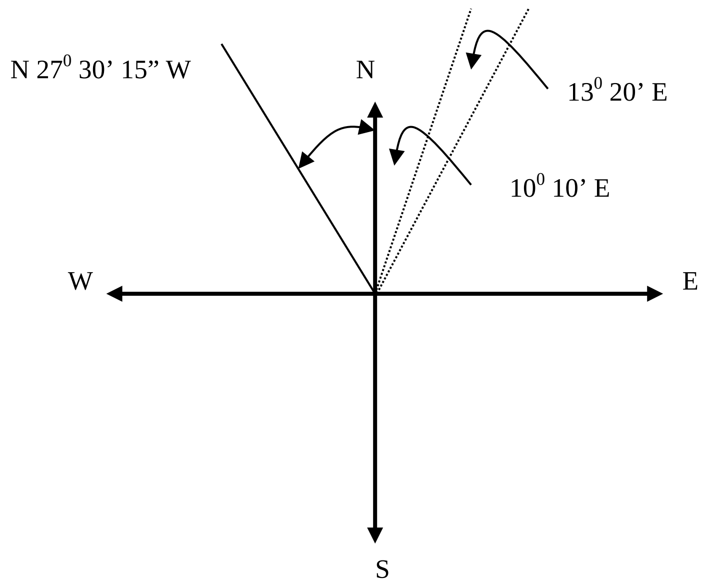
Conversion of magnetic bearings for different declinations

Problem 3

The magnetic bearing of a line from an original 1891 property line survey is N 27^0 30' 15" W. The magnetic declination was 10^0 10' E at that time. The magnetic declination now is 13^0 20' E. What magnetic bearing must be run to do a retracement of the line?

Solution

Draw a sketch



Current magnetic bearing = N 27^0 30’ 15” W + (13^0 20’ E - 10^0 10’ E)
Current magnetic bearing = N 27^0 30’ 15” W + 3^0 10’ E
Current magnetic bearing = N 30^0 40’ 15” W

Or:

1891 true bearing = N 27^0 30’ 15” W - 10^0 10’ E
1891 true bearing = N 17^0 20’ 15” W

1999 true bearing = N 17^0 20’ 15” W
1999 magnetic bearing = N 17^0 20’ 15” W + 13^0 20’ E
1999 magnetic bearing = N 30^0 40’ 15” W

Reading for this Section
Moffitt and Bossler, pages 230-240
Kiser, pages 121-133
“Chapter 6 Compasses” additional reading