BIO 117- FIELD BIOLOGY
Topographic Maps and Basic Orienteering

The ability to use (read) maps is an essential tool in the environmental field. In many instances, you will be called upon to produce maps or your own or modify existing maps. In recent years, computer assisted map generation and manipulation has evolved into the field of **Geographic Information Systems** that we will discuss in some detail later in the course.

Today's lab will introduce you to U. S. Geological Survey topographic maps; their basic symbols; how to orient them; and, basic triangulation skills. Topographic maps are available in a variety of forms for nearly every part of the United States and much of the rest of the world. You will find them to be useful whether or not you continue in a career that requires the use of maps.

After your introduction to maps and their symbols, examine the Lemoyne Quadrangle that is available in the lab and answer the following questions. At the end of class, we will discuss your answers.

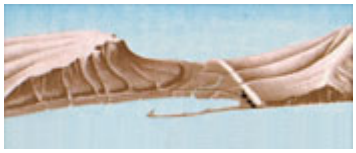
1. What is the difference in elevation between the top of the water tower hill on Messiah's Campus and the Yellow Breeches Creek at its point closest to the water tower?

2. If you were to launch a canoe on the Yellow Breeches at the covered bridge on Messiah's campus and float down stream until you reached the bridge where highway 114 crosses the creek, what would be the total distance that you would have floated?

3. What is the highest elevation recorded on the Quadrangle? What is the lowest?

4. Examine the aerial photograph of Messiah's campus. What time of the day was the picture taken? Can you tell the time of the year?

5. What is the latitude and longitude of the water tower on our campus?



What is a Topographic Map?

A map is a representation of the Earth, or part of it. The distinctive characteristic of a topographic map is that the shape of the Earth's surface is shown by contour lines. Contours are imaginary lines that join points of equal elevation on the surface of the land above or below a reference surface, such as mean sea level. Contours make it possible to measure the height of mountains, depths of the ocean bottom, and steepness of slopes.

A topographic map shows more than contours. The map includes symbols that represent such features as streets, buildings, streams, and vegetation. These symbols are constantly refined to better relate to the features they represent, improve the appearance or readability of the map, or reduce production cost.

Consequently, within the same series, maps may have slightly different symbols for the same feature. Examples of symbols that have changed include built-up areas, roads, intermittent drainage, and some lettering styles. On one type of large-scale topographic map, called provisional, some symbols and lettering are handdrawn.

Reading Topographic Maps

Interpreting the colored lines, areas, and other symbols is the first step in using topographic maps. Features are shown as

Many features are shown by lines that may be straight, curved, solid, dashed, dotted, or in any combination. The colors of the lines usually indicate similar classes of information: topographic contours (brown); lakes, streams, irrigation ditches, and other hydrographic features (blue); land grids and important roads (red); and other roads and trails, railroads, boundaries, and other cultural features (black). At one time, purple was used as a revision color to show all feature changes. Currently, purple is not used in our revision program, but purple features are still present on many existing maps.

Various point symbols are used to depict features such as buildings, campgrounds, springs, water tanks, mines, survey control points, and wells. Names of places and features are shown in a color corresponding to the type of feature. Many features are identified by labels, such as "Substation" or "Golf Course."

Topographic contours (above) are shown in brown by lines of different widths. Each contour is a line of equal elevation; therefore, contours never cross. They show the general shape of the terrain. To help the user determine elevations, index contours are wider. Elevation values are printed in several places along these lines. The narrower intermediate and supplementary contours found between the index contours help to show more details of the land surface shape. Contours that are very close together represent steep slopes. Widely spaced contours or an absence of contours means that the ground slope is relatively level. The

points, lines, or areas, depending on their size and extent. For example, individual houses may be shown as small black squares. For larger buildings, the actual shapes are mapped. In densely built-up areas, most individual buildings are omitted and an area tint is shown. On some maps, post offices, churches, city halls, and other landmark buildings are shown within the tinted area.

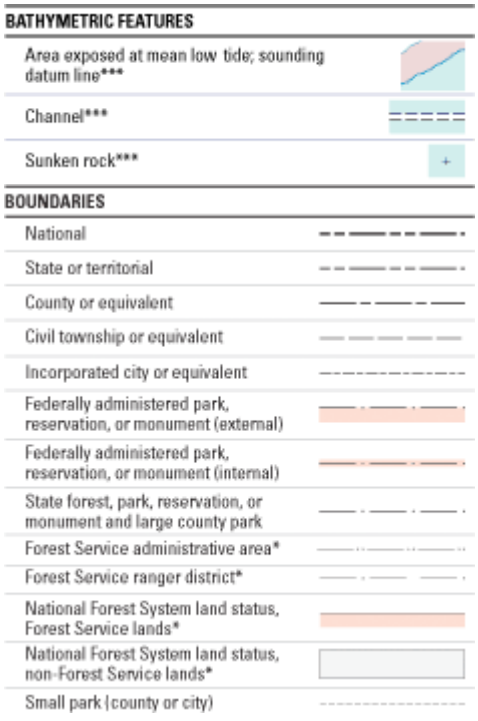
The first features usually noticed on a topographic map are the area features, such as vegetation (green), water (blue), and densely built-up areas (gray or red).

elevation difference between adjacent contour lines, called the contour interval, is selected to best show the general shape of the terrain. A map of a relatively flat area may have a contour interval of 10 feet or less. Maps in mountainous areas may have contour intervals of 100 feet or more. The contour interval is printed in the margin of each U.S. Geological Survey (USGS) map.

Bathymetric contours are shown in blue or black, depending on their location. They show the shape and slope of the ocean bottom surface. The bathymetric contour interval may vary on each map and is explained in the map margin.

Link- http://erg.usgs.gov/isb/pubs/booklets/symbols/reading.html

Topographic Map Symbols



BUILDINGS AND RELATED FEATURES

- Building
- School; house of worship
- Athletic field
- Built-up area
- Forest headquarters*
- Ranger district office*
- Guard station or work center*
- Racetrack or raceway
- Airport, paved landing strip, runway, taxiway, or apron
- Unpaved landing strip
- Well (other than water), windmill or wind generator
- Tanks
- Covered reservoir
- Gaging station
- Located or landmark object (feature as labeled)
- Boat ramp or boat access*
- Roadside park or rest area
- Picnic area
- Campground
- Winter recreation area*
- Cemetery (Cem)

CONTOURS

Topographic

- Index (6000)
- Approximate or indefinite
- Intermediate
- Approximate or indefinite
- Supplementary
- Depression
- Cut
- Fill
- Continental divide

Bathymetric

- Index***
- Intermediate***
- Index primary***
- Primary***
- Supplementary***

CONTROL DATA AND MONUMENTS

- Principal point** (J-20)
- U.S. mineral or location monument (▲ USMM 438)
- River mileage marker (Mile 69)

Boundary monument

- Third-order or better elevation, with tablet (BM 9134, BM 277)
- Third-order or better elevation, recoverable mark, no tablet (5628)
- With number and elevation (67, 4567)

Horizontal control

- Third-order or better, permanent mark (Neace, Neace)
- With third-order or better elevation (BM 52, Pike BM393)
- With checked spot elevation (1012)
- Coincident with found section corner (Cactus, Cactus)
- Unmonumented**

CONTROL DATA AND MONUMENTS – *continued*

Vertical control

- Third-order or better elevation, with tablet (BM 5280)
- Third-order or better elevation, recoverable mark, no tablet (528)
- Bench mark coincident with found section corner (BM 5280)
- Spot elevation (7023)

GLACIERS AND PERMANENT SNOWFIELDS

- Contours and limits
- Formlines
- Glacial advance
- Glacial retreat

PROJECTION AND GRIDS

- Neatline (39°15′, 90°37′30″)
- Graticule tick (55′)
- Graticule intersection
- Datum shift tick

State plane coordinate systems

- Primary zone tick (640 000 FEET)
- Secondary zone tick (247 500 METERS)
- Tertiary zone tick (260 000 FEET)
- Quaternary zone tick (98 500 METERS)
- Quintary zone tick (320 000 FEET)

Universal transverse mercator grid

- UTM grid (full grid) (73)
- UTM grid ticks* (69)

LAND SURVEYS

Public land survey system

- Range or Township line
- Location approximate
- Location doubtful
- Protracted
- Protracted (AK 1:63,360-scale)
- Range or Township labels — R1E T2N R3W T4S
- Section line
- Location approximate
- Location doubtful
- Protracted
- Protracted (AK 1:63,360-scale)
- Section numbers — 1 - 36
- Found section corner
- Found closing corner
- Witness corner — WC
- Meander corner — MC
- Weak corner*

Other land surveys

- Range or Township line
- Section line
- Land grant, mining claim, donation land claim, or tract
- Land grant, homestead, mineral, or other special survey monument
- Fence or field lines

MARINE SHORELINES

- Shoreline
- Apparent (edge of vegetation)***
- Indefinite or unsurveyed

MINES AND CAVES

- Quarry or open pit mine
- Gravel, sand, clay, or borrow pit
- Mine tunnel or cave entrance
- Mine shaft
- Prospect
- Tailings — Tailings
- Mine dump
- Former disposal site or mine

RAILROADS AND RELATED FEATURES

- Standard guage railroad, single track
- Standard guage railroad, multiple track
- Narrow guage railroad, single track
- Narrow guage railroad, multiple track
- Railroad siding
- Railroad in highway
- Railroad in road
- Railroad in light duty road*
- Railroad underpass; overpass
- Railroad bridge; drawbridge
- Railroad tunnel
- Railroad yard
- Railroad turntable; roundhouse

RIVERS, LAKES, AND CANALS

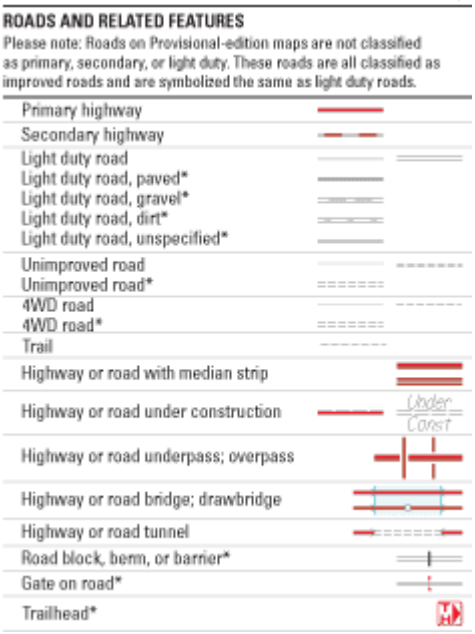
- Perennial stream
- Perennial river
- Intermittent stream
- Intermittent river
- Disappearing stream
- Falls, small
- Falls, large
- Rapids, small
- Rapids, large
- Masonry dam
- Dam with lock
- Dam carrying road

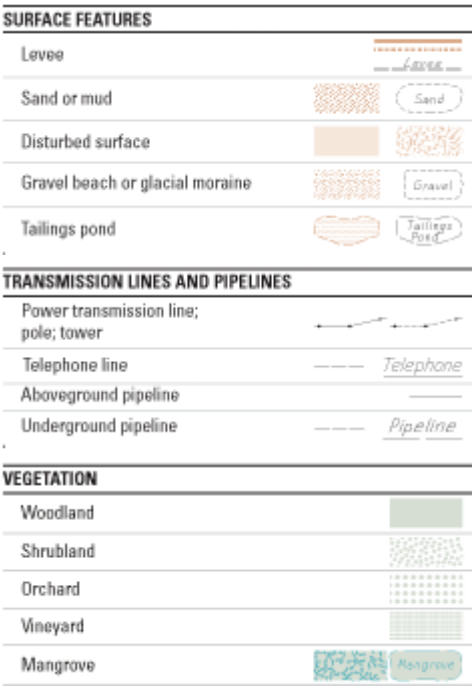
RIVERS, LAKES, AND CANALS – *continued*

- Perennial lake/pond
- Intermittent lake/pond
- Dry lake/pond — Dry Lake
- Narrow wash
- Wide wash — Wash
- Canal, flume, or aqueduct with lock
- Elevated aqueduct, flume, or conduit
- Aqueduct tunnel
- Water well, geyser, fumarole, or mud pot
- Spring or seep

SUBMERGED AREAS AND BOGS

- Marsh or swamp
- Submerged marsh or swamp
- Wooded marsh or swamp
- Submerged wooded marsh or swamp
- Land subject to inundation — Max Pool 431





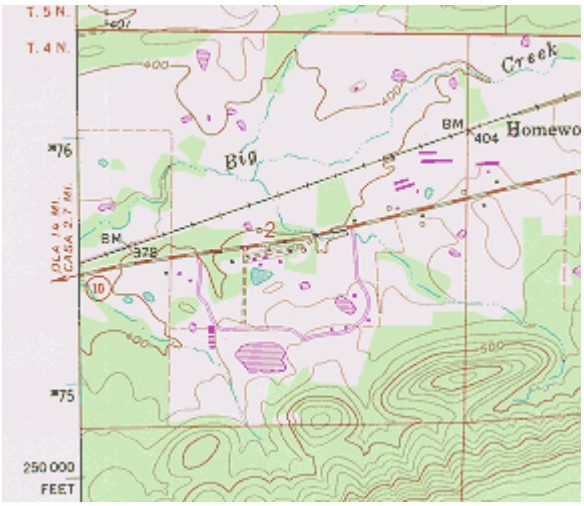
Link- http://erg.usgs.gov/isb/pubs/booklets/symbols/

UNITED STATES SEARCH AND RESCUE TASK FORCE

Adapted from From http://www.ussartf.org/compass_basics.htm

Compass Basics

Quick Map Basics Review For Compass Use



Part of a 7.5-minute topographic map at 1:24,000 scale

A topographic map tells you where things are and how to get to them, whether you're hiking, biking, hunting, fishing, or a field ecologist. These maps describe the shape of the land. They define and locate natural and manmade features like woodlands, waterways, important buildings, and bridges. They show the distance between any two places, and they also show the direction from one point to another.

Precise navigation using distances and directions takes calculation and practice, but the topography and features of the land are easy to determine. The topography is shown by contours. These are imaginary lines that follow the ground surface at a constant elevation; they are usually printed in brown, in two thicknesses. The heavier lines are called index contours, and they are usually marked with numbers that give the height in feet or meters. The contour interval, a set difference in elevation between the brown lines, varies from map to map; its value is given in the margin of each map. Contour lines that are close together represent steep slopes.

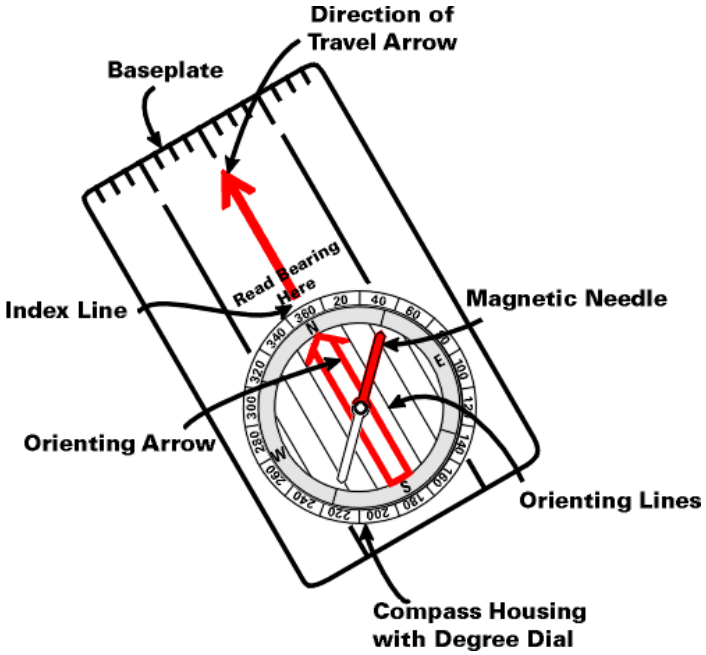
Natural and manmade features are represented by colored areas and by a set of standard symbols on all U.S. Geological Survey (USGS) topographic maps. Woodlands, for instance, are shown in a green tint; waterways, in blue. Buildings may be shown on the map as black squares or outlines. Recent changes in an area may be shown by a purple overprint. A road may be printed in red or black solid or dashed lines, depending on its size and surface. Standard USGS symbols are displayed in this handout.

Getting to Know Your Compass

The basic compass consists of a magnetized metal needle that floats on a pivot point. The needle orients to the magnetic field lines of the earth. The basic orienteering compass is composed of the following parts:

- Base plate
- Straight edge and ruler, often with several scales for distance measure.
- Direction of travel arrow

- Compass housing with 360° degree markings (Bezel)
- North label
- Index line
- Orienting arrow
- Magnetic needle (north end is red)

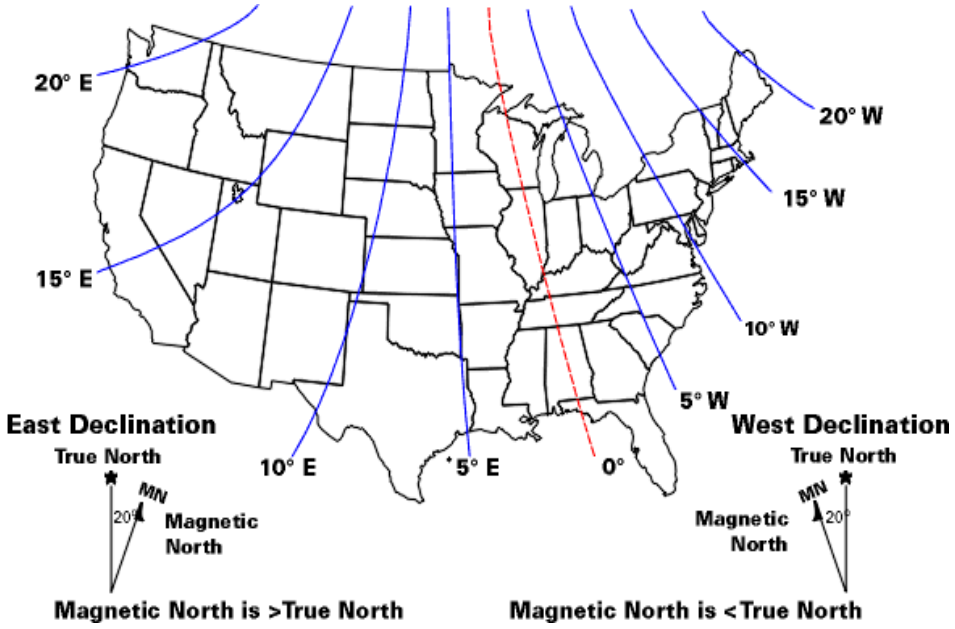


To determine the direction, or bearing, from one point to another, you need a compass as well as a map. Most compasses are marked with the four cardinal points —north, east, south, and west—but some are marked additionally with the number of degrees in a circle (360° north is also 0°, east is 90°, south is 180°, and west is 270°).

One thing to remember is that a compass does not really point to true north, except by coincidence in some areas. The compass needle is attracted by magnetic force, which varies in different parts of the world and is constantly changing. When you read north on a compass, you're really reading the direction of the magnetic north pole. A diagram in the map margin will show the difference (declination) at the center of the map between compass north (magnetic north indicated by the MN symbol) and true north (polar north indicated by the "star" symbol). This diagram also provides the declination between true north and the orientation of the Universal Transverse Mercator (UTM) grid north (indicated by the GN symbol). The declination diagram is only representational, and true values of the angles of declination should be taken from the numbers provided rather than from the directional lines. Because the magnetic declination is computed at the time the map is made, and because the position of magnetic north is constantly changing, the declination factor provided on any given map may not be current. **Contact the National Geophysical Data Center (NGDC) http://www.ngdc.noaa.gov/** to obtain current and historical magnetic declination information for any place in the United States.

What is North?

- True North: (also known as Geographic North or Map North) is the geographic north pole where all longitude lines meet. All maps are laid out with true north directly at the top. Unfortunately for the wilderness traveler, true north is not at the same point on the earth as the magnetic north Pole which is where your compass points.
- Magnetic North: Think of the earth as a giant magnet (it is actually). The shape of the earth's magnetic field is roughly the same shape as the field of a bar magnet. However, the earth's magnetic field is inclined at about 11° from the axis of rotation of the earth, so this means that the earth's magnetic pole doesn't correspond to the Geographic North Pole and because the earth's core is molten, the magnetic field is always shifting slightly. The red end of your compass needle is magnetized and wherever you are, the earth's magnetic field causes the needle to rotate until it lies in the same direction as the earth's magnetic field. This is magnetic north (marked as MN on a topographic map). The picture below shows the magnetic lines for the United States. If you locate yourself at any point in the U.S., your compass will orient itself parallel to the lines of magnetic force in that area.



Declination

You can see that location makes a great deal of difference in where the compass points. The angular difference between true north and magnetic north is known as the declination and is marked in degrees on your map. Depending on where you are, the angle between true north and magnetic north is different. In the U.S., the angle of declination varies from about 20 degrees west in Maine to about 21 degrees east in Washington. The magnetic field lines of the earth are constantly changing, moving slowly westward (½to 1 degree every five years). This is why it is important to have a recent map. An old map will show a declination that is no longer accurate, and all your calculations using that declination angle will be incorrect. As you will see, understanding this distinction becomes important when navigating with a map and a compass. More on declination below...

Which North to Use

So we have two types of north to contend with. When you look at your map, it is drawn in relation to true north;, when you look at your compass, it points to magnetic north. T to make the map and compass work together you must decide on one North as your point of reference and base all your calculations on that. As you can see the following chart, failure to take declination into account can put you way off target.

Declination or Degrees Off Course	Error Off Target after Walking 10 Miles
1°	920 feet (280meters)
5°	4,600 feet (1,402 meters)
10°	9,170 feet (2,795 meters)

Using Map and Compass

What's your Map Declination?

The first thing you need to know is where you are in relation to magnetic north. You can find this information by looking on your map legend. If you look at a map of North America you will see the line roughly marking 0° declination. If you are on the line where the declination is 0 degrees, then you don't have to worry about any of this, since magnetic north and map north are equivalent. If you are to the right of that line, your compass will point toward the line (to the left) and hence the declination is to the west. If you are to the left of the line, your compass will point toward the line (to the right) and hence the declination is to the east. You use the compass on the compass rose to adjust your map position for declination.

Adjusting Your Compass for the Local Declination:

Another way to deal with declination is to adjust your compass. Some compasses have an outer degree ring that can be unlocked either with a set screw or a latch. This allows you to reset the compass to account for declination. For example, if the declination were 14° East, you could rotate the degree dial to the right so that the magnetic needle was pointing to 14° instead of 360°. Once you do this, you will no longer have to add or subtract for declination because your compass is aligned to true north (UNLESS you travel from place to place across the country. If you travel I recommend NOT adjusting your compass). Now when the compass needle is inside the orienting needle, the compass bearing that you read off your compass will be in relation to true north instead of magnetic north. If you have a fixed-ring compass, you can mark the declination angle on the compass ring with a piece of tape.

Orienting Your Map

Before doing anything else you must orient your map with the landscape. You should learn to do this first using a compass. Later as your orienteering skills develop you may do this using prominent features in the landscape such as ridges, peaks and buildings, or, even use the North Star.

1. Find the compass rose at the bottom of your map.

2. Set your compass direction of travel arrow to point north.

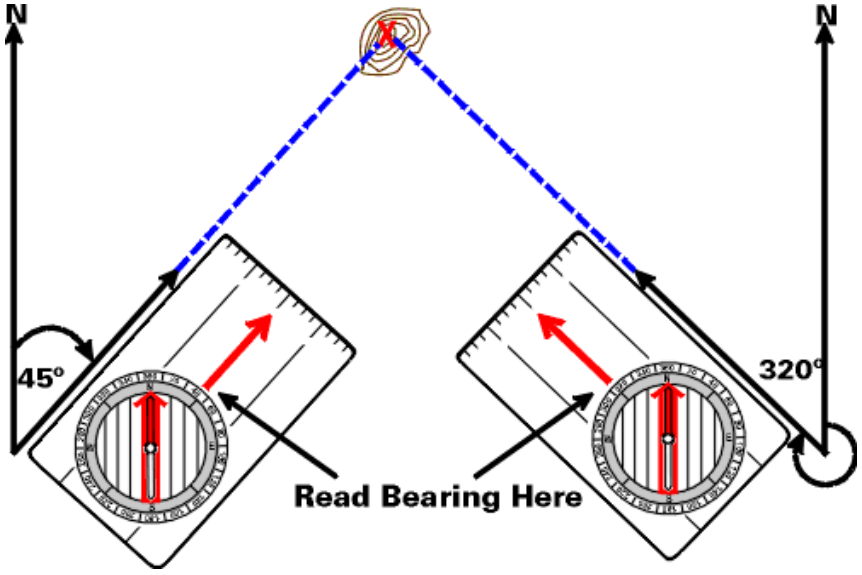
3. Place your map on a flat surface and place your compass on the compass rose. Align the parallel lines or the side of your compass base with the magnetic north of the compass rose.

4. Turn your map and compass simultaneously so that the needle again aligns with the north arrow. Your map is now aligned and adjusted for declination.

If you have adjusted your compass for declination, use the above procedure but align your compass with the true north arrow on the compass rose.

Bearings

The compass is used primarily to take bearings. A bearing is a horizontal angle measured clockwise from north (either magnetic north or true north) to some point (either a point on a map or a point in the real world). Bearings are used to accurately travel to a destination or to locate your position. If you are working from your map, it is called a map bearing and the angle you are measuring is the angle measured clockwise from true north on your map to this other point on the map. If you are taking a bearing off a real point on the landscape with a compass, you are using your compass to measure the angle clockwise from magnetic north to this point on the landscape. This is called a magnetic bearing. Remember that the bearing is measured clockwise. If you think of true north as 12 o'clock then a bearing to the right of that (1 o'clock) is greater than true north and a bearing to the left of True north (11 o'clock) is less than true north.



Taking a compass bearing to an object-

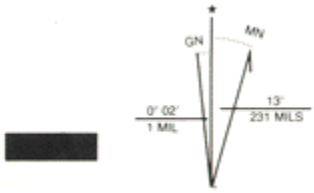
- Open your compass lid to a 45° to 60° angle with base.
- Sight through the notch in the top toward an object in the distance.
- Hold the lid and base plate fixed with one hand, keeping the chosen object in sight through the notch. Turn the compass housing with degree marks until the red arrow is lined up with the red arrow on the base plate.
- Read the degree bearing at the direction of travel mark on the front of the compass dial. This is the bearing in degrees towards your chosen mark. It is not corrected for declination. To get to the object simply hold the compass in front of you and follow the direction of travel arrow while keeping the compass needle lined up with the north arrow.

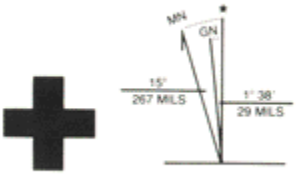
Taking a compass bearing from a map-

- Draw a straight line on the map passing through your location and your destination and extending across any one of the map borders.
- Center the compass where your drawn line intersects the map border, align the compass axis N-S or E-W with the border line, and read on the compass circle the true bearing of your drawn line. Be careful to get the bearing in the correct sense because a straight line will have two values 180° apart. Remember north is 0, east is 90, and so on.
- To use this bearing, you must compensate for magnetic declination. If the MN arrow on the map magnetic declination diagram is to the right of the true north line, subtract the MN value. If the arrow is to the left of the line, add the value.

(1) Drawing a straight line over the map edge

(2) Reading the compass on the map





(3) Using the magnetic declination diagrams

Check Your Position Regularly

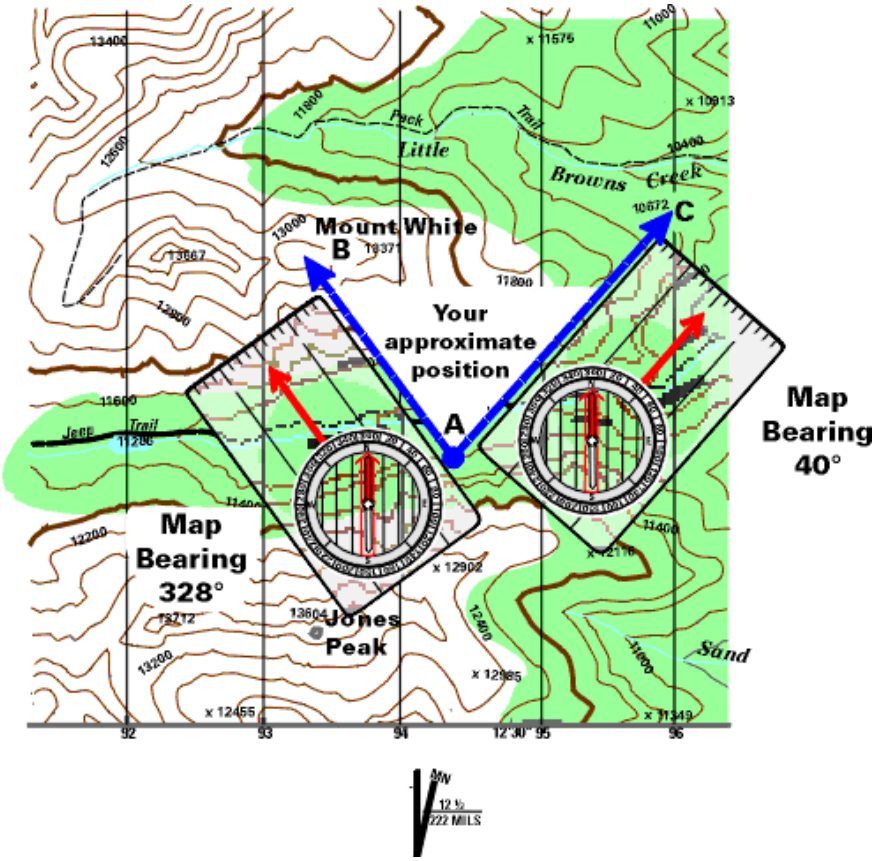
Make it a habit of keeping your map and compass handy and refer to them every hour or so to locate your position (more often in low visibility). Keep track of your starting time, rest breaks and lunch stops, and general hiking pace. This will also give you an idea of how far you have traveled.

What If You Get Lost?

Triangulation:

Triangulation is used to locate your position when two or more prominent landmarks are visible. Even if you are not sure where you are, you can find your approximate position as long as you can identify at least 2 prominent landmarks (mountain, end of a lake, bridge, etc.) both on the land and on your map.

1. Orient the map.
2. Look around and locate prominent landmarks.
3. Find the landmarks on the map (preferably at least 90° apart).
4. Determine the bearing of one of the landmarks.
5. Place the compass on the map so that one side of the base plate points toward the landmark.
6. Keeping the edge of the base plate on the symbol, turn the entire compass on the map until the orienting arrow and the compass needle point to north on the map.
7. Draw a line on the map along the edge of the base plate, intersecting the prominent landmark symbol. Your position is somewhere along this line.
8. Repeat this procedure for the other prominent landmark. The second landmark should be as close to 90° from the first as possible. Your approximate position is where the two lines intersect.
9. You can repeat this process a third time to show an area bounded by three lines. You are located within this triangle.
10. If you are located on a prominent feature marked on the map such as a ridge, stream, or road, only one calculation from a prominent landmark should be necessary. Your position will be approximately where the drawn line intersects this linear feature.



Compass Glossary

- ***adjustable compass*** **-** a compass whose azimuth circle can be rotated relative to the lubber's line.
- ***azimuth circle*** **-** a circular compass scale graduated in angular units: degrees, cardinal points, or other units, usually clockwise from north or 0°.
- ***bearing*** **-** the angular direction to a landmark.
- ***boxing mark*** **-** a box, arrow, line, or other mark permanently fixed to point to the N or 0° index on a compass azimuth circle. The boxing mark is usually part of the capsule. To "box" a compass, align the compass needle or card with the boxing mark, north-to-north, or with N or 0° on the azimuth circle.
- ***capsule*** **-** a sealed transparent case which houses the compass needle, the azimuth circle, and the boxing mark. The capsule may be filled with liquid to amp needle or card swinging.
- ***card*** **-** an azimuth circle (also called bezel) mounted on a compass needle. The card rotates relative to the lubber's line.
- ***course*** **-** angular direction of travel.
- ***fix*** **-** the position indicated by the intersection of two or more lines of bearing.
- ***landmark*** **-** a recognizable real object in the terrain.

- ***lubber's line* -** a line or mark on the compass body that points toward the direction of travel. Simple compasses may use north or 0º on the azimuth circle as a lubber's line. On sighting compasses the sight centerline is the lubber's line.
- ***magnetic declination* -** easterly or westerly angular difference between the direction to the earth's geometric and magnetic poles.
- ***magnetic inclination* -** the vertical component of the earth's magnetic field which causes compasses needles to dip.
- ***map object* -** a picture or symbol used on a map to represent a landmark or other object.
- ***needle* -** a magnetized pointer resting on a pivot in the capsule, free to rotate relative to the lubber's line and azimuth circle.
- ***north - grid north*:** the direction to the earth's geometric north pole along a meridian.
- ***north - magnetic north*:** the apparent direction to the earth's magnetic north pole, not usually indicated by a grid on maps. This net magnetic north comprises all the magnetic effects acting on your compass.
- ***true north*:** the direction to the earth's geographic north pole, indicated in life approximately by Polaris; indicated on maps by DMS scales and tick marks along the map borders.
- ***orienteering compass* -** an adjustable compass with special features that make it more convenient to use in the field with maps.
- ***orienting* –** *the act of aligning your map with the landscape, usually using a magnetic compass. The word comes from the first European cartographers producing maps with the purpose of getting to the Orient to participate in lucrative trade*.
- ***orienting lines* -** visible lines in the capsule engraved parallel to the boxing mark; used as reference lines when marking angles on the map with an orienting compass.
- ***sighting compass* -** a compass with a mirror or peep sight aligned with the lubber's line.
- ***simple compass* -** a compass with the lubber's line fixed at north or 0°, and a fixed azimuth circle.

Words of Caution

Compass readings are also affected by the presence of electromagnetic fields, iron, steel or large bodies of iron containing rock. Be sure to look out for—and stay away from—pocket knives, belt buckles, railroad tracks, trucks, electrical lines, and so forth when using a compass in the field.

Secondly, if you regularly travel to the southern hemisphere you will need a southern hemisphere compass otherwise the tip of the north arrow will skid along the surface of the compass dial and not work well at all.

Extending Your New Skills For Route Planning

PACES

A Pace is the distance between 2 right, or 2 left foot steps. It is about 5 feet in an adult. Roman soldiers counted 1000 paces as one mile (5,280 feet). There are roughly 250 Adult paces in 1/4 mile, and 500 paces in a 1/2 mile. Everyone has a slightly different pace, so measure your own by marking off 100 feet and see how many paces it takes you to travel 100 feet. It should be from 18 to 21 paces.

Time of Travel. Adapted from http://www.ixi.net/~4waystop/NAVIG.HTM

time = distance / speed

Estimating the time of travel between two points is very helpful in keeping your self from getting lost. In this way you can anticipate landmarks along your future course. Likewise, since work = force times distance, work done to walk straight up a steep hill 100 feet, can be greatly reduced by increasing the distance over which the work is to be done, as in switch-backing the hill. That way the same amount of work is done over a longer time.

It takes about 20 minutes to walk a mile on open highway, 30 minutes to walk through open woods, 40 minutes for thick woods or foothills. This can vary substantially off trail. So your best bet is to not use time, but use your pace to measure distance in the wilderness instead. Nonetheless, some standard times to calculate travel time with a 35 pound backpack including one 10 minute break per hour are...

Ascending - 1 hour for every 2 horizontal miles, plus 1 hour for every 400 vertical feet of elevation gain.

Descending - 1 hour for every 2 horizontal miles, plus 1/2 hours for every 1,000 vertical feet of elevation lost.