The Tacoma Mountaineers

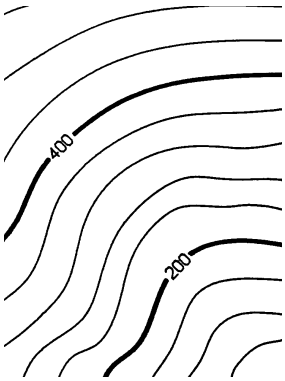
Wilderness Navigation

Navigation Fundamentals

Navigation in mountainous terrain and wilderness areas requires a set of skills, of which using a map and compass is only one part. These skills will not only assist in reaching a destination, but may also be necessary for taking an alternate route. Navigation is an art because of the abilities and techniques required, and a science because it is based on the systematic application of physical laws. All navigation, from the most elementary to the most complex, involves two things: (1) Determining your present location; and (2) Getting from one known point to another.

Maps

The first thing that should be known about a map is that it's nothing more than a drawing or representation of a piece of the earth's surface. It's a drawing of the earth as would be seen from an airplane, looking straight down. Being able to visualize terrain features from contour lines is one of the most useful map reading skills that can be developed. The map not only shows terrain, but also streams, rivers, lakes, roads, trails, and sometimes man-made objects.



Maps are drawn to **SCALE,** which is usually printed at the bottom of the map. This means that a certain distance on the map equals a certain distance in the field. A map is said to have a **LARGE** scale when there is a lot of detail within a given area. A **BAR SCALE** is usually printed at the bottom in three different units: miles, feet, and kilometers. To find the distance in the field, measure the distance between the two points on the map. Take this measurement and place it just under one of the bar scales, and then read the field distance.

What is a Topographic Map?

(→) The distinctive characteristic of a topographic map is that the shape of the Earth's surface, or terrain, is shown by contour lines, represented by thin brown (sometimes red) 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.

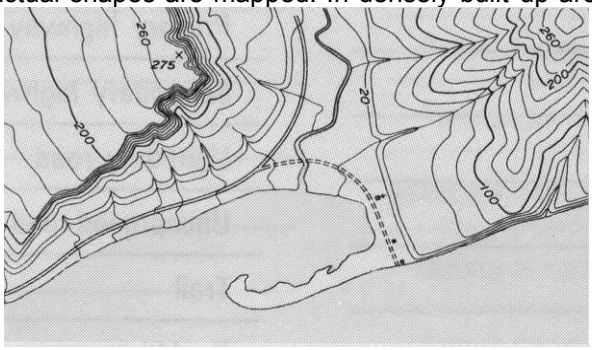
Contour intervals are not the same on all maps. Typically, they are 40 ft, 80 ft, 100 ft, and, sometimes, as much as 250 ft, depending on the scale of the map and the steepness of the terrain. Usually every fifth contour line is wider, and its elevation is printed periodically along its length.

A topographic map shows more than contours. The map includes symbols (see under "symbols" below) that represent such features as streets, buildings, streams, and woods. These symbols are constantly refined to better relate to the features they represent, improve the appearance or readability of the map, or to 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 type styles.

Reading Topographic Maps

Interpreting the colored lines, areas, and other symbols is the first step in using topographic maps. Features are shown as 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), information added during update (purple), and densely built-up areas (gray or red).

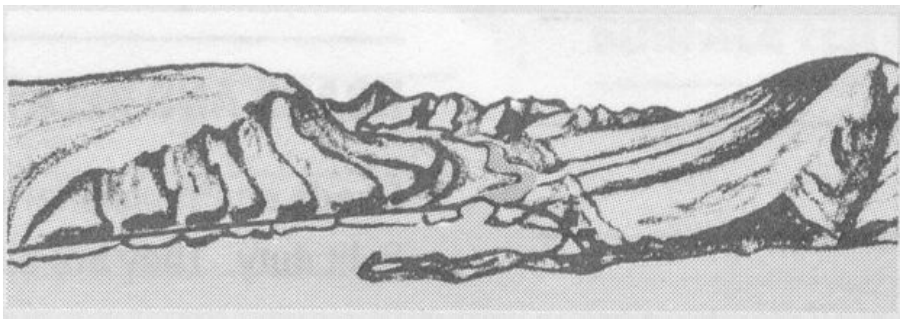
Many features are shown by lines that may be straight, curved, solid, dashed, dotted, or in any combination.

The colors of the lines usually indicate similar kinds or classes of information: topographic contours (brown); lakes, streams, irrigation ditches, etc. (blue); land grids and important roads (red); other roads and trails, railroads, boundaries, etc. (black); and some features that have been updated using aerial photography, but not field verified (purple).

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 also 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 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 elevation difference, or height, 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 bottom margin of each U.S. Geological Survey (USGS) map.



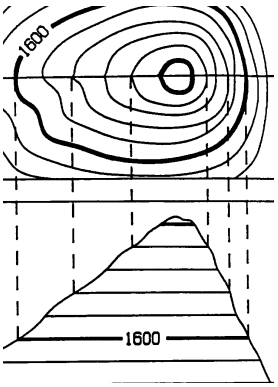
Recognizing Topographic Features: The land features shown on the left are represented by the contour lines in the figure above.

Roads, railroad tracks, power lines, and other man-made objects are usually shown in black, glacier and permanent snowfields in white, vegetation in green, and blue is used for water features. The date of the survey, revision date of the map, and the reference names of adjacent maps for other areas are usually given as well. Study the contour lines, symbols, colors, and other features before going to the field.

The magnetic needle in the compass is attracted by the earth's magnetism, and that's why it points north. However, on a map there are two north references to be considered. One is **Magnetic North**, which is where the magnetic lines of force come together. The other is **True North**, which is located geographically by longitude (north-south) lines that pass through each of the earth's poles. The compass needle points to magnetic north, which is located in the Hudson Bay region of northeast Canada, but moves slightly each year. Maps and directions are usually based on true north, which does not move.

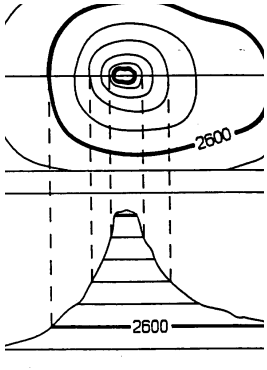
Terrain Interpretation

Interpretation of topographic maps is quite simple.



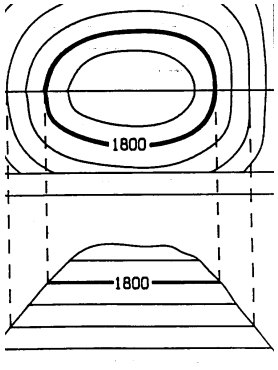
(←) Contour lines widely spaced show a gentle slope. When they are close together, the slope is steep.

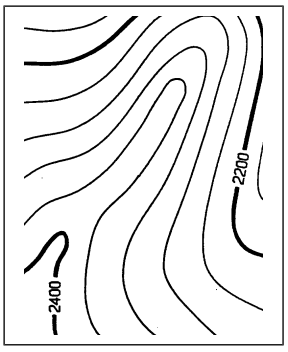
(→) Contour lines across a stream always come together in a **V**. The point of the **V** points upstream.



(→) The hilltop is flat when the contour lines are widely spaced at the top.

(←) When the contour lines are close together at the top of a hill, the hilltop is pointed.





(←) Another terrain feature is the **Ridge.** A ridge is a fairly long and narrow piece of terrain. Standing on a ridge, the ground will go uphill in one direction and downhill in the other three directions. The **U**'s point downhill.

(→) Sometimes contour lines show two hilltops fairly close together. The lower terrain between the two hilltops is called a **Saddle**.

Topographic Map Symbols

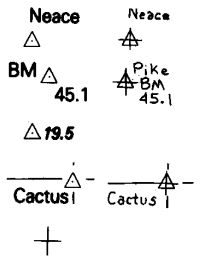
U.S. Department of the Interior, U.S. Geological Survey publication (excerpt)

USGS Symbols (examples)

Control Data Monuments

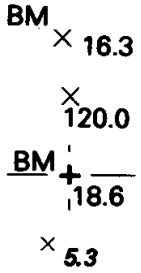
Horizontal Control

- Permanent Mark
- Elevation Mark
- Checked Spot Elevation
- At Corner section
- Unmarked



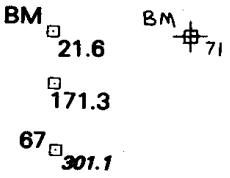
Vertical Control

- With Tablet
- Recoverable Mark
- Benchmark at corner section
- Spot Elevation



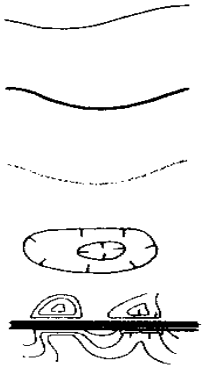
Boundary Monument

- With Tablet
- Without Tablet
- With Number and Elevation



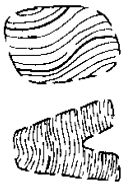
Contours

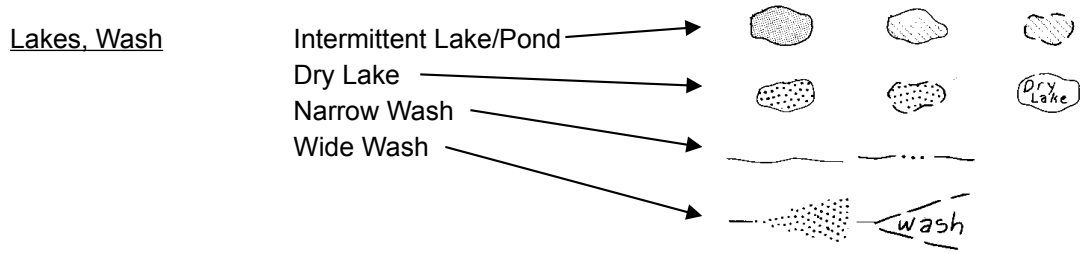
- Intermediate
- Index
- Supplementary
- Depression
- Cut; fill



Glaciers

- Contours
- Form Lines





Using a map and compass

Declination

USGS maps, and most other maps you will use for wilderness navigation, are oriented such that true north is towards the top of the map. **True north** is defined by the axis the earth rotates about on a daily basis. The needle in your compass will align itself with the local magnetic field (**magnetic north**) which generally is not aligned with true north, thus we need a measurement of the difference between true north and local magnetic north to relate compass measurements to our maps.

Declination is the angle between true north and magnetic north. The amount of declination in a given area depends on the location of that point on the earth. Where true and magnetic north are the same direction, then the declination is zero. In North America, zero declination runs roughly from west of Hudson Bay down along eastern Lake Michigan to the Atlantic coast of Georgia. At any point on the west side of this line, the compass needle will point east of true north. This is called **Easterly** declination. Conversely, at any point east of zero declination, the compass needle will point west of true north. This is called **Westerly** declination.

In North America, the declination varies from 30 degrees east in Alaska to 30 degrees west in Labrador. In the Washington Cascades the declination is approximately 16 degrees East. Be sure to check your map for the correct declination and make sure the measurement referred to on the map is current – declination changes with time (approximately one degree per decade in this area). By setting the declination on your compass you automatically correct for the difference between magnetic north and true north allowing you to relate compass bearings directly to your map.

Is declination adjustment confusing you?

When taking a bearing with your compass' red orienting arrow, the most common error navigation students make results from confusion between declination-adjusted and non-adjusted compasses.

In short, a non-adjusted (or non-adjustable) compass reads **magnetic** north. Compasses adjusted for declination read **true** north.

When taking a bearing, if your compass has a mirror, tilt the mirror toward you so you can view the needle through the mirror and align it with the red orienting arrow. You'll also be able to read out degrees of azimuth using the mirror.

Using a non-adjusted compass

When taking a bearing with a compass that is not adjustable for local declination, or an adjustable compass that has NOT been declination-adjusted (set to zero), your sighting will yield a magnetic bearing, because the compass needle always aligns itself to magnetic north AND the red orienting arrow and the black meridian lines under the orienting arrow are parallel.

Using an adjusted compass

When taking a bearing with a compass that has been adjusted for local declination, then:

1. The red orienting arrow and the black meridian lines in your compass are NOT parallel.

2. If while taking a bearing you align the needle with the compass' black meridian lines (permissible, but not common practice), you are still reading magnetic north.

3. If while taking a bearing you align the needle with the compass' red orienting arrow, as is common practice, then you are reading true north.

Bearings

The direction from one point to another, on a map or in the field, is called a **Bearing.** Sometimes bearings are referred to as **course** or **azimuth**; they are the same thing. When a bearing is determined from a map it is measured relative to True North and is known as a **true bearing**. If you measure a bearing with a compass that does not have a declination setting, or the declination is set to zero, you are measuring a bearing relative to magnetic north, which is known as a **magnetic bearing**. When measuring a bearing with a compass that has declination properly set for your area you are automatically correcting for the difference between magnetic north and true north, thus the resulting bearing is a true bearing.

The proper form for recording a bearing is to use three digits with a T for true bearing or M for magnetic bearing appended to the digits.

The principal/cardinal directions in true bearings are:

0/360T—North	045T—North-East	090T—East	135T—South-East
180T—South	225T—South-West	270T—West	315T—North-West

Field Bearings

When measuring a bearing between your current location and another feature such as a peak or lake with your compass you are taking a **field bearing**. Follow the steps below to take accurate field bearings.

Shooting accurate bearings with your compass:

- Do not wear the lanyard around your neck if it is not long enough to fully extend your arm.
- Place the compass flat in the palm of your hand.
- **Keeping the compass level**, raise your hand away from you (arm extended) and to eye level.
- Move the mirror so that you can see the magnetic needle and the declination arrow in the mirror (approx. 45° angle).
- **Close one eye** when sighting a target.
- Sight the desired target with the sighting notch on the top of the mirror (move your entire body left or right to locate the target – not just your arm or hand). (Note: Some compasses also have a sighting "notch" at the base of the mirror.)
- **When sighting the target make sure that the thin line on the mirror is aligned with the needle pivot.** The target, the sighting notch, the thin line on the mirror, and the needle pivot should all be aligned for an accurate reading.
- Move the bezel until the **needle is parallel along its length to the sides of the declination 'arrow' or lines** (don't just look at one end of the needle**)**. On most compasses, the red end of the magnetic needle should be pointed at the red end of the declination arrow (unless you are taking a back bearing). (Note: Some compasses only have parallel lines instead of an arrow.)
- Check again that you are **holding the compass level**.
- Read the bearing at the index line.
- Be aware that metal objects near the compass could affect its reading – your watch, altimeter, bracelets, pencils with metal clips or eraser holders, metal roofs, cars, etc.

Orienting The Map With A Compass

This operation will align true north on the map with true north in the field. (It is assumed that declination is set correctly on your compass, which is approximately 16 degrees E for the Central Washington Cascades).

1. Rotate the graduated dial on the compass so that 0 appears at the index line.
2. Place a compass straightedge on any longitude (north-south) line of the map.
3. Physically turn both the map and compass until the magnetic needle is aligned in the orienting arrow.

Map To Field Bearing

This technique is used when the present location (start point) and objective/landmark (end point) are known. **The map does not have to be oriented.** In determining the true bearings on the map, the magnetic needle direction is disregarded since the compass is only used as an instrument for measuring angles (a protractor).

1. Place a compass straightedge along a line connecting the start point and end point. The direction of travel arrow must point towards the end point (objective/landmark.)
2. Rotate the graduated dial so that the meridian lines are parallel to the longitudinal (north-south) lines on the map. The orienting arrow will also point towards true north (if you have set the declination on your compass the orienting arrow will actually point approximately 16 degrees east of north).
3. The true bearing is the number at the index line (XXXT).
4. To use in the field, hold the compass in front of you, chest high, and level so the magnetic needle is free to swing. Turn your <u>body</u> until the magnetic needle is aligned inside the orienting arrow.
5. The direction of travel arrow will point in the field to the end point (objective/landmark) selected on the map.

Field To Map Bearings (Intersection)

Determining an intersect requires a minimum of two (2) known landmarks, and it is best if they are at right angles to each other. This technique is used when landmarks are known and the point at which the bearings are taken is not. Intersection is sometimes referred to as “cross bearings,” or “triangulation;” they are the same thing. The most common landmarks are two (2) peaks. However, another choice could be a peak and a geographical feature, such as a stream/river, ridge/valley, shoreline, etc.

1. Point the ‘direction-of-travel’ arrow at the first known landmark.
2. Hold the compass in front of you, chest high, and level so the magnetic needle is free to swing. Rotate the graduated dial until the orienting arrow is aligned with the magnetic needle.
3. The bearing is the number at the index line (XXX.)
4. Place the compass on the map so that:
5. One of the straightedges is on the landmark (known point.)
6. The ‘direction-of-travel’ arrow points to the landmark.
7. The north arrow on the graduated dial points towards true north (straight up) on the map.
8. The meridian lines are parallel with the longitude (north-south) lines on the map.
9. The point at which the bearing was taken is somewhere along the line formed by the straightedge.
10. Repeat steps 1 through 5 for the second known landmark.
11. The point at which the bearings (lines) cross is your location.
12. If possible, it is desirable to get more than two landmarks for bearings.

NOTE: The map does not have to be oriented to do steps 4 and 5. Disregard the magnetic needle for working on the map; the compass is only used as a protractor.

Care And Use Of A Map

Always remember two things:

1. That a map buried in your pack is just extra weight that your are carrying if you don’t use it,
2. If it’s a soaking mass of goo because of rain, its still no good.

Navigation Techniques

Leapfrogging

To leapfrog, person (A) sets a desired bearing on his/her compass while person (B) walks in the general direction of the bearing for a desired distance, or until just before the two parties are unable to see each other and/or communicate. Person (A) has person (B) move until they are lined up with the bearing. (A) is now free to walk towards (B) without trying to exactly following the bearing. (A) then "leapfrogs" past (B) allowing them to switch roles where (B) can now direct (A) to the correct bearing.

Back Bearings

A back bearing is the opposite direction to your desired bearing. Back bearings are used when you are following a particular bearing and want to ensure you are still on that bearing line by taking a back bearing to an identifiable object at your starting point. To increase your accuracy when leapfrogging, person (B) can take a back bearing to person (A) to ensure accurate alignment along the desired path. There are two simple ways to take a back bearing:

- The easiest way to take a back bearing is to simply keep your compass set to your desired bearing, but align the south seeking end of the magnetic needle (typically white or black) with the pointed end of the declination arrow.

- Another way to take a back bearing is to set your compass to 180° from your desired bearing and shoot back to your partner. If your bearing is less than 180°, the back bearing is found by adding 180°. If the bearing you are on is greater than 180°, the back bearing is found by subtracting 180°. For example, if you are following a bearing of 82° set your compass to 262° and sight your partner.

Intermediate Objectives

Many times obstacles will be in your path such as streams, crevasses, or heavy brush. If you can see over the obstruction you may be able to sight past the obstruction to an identifiable object such as a tree or rock that is exactly on your bearing line. Once you have identified the object, you are free to take whatever route is easiest to the object and then resume following your bearing.

Offsets

When you cannot see around an obstacle or identify an intermediate objective, you can use an offset to navigate around the obstruction. To navigate along an offset (see the figure below):

- Travel a paced distance **90°** from the original bearing.
- Resume your bearing parallel to your original course to pass the obstruction
- Return to your original course by turning **90°** in the opposite direction as before and pace off the distance to your bearing line.