# MAP SCALE

**What is Map Scale ?**

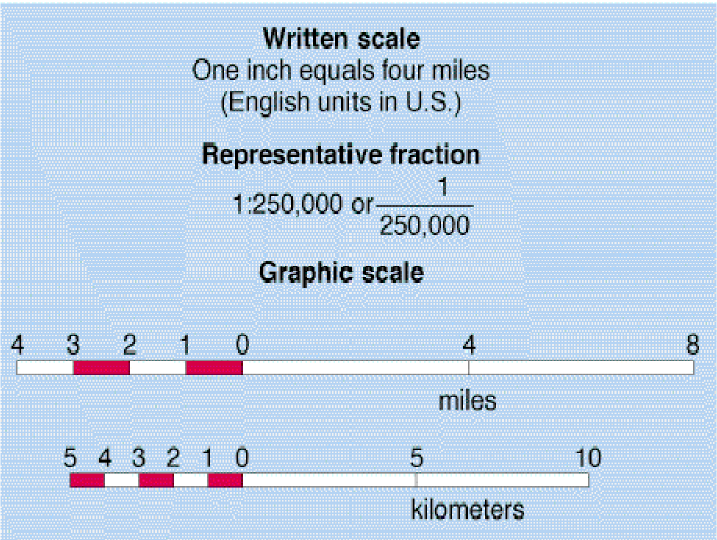
You must have seen maps with a scale bar indicating equal divisions, each marked with readings in kilometres or miles. These divisions are used to find out the ground distance on the map. In other words, a map scale provides the relationship between the map and the whole or a part of the earth's surface shown on it. We can also express this relationship as a ratio of distances between two points on the map and the corresponding distance between the same two points on the ground.

$$\text{Map Scale} = \frac{\text{Map Distance}}{\text{Earth Distance}}$$

There are at least three ways in which this relationship can be expressed.

These are:

1. Statement of Scale
2. Representative Fraction (R. F.)
3. Graphical Scale



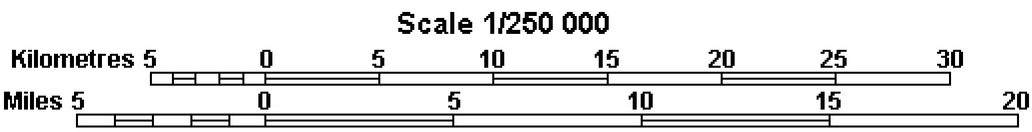

Each of these methods of scale has advantages and limitations. But before taking up these issues, let us understand that the scale is normally expressed in one or the other system of measurement. You must have read and/or used kilometre, metre, centimetre etc. to measure the linear distances between two points on the ground. You might have also heard of miles, furlongs, yards, feet, etc. These are two different systems of measurement of the distances used in different countries of the world. Whereas the former system is referred to as the Metric System of Measurement and presently used in India and many other countries of the world, the latter system is known as the English System of Measurement and is prevalent in both the United States and the United Kingdom. India also used this system for measuring/showing linear distances before 1957.

**1. Statement of Scale:**

The scale of a map may be indicated in the form of a written statement. For example, if on a map a written statement appears stating 1 cm represents 10 km, it means that on that map a distance of 1 cm is representing 10 km of the corresponding ground distance. It may also be expressed in any other system of measurement, i.e. 1 inch represents 10 miles. It is the simplest of the three methods. However, it may be noted that the people who are familiar with one system may not understand the statement of scale given in another system of measurement. Another limitation of this method is that if the map is reduced or enlarged, the scale will become redundant and a new scale is to be worked out.

**2. Graphical or Bar Scale:**

The second type of scale shows map distances and the corresponding ground distances using a line bar with primary and secondary divisions marked on it. This is referred to as the graphical scale or bar scale. It may be noted that the scale readings as shown on the bar scale in reads only in kilometres and metres. In yet another bar scale the readings may be shown in miles and furlongs. Hence, like the statement of scale method, this method also finds restricted use for only those who can understand it. However, unlike the statement of the scale method, the graphical scale stands valid even when the map is reduced or enlarged. This is the unique advantage of the graphical method of the map scale.




**3. Representative Fraction ( R. F. ):**

The third type of scale is R. F. It shows the relationship between the map distance and the corresponding ground distance in units of length. The use of units to express the scale makes it the most versatile method. R. F. is generally shown in fraction because it shows how much the real world is reduced to fit on the map. For example, a fraction of 1 : 24,000 shows that one unit of length on the map represents 24,000 of the same units on the ground i.e. one mm, one cm or one inch on the map representing 24,000 mm, 24,000 cm and 24,000 inches, respectively of the ground. It may, however, be noted that while converting the fraction of units into Metric or English systems, units in centimetre or inch are normally used by convention. This quality of expressing scale in units in R. F. makes it a universally acceptable and usable method. Let us take R. F. of 1 : 36,000 to elaborate the universal nature of R. F. If the given scale is 1: 36,000, a person acquainted with the Metric System will read the given units by converting them into cm, i.e. the distance of 1 unit on the map as 1 cm and the distance of 36,000 units on the ground distance as 36,000 cm. These values may subsequently be converted into a statement of scale, i.e. 1 cm represents 360 metres. (by dividing values in denominator by the number of centimetres in a metre, i.e. 100). Yet another user of the map familiar with the English system of measurement will understand the map scale by converting it into a statement of scale convenient to him/her and read the map scale as 1 inch represents 1,000 yards. The said statement of scale will be obtained by dividing 36,000 units in the denominator by 36 (number of inches in a yard).

• Scale: the relationship between the length measured on a map and the corresponding distance on the ground.

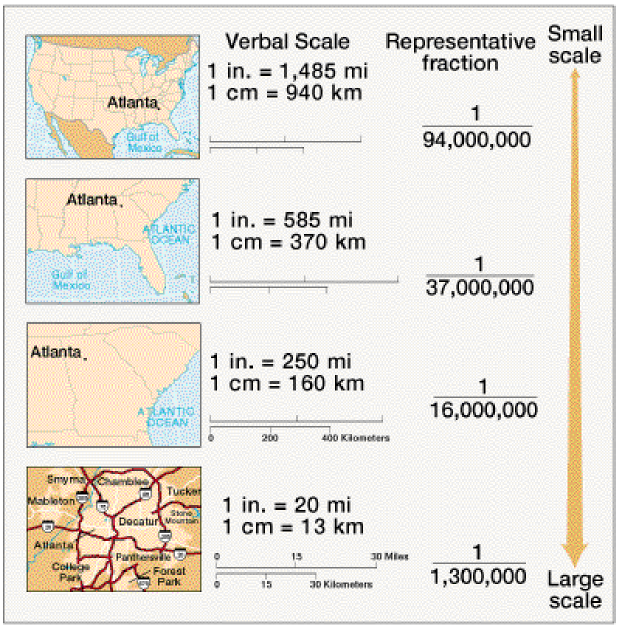
• Allows the map reader to calculate real world distances from a remote location.

– e.g. Map scale is 1: 15000

• on the map you measure the length of a road and find it to be 3 inches.

• 3(15000) = 45000”

• the 3” measured on the map represents 45000” in the real world (then you can convert to desired units)




## <u>Reduction and Enlargement of Maps</u>

In the process of compiling maps cartographers are often required to reduce or enlarge maps. Reduction or enlargement involves change in the size. One simple way to illustrate what happens to the size of a map when it is reduced or enlarged is to fold a sheet of paper. Take a sheet of ordinary notebook and assume it to be a map of a given scale. To show the same area reduced to 1/2 of the original scale, fold the paper in half each way since the both length and breadth of the map are being reduced to half. Now we have one-fourth of the paper area of the original, while the scale is 1/2 of the original. Fold the paper once again in each direction to illustrate four times reduction which gives a paper having 1/16 the size of the original.

This paper folding can also be depicted mathematically. The ratio between the area of a map on one scale and its area on another scale is equal to the square of the ratios between the scales of the original and enlarged maps.

In the process of compiling maps cartographers are often required to either reduce or enlarge maps. Reduction or enlargement involves change in the size.

- An enlargement provides the same map but proportionally larger than the original.
- A reduction gives the same map that is proportionally smaller than the original.

The above image or map has been reduced by ½ .The amount that an original image has been enlarged or reduced is called a scale factor, or an enlargement or reduction factor. It is the constant factor by which all dimensions of an object are enlarged or reduced in a map. If shapes have been reduced by half, the scale factor is ½.

The ratio between the area of a map on one scale and its area to another scale is equal to the square of the ratios between the scales of the original and enlarged or reduced maps.

**Graphical Method**

Graphically maps can be enlarged or reduced with the help of similar squares.

The square method is the most common and simplest method for enlargement and reduction of maps. In order to enlarge a map, cover the original map with a set of squares of equal sides. The side of the squares has to be enlarged proportionally to that the original map. The side of the square of the new map has to be determined using the formula.

Scale of the new map = New scale/old scale x Side of the square of the original map.

1. Square method
2. Method of similar triangles

**Example 1:** . Reduce 1:10,000 to 1:50,000 scale.

10,000:50,000 = 10,000 / 50,000 Or 1/5 of the original line or scale.

And $1/5)^2$ = 1/25 of the area of the original

**Example 2:** Enlarge 1: 100,000 to 1: 20,000

100,000 : 20,000 = 100,000/20,000 = 5 times of the original line or scale and

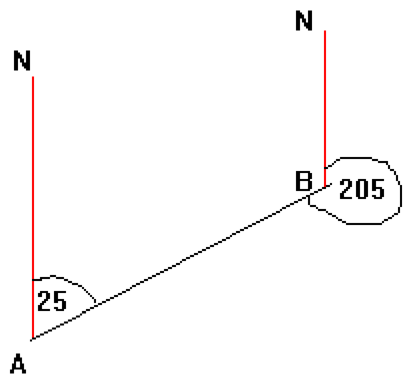
$(5)^2$ = 25 times the area of the original.

If we know the original scale of a map and want to find the new scale of its reduced or enlarged version, we should use the principle of ratios.

**Direction and Bearings**

The main directions in a compass are north, south, east and west. This are shown in a purple and white colour in the diagram. There are also North East, South East, South West and North West this ones are the arrows in blue on the compass.


Bearings is the measurement of an angle between one point to another. They are measured clockwise so for example the bearing from A to B is 25 and from B to A is 205. To measure a bearing first you have to do a north line like shown in the diagram above and from there you measure the angle of the curve until it touches the line connecting the two points.



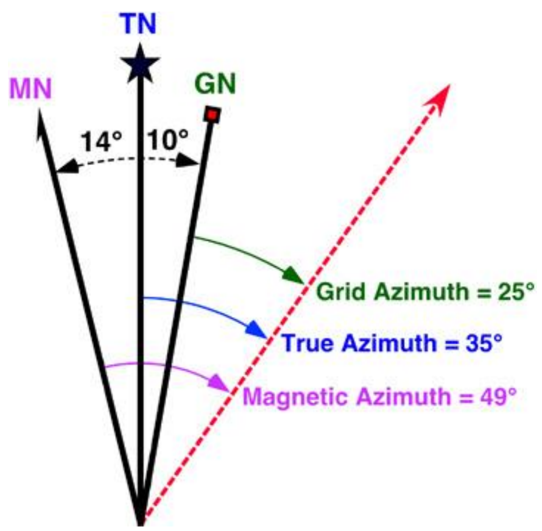

**Coordinates and Their Functions**

We have already noted that a map is a working model of the earth or its parts. To know whether this model represents the earth truly or not, we need a frame of reference to compare the details of the real earth with that of its model. Geographic coordinates are the most commonly used frame of reference. Another frame of reference is known as 'grid system'. The latest method of locating one's position while moving of the land or navigating in the ocean or air is the GPS.

**Direction on Maps**

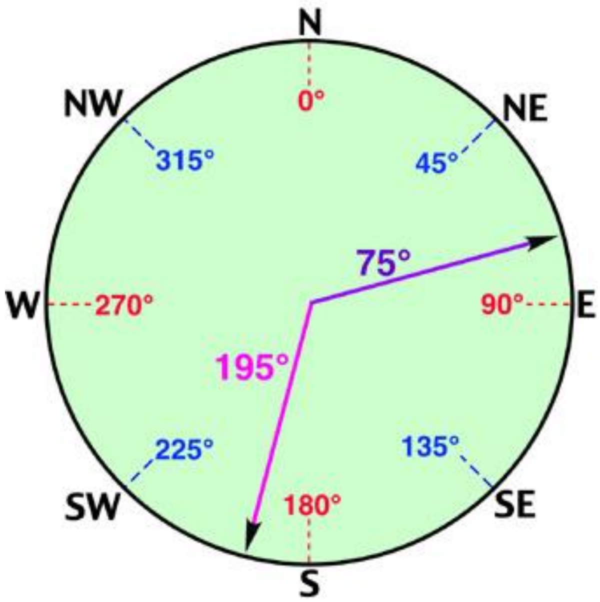
Like distance, direction is difficult to measure on maps because of the distortion produced by projection systems. However, this distortion is quite small on maps with scales larger than 1:125,000. Direction is usually measured relative to the location of **North** or**South Pole**. Directions determined from these locations are said to be relative to **True North** or **True South**. The magnetic poles can also be used to measure direction. However, these points on the Earth are located in spatially different spots from the geographic North and South Pole. The **North Magnetic Pole** is located at 78.3° North, 104.0° West near Ellef Ringnes Island, Canada. In the Southern Hemisphere, the **South Magnetic Pole** is located in Commonwealth Day, Antarctica and has a geographical location of 65° South, 139° East. The magnetic poles are also not fixed overtime and shift their spatial position overtime.

Topographic maps normally have a declination diagram drawn on them. On Northern Hemisphere maps, declination diagrams describe the angular difference between Magnetic North and True North. On the map, the angle of True North is parallel to the depicted lines of longitude. Declination diagrams also show the direction of **Grid North**. Grid North is an angle that is parallel to the**easting** lines found on the **Universal Transverse Mercator** (**UTM**) **grid system**.



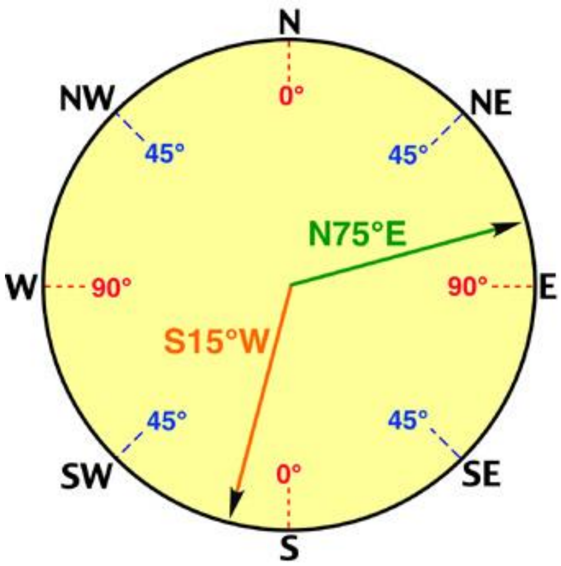
This declination diagram describes the angular difference between Grid, True, and Magnetic North. This illustration also shows how angles are measured relative grid, true, and magnetic azimuth.

In the field, the direction of features is often determined by a magnetic compass which measures angles relative to Magnetic North. Using the declination diagram found on a map, individuals can convert their field measures of magnetic direction into directions that are relative to either Grid or True North. Compass directions can be described by using either the **azimuth** system or the **bearing** system. The azimuth system calculates direction in degrees of a full circle. A full circle has 360 degrees. In the azimuth system, north has a direction of either the 0 or 360°. East and west have an azimuth of 90° and 270°, respectively. Due south has an azimuth of 180°.




**Azimuth** system for measuring direction is based on the 360 degrees found in a full circle. The illustration shows the angles associated with the major cardinal points of the compass. Note that angles are determined clockwise from north.

The bearing system divides direction into four quadrants of 90 degrees. In this system, north and south are the dominant directions. Measurements are determined in degrees from one of these directions. The measurement of two angles based on this system are described in

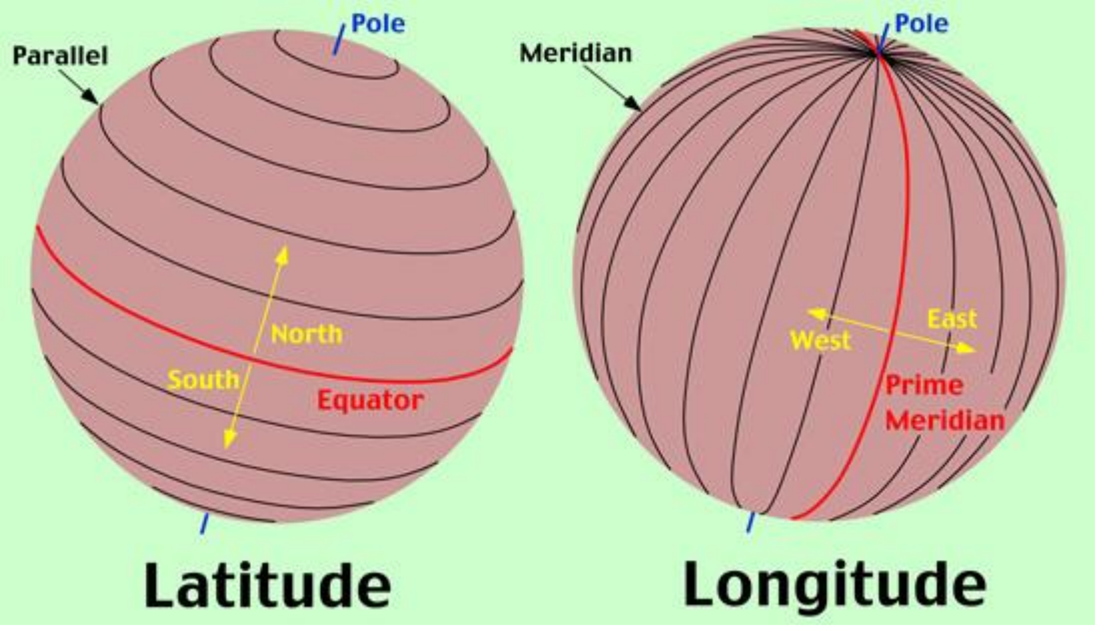



The **bearing** system uses four quadrants of 90 degrees to measure direction. The illustration shows two direction measurements. These measurements are made relative to either north or south. North and south are given the measurement 0 degrees. East and west have a value of 90 degrees. The first measurement (**green**) is found in the north - east quadrant. As a result, its measurement is north 75 degrees to the east or N75°E. The first measurement (**orange**) is found in the south - west quadrant. Its measurement is south 15 degrees to the west or S15°W.

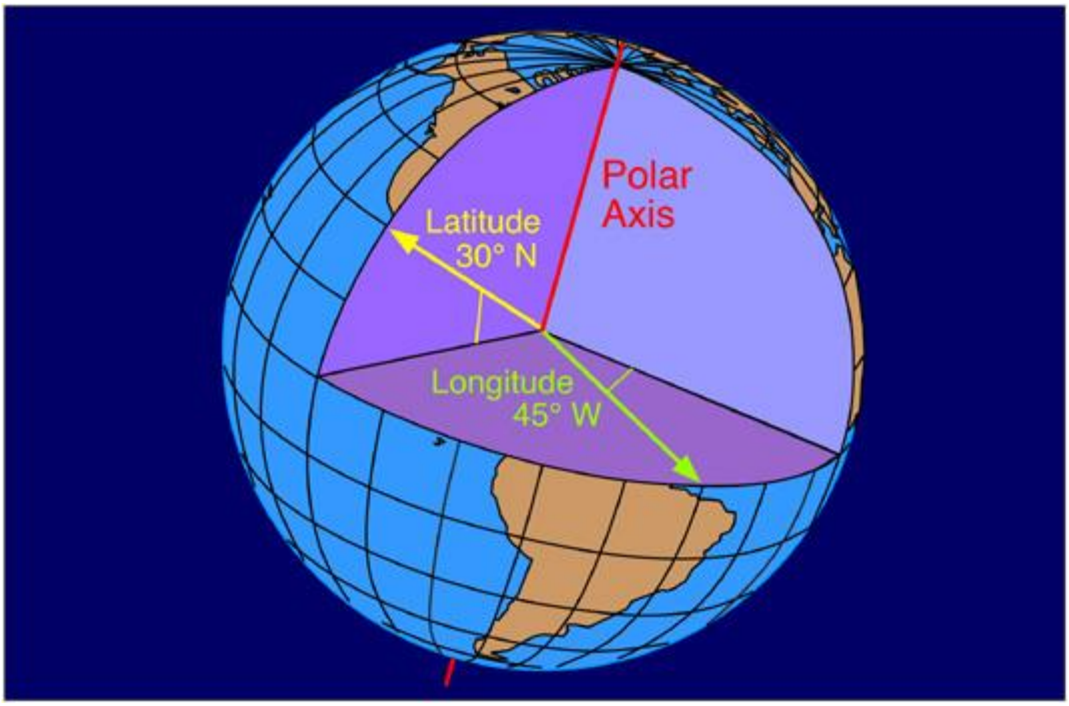
Two types of coordinate systems are currently in general use in geography: the **geographical coordinate system** and the **rectangular**(also called **Cartesian**) **coordinate system**.

**Geographical Coordinate System**

The **geographical coordinate system** measures location from only two values, despite the fact that the locations are described for a three-dimensional surface. The two values used to define location are both measured relative to the **polar axis** of the Earth. The two measures used in the geographic coordinate system are called **latitude** and **longitude**.




**Latitude** measures the north-south position of locations on the Earth's surface relative to a point found at the center of the Earth. This central point is also located on the Earth's rotational or **polar axis**. The equator is the starting point for the measurement of latitude. The equator has a value of zero degrees. A line of latitude or **parallel** of 30° North has an angle that is 30° north of the plane represented by the equator (**Figure 2b-3**). The maximum value that latitude can attain is either 90° North or South. These lines of latitude run parallel to the rotational axis of the Earth.




**Longitude** measures the west-east position of locations on the Earth's surface relative to a circular arc called the **Prime Meridian**. The position of the Prime Meridian was determined by international agreement to be in-line with the location of the former astronomical observatory at Greenwich, England. Because the Earth's circumference is similar to circle, it was decided to measure longitude in degrees. The number of degrees found in a circle is 360. The Prime Meridian has a value of zero degrees. A line of longitude or **meridian** of 45° West has an angle that is 45° west of the plane represented by the Prime Meridian The maximum value that a **meridian** of longitude can have is 180° which is the distance halfway around a circle. This meridian is called the**International Date Line**. Designations of west and east are used to distinguish where a location is found relative to the Prime Meridian. For example, all of the locations in North America have a longitude that is designated west.

Geographic coordinates provide the convenient reference points for determining location, distance and direction relationships on the ground as well as on the map. Had the earth been flat, the development of the networks of geographical coordinates would have been a simple matter. Because of its spherical shape the principle of spherical geometry involving complicated trigonometric calculations have to be used for this purpose.

The principle underlying the division of the earth by a network of geographic coordinates is the same as the preparation of a line graph with Y and X axis. In all graphs we must have a point of origin and two reference lines: a horizontal line or X axis or abscissa, and a vertical line or Y axis or ordinate. we can draw innumerable lines parallel to OX and OY. The intersection of a pair of these lines will give the location of a point. If we want the location of point m, we can say it is at 2X and 2Y. When a similar set of lines are drawn on the spherical earth, the horizontal lines are called parallels or latitudes and the vertical lines are called meridians or longitudes. The network of these parallels and meridians is called geographic coordinates.

**PARALLELS OR LATITUDES**

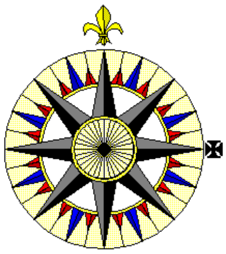
There are three types of parallels of latitudes. They are:

1. Astronomical,

2. Geocentric, and

3. Geographical.

- Longitude
  - Measures distance east to west around the globe beginning at the Prime Meridian
  - Prime Meridian
  - International Date Line
  - 0-180 degrees East or West

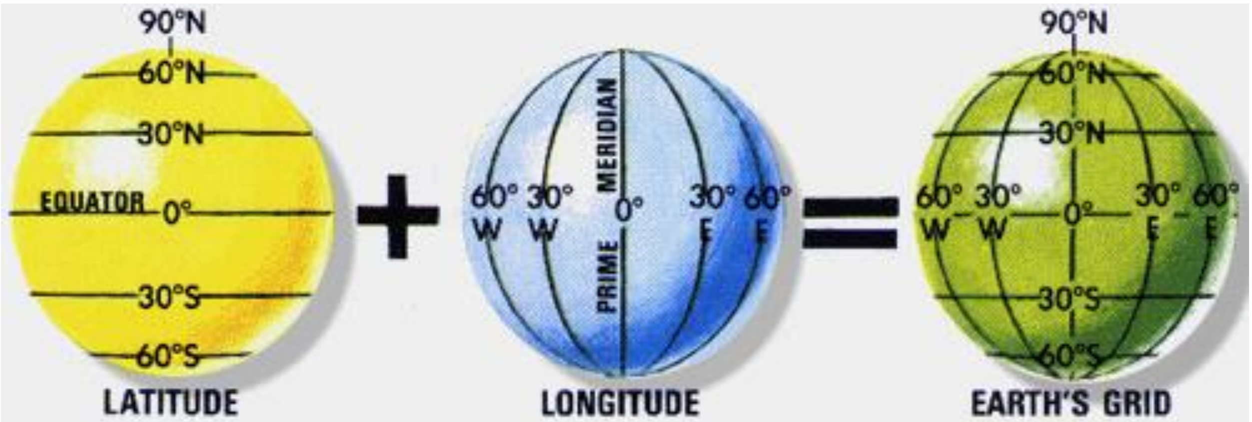


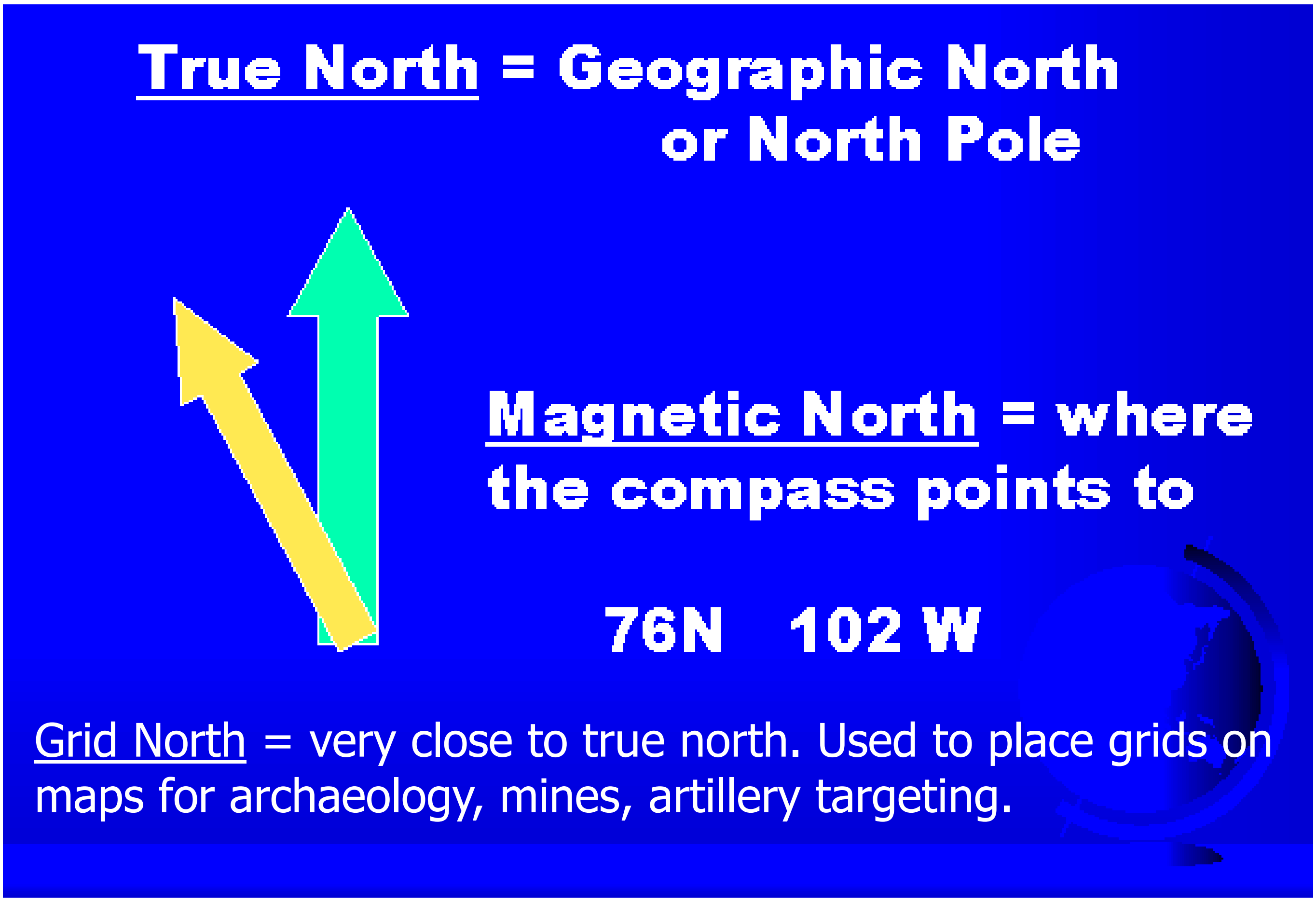
- Latitude
  - Location on the Earth's surface between the equator and either the north or south pole
  - Parallels
  - 0-90 degrees North or South

- **Latitude** – angular distance measured north or south of the Equator through 90º of arc. Degree of constant length – 69 miles.
- **Parallels** – not lines of latitude
- Poleward reduction in length
- **Longitude** – angular distance measured east or west of the Prime Meridian through 180º of arc. Degree distance decreases poleward.
- **Meridians** – not lines of longitude
- All meridians have the same length ½ of Equator

**A Grid**

Latitude and longitude may be combined on a globe or map to create a grid. One specific parallel will only intersect a specific meridian at one place on the earth. Using the two together allows for locating places precisely.






**Map projection**

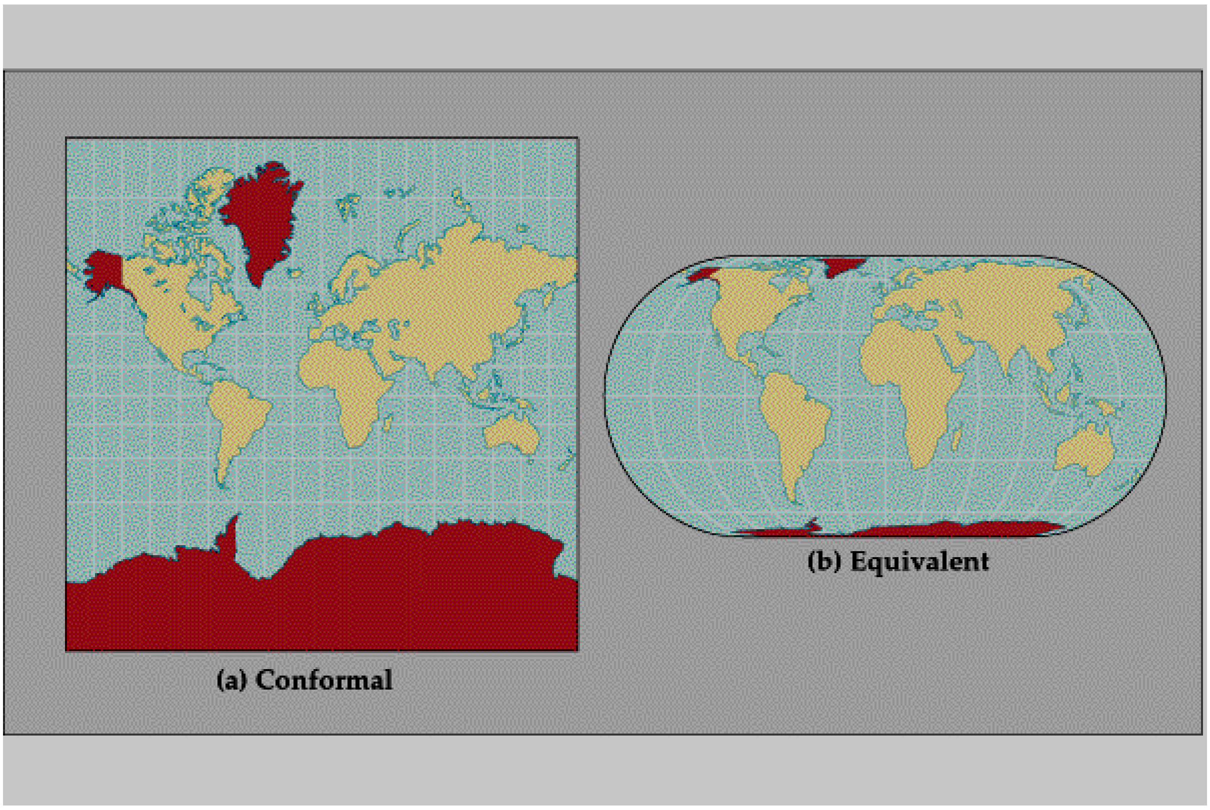
Mathematical method for systematically transforming a 3-D earth into a 2-D map.

A great variety of map projections has been devised to provide for the various properties that may be desired in maps. In effect, a projection is a systematic method of drawing the Earth's meridians and parallels on a flat surface. Some projections have equal-area properties, while others provide for conformal delineations in which, for small areas, the shape is practically the same as it would be on a globe. Only on a globe can areas and shapes be represented with true fidelity. On flat maps of very large areas, distortions are inevitable. These effects may be minimized by selecting the projection best suited to the purpose of the map to be produced.

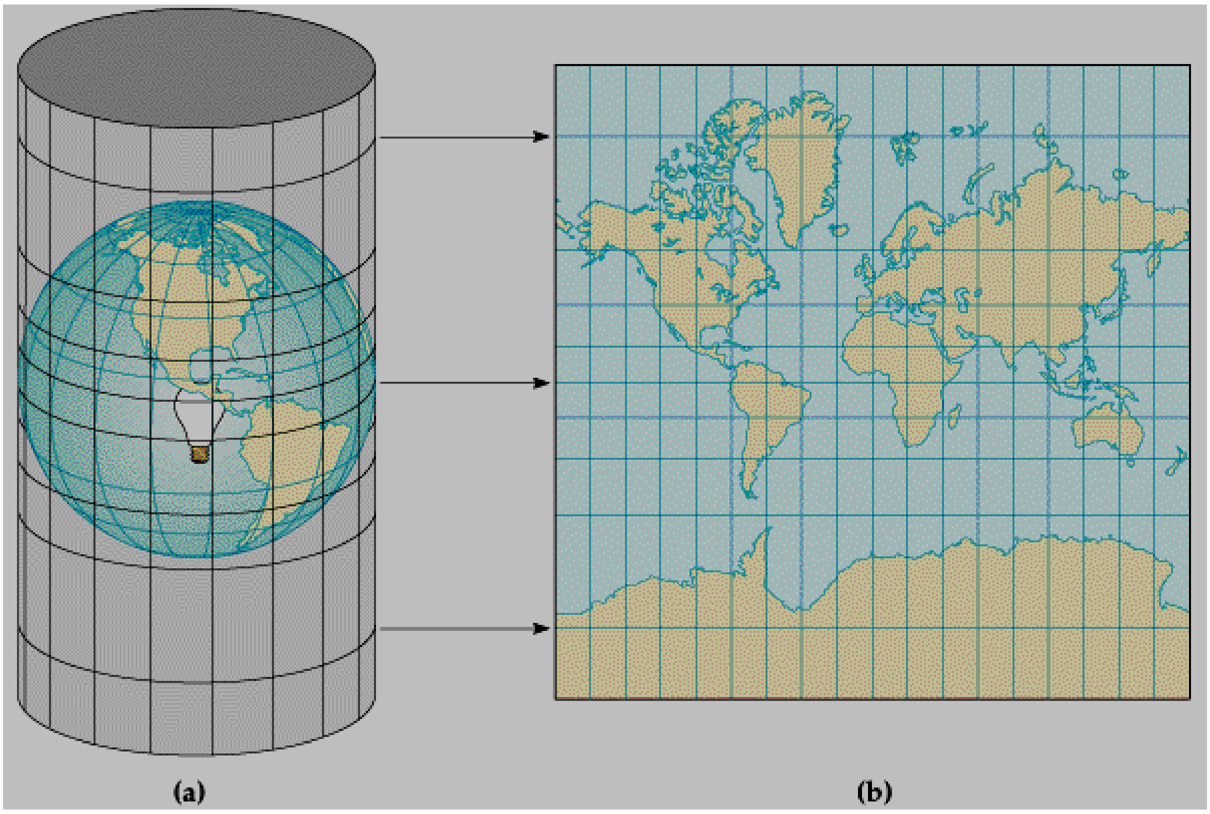
Three traditional types:

1. cyllindrical
2. conical

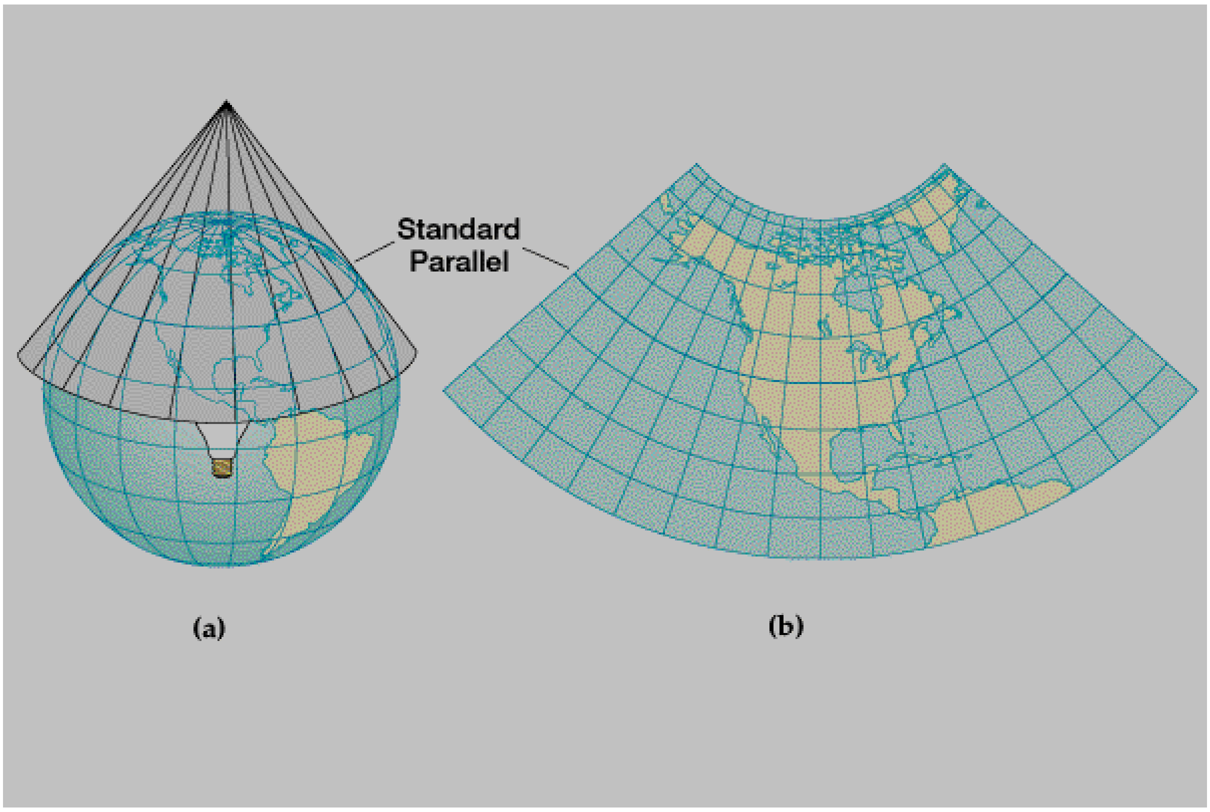
3. planar (azimuthal-zenithal)



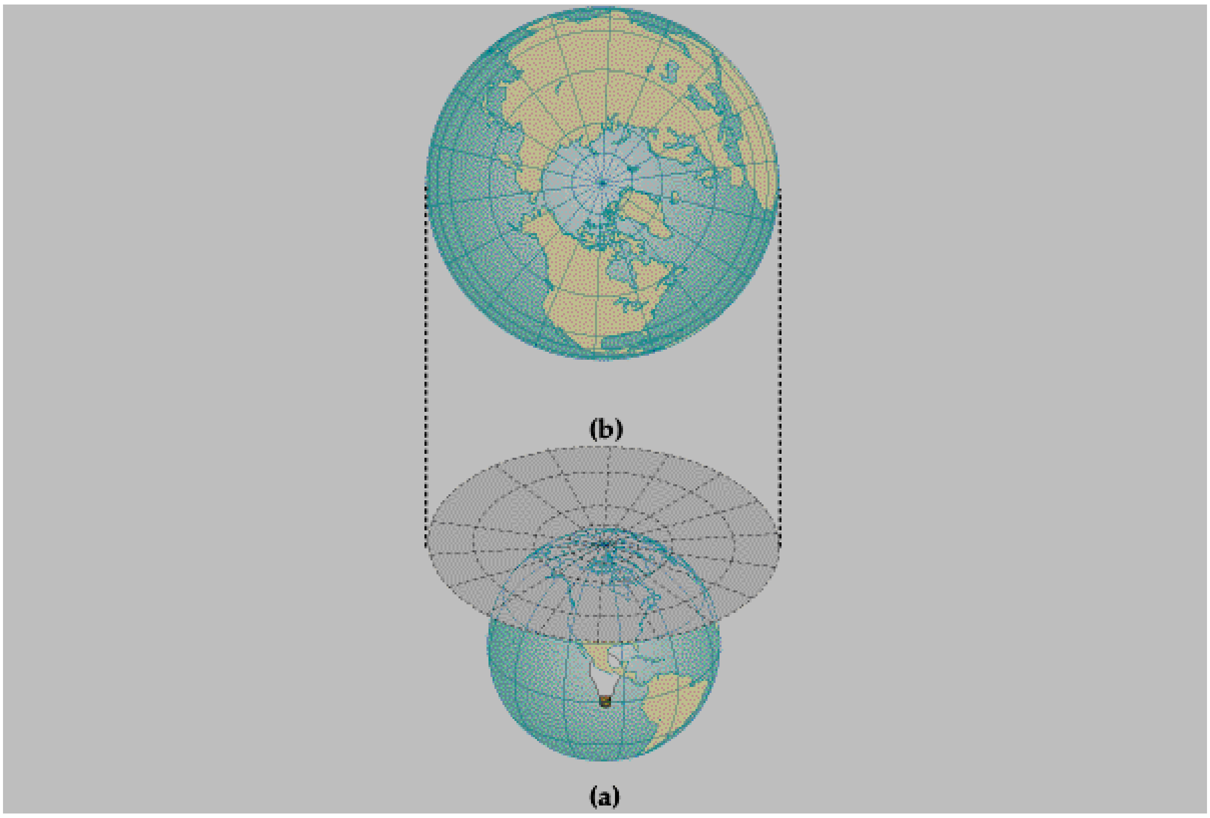

1. cyllindrical



2. conical




3. planar (azimuthal-zenithal)



**Uses of Map Projections**

The method used to portray a part of the spherical Earth on a flat surface, whether a paper map or a computer screen, is called a map projection. No flat map can rival a globe in truly representing the surface of the entire Earth, so every flat map misrepresents the surface of the Earth in some way. A flat map can show one or more--but never all--of the following:

- True directions
- True distances
- True areas
- True shapes

Different projections have different uses. Some projections are used for navigation, while other projections show better representations of the true relative sizes of continents.

For example, the basic Mercator projection yields the only map on which a straight line drawn anywhere within its bounds shows a true direction, but distances and areas on Mercator projection maps are grossly distorted near the map's polar regions. On an equidistant map projection, distances are true only along particular lines, such as those radiating from a single point selected as the center of the projection. Shapes are more or less distorted on every equal-area map.

The scale of a map on any projection is often crucial to the map's usefulness for a given purpose. For example, the extreme distortion that is present at high latitudes on a small-scale Mercator map of the World disappears almost completely on a properly oriented Transverse Mercator map of a small area in the same high latitudes. A large-scale (1:24,000) 7.5-minute USGS topographic map based on the Transverse Mercator projection is nearly correct in every respect.