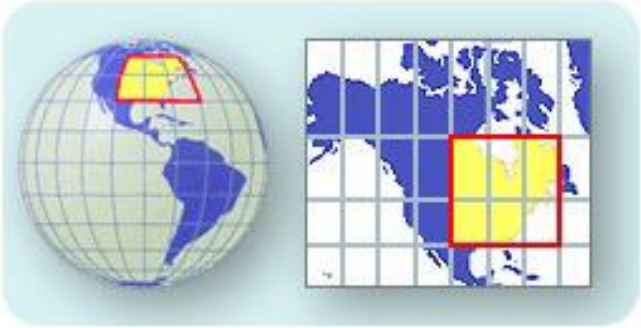
1. Map Projections

Map projection is the geographic grid (Lat. &Long.) transformation to a plain Coordinate system (E & N), (i.e. Displaying the Earth on 2-dimensional maps). It has interacted with Cartography, Photogrammetry, GIS, Remote Sensing, etc.

Advantages:

- The map is specified to be flat.
- Managed for handling.
- Able to define the scale.



2. Why Map Projections?

The shape of the Earth is spherical. Therefore the best model used to represent the Earth is a globe. Disadvantages of the model:

- Difficult to handle.
- Having problems in taking measurements on it (e.g. distance, area, angle).

3. Map History, the map appeared a long time ago in different stages:

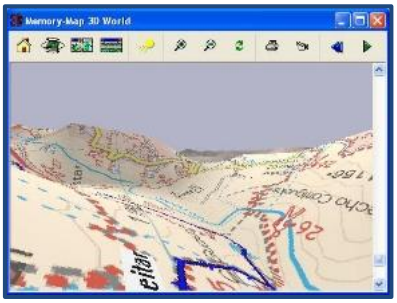
a) **Early Maps,** The oldest known maps are preserved on Babylonian clay tablets from about 2300 B.C.

b) **Medieval Maps**, During the Medieval period, European maps were dominated by religious views.

c) **Renaissance Maps** (14th to 17th century), The invention of printing made maps much more widely available beginning in the 15th century (i.e. printed on wooden blocks).

d) **Modern Maps:** Maps became increasingly accurate and factual during the 17th, 18th and 19th centuries with the application of scientific methods. Many countries undertook national mapping programs. Modern cartography is based on a combination of ground observations and remote sensing.

e) **Digital Maps, Digital mapping** (also called **digital cartography**) is the process by which data collection is compiled and formatted into a virtual image.



4. **Coordinate systems,**
   Different coordinates are used to position objects in a two- or three-dimensional space.

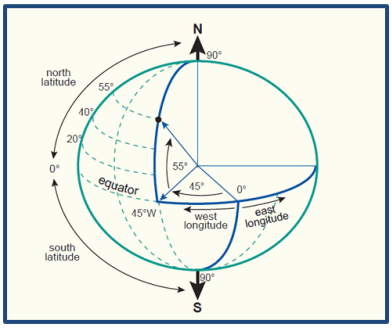
Spatial coordinates (also known as global coordinates) are used to locate objects on the Earth's surface in a 3D space or on the Earth's reference surface (ellipsoid or sphere) in a 2D space.

The coordinate systems that are used to define the point are as follows:

a) 2D geographic coordinates (ϕ,λ)

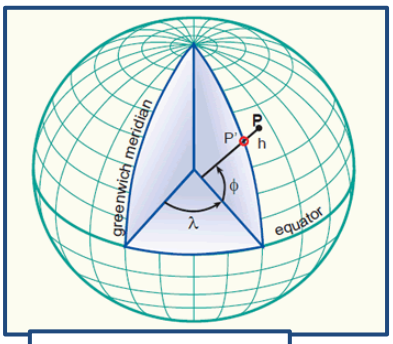
Geographic coordinates are always given in angular units. It is consisted from

- *Latitude*(phi or ϕ or φ): the angle north or south from the equatorial plane. ($\phi = 0°$), at the equator and increases toward the poles. ranges from +90 (90°N) to -90 (90°S).



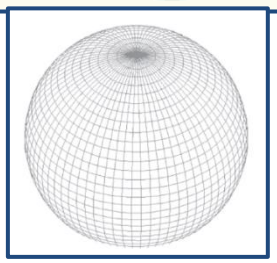
- *Longitude* (lambda or λ): the angle east or west from an identified meridian of Greenwich ($\lambda = 0°$) ranges from + 180° (180°E) to -180° (180°W).

- Latitude and longitude represent the ***geographic coordinates*** (ϕ,λ) of a point P' (figure below) with respect to the selected reference surface.
- They are also called **<u>geodetic coordinates or ellipsoidal coordinates</u>** when an ellipsoid is used to approximate the shape of the Earth.

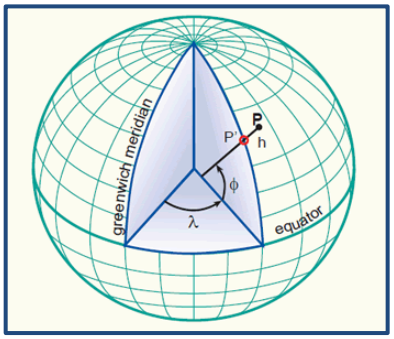


b) Latitude and longitude specifications

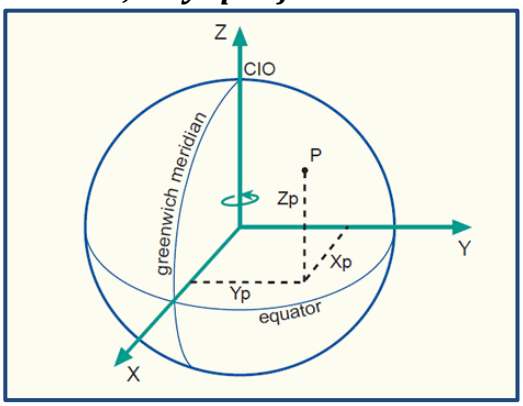
- Lines of equal latitude are called parallels, and they form circles on the surface of the ellipsoid.
- Lines of equal longitude are called meridians, and they form ellipses (meridian ellipses) on the ellipsoid.
- Both lines form the graticule when projected onto a map plane, producing lattice on the surface.
- A Graticule produced from the intersection of parallels and meridians



c) ***3D geographic coordinates*** (ϕ, λ, h), Are obtained by introducing the ellipsoidal height **h** to the system. The **ellipsoidal height** (h) of a point is the vertical distance of the point in the question above the ellipsoid.



d)* Geocentric coordinates (*X,Y,Z*) or *3D Cartesian coordinates, they specified to be:



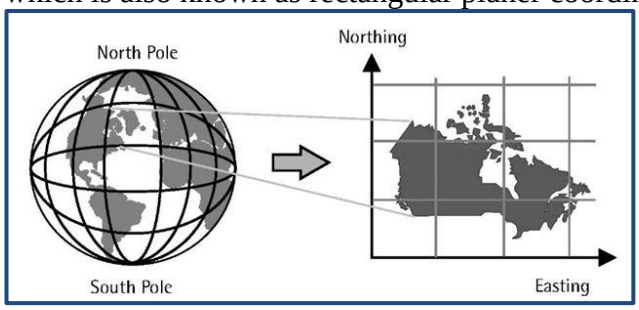
- Used to define a position on the surface of the Earth (point P in the figure right).
- Has its origin at the mass centre of the Earth with the *X*- and *Y*-axes in the plane of the equator.
- The *X*-axis passes through the meridian of Greenwich, and the *Z*-axis coincides with the Earth's axis of rotation.
- The three axes are mutually orthogonal and form a right-handed system.

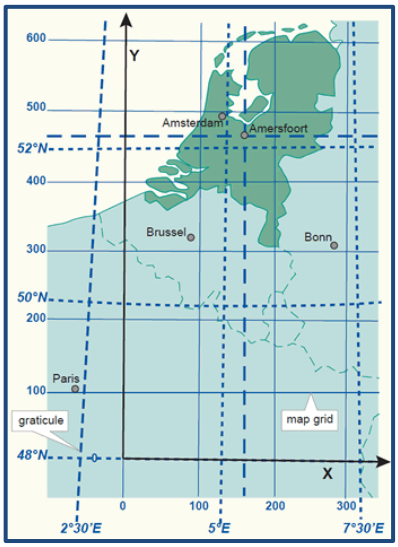
Note: The rotational axis of the Earth changes its position over time (referred to as ***polar motion***). To compensate for this, the mean position of the pole in the year 1903 (based on observations between 1900 and 1905) has been used to define the so-called 'Conventional International Origin' (CIO).

e) 2D Cartesian coordinates (*X,Y*) ,

Transforming the three-dimensional Earth into a two-dimensional map is the subject of map projections and coordinate transformations.

To describe the location of any point in a map plane, noticeably, like other cartographic applications, rectangular planer coordinates (x,y), which is also known as rectangular planer coordinate is used.





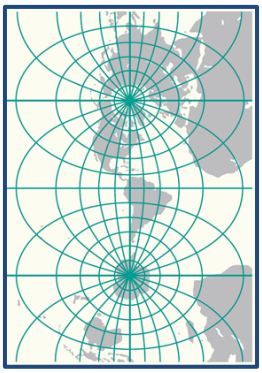
<u>The specification of 2D Cartesians are:</u>

- It is consisted of intersecting two perpendicular lines: the horizontal axis, the *X*-axis, which is also sometimes called ***Easting,*** and the vertical, *Y*-axis, called ***Northing***.
- The intersection of the *X*- and *Y*-axis forms the ***origin***.
- The plane is marked at intervals by equally spaced coordinate lines, called the map grid.
- Normally, the coordinates $x = 0$ and $y = 0$ are given to the origin, which is called the ***false origin***. However, sometimes large positive values are added to the origin coordinates. This is to avoid negative values for the *x* and *y* coordinates in case the origin of the coordinate system is located inside the area of interest.
- The ***grid*** on a map represents lines having constant 2D Cartesian coordinates (*x,y*). It is almost always a rectangular system and is used on **large and medium**-scale maps to enable detailed calculations and positioning.
- The map grid is usually not shown on small-scale maps (about one to a million or smaller). Scale distortions that result from transforming the Earth's curved surface to the map plane are so great on small-scale maps that detailed calculations and positioning are complicated.

Graticule, the ***graticule*** on a map represents the projected position of the geographic coordinates (ϕ,λ) at constant intervals, or in other words,, the projected position of selected meridians and parallels.

The grid specifications are:

- Used in topographic mapping,
- Specified to be rectangular, all the sheet maps will be the same size.
- Allowing a completely uniform arrangement of the marginal information.

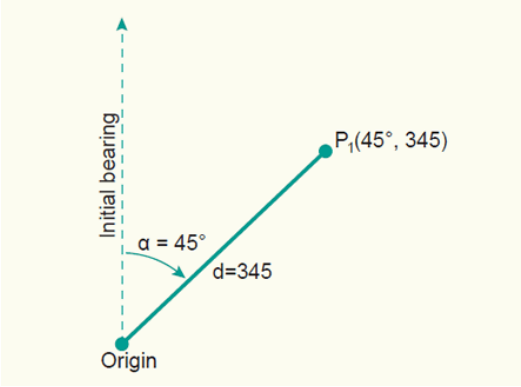


These graticule specifications are:

- The graticule as an outline of the mapped area might give a curved outline
- The shape of the graticule depends largely on the characteristics of the map projection used and the scale of the map,

f) 2D polar coordinates (α,d)

It is another method to define the point, the distance d from the origin to the point concerned and the angle α between a fixed (or zero) direction and the direction to the point.
The angle α is called ***azimuth*** or ***bearing*** and is measured in a clockwise direction. It is given in angular units, while the distance d is expressed in length units.



An illustration of the 2D Polar coordinate system.

Bearings are always related to a fixed direction (initial bearing) or a datum line.

In principle, this reference line can be chosen freely. However, in practice, three different directions are widely used: ***True North***, ***Grid North*** and ***Magnetic North***. The corresponding bearings are true (or geodetic) bearing, grid bearing and magnetic (or compass) bearing.

Reading list:

http://www.icsm.gov.au/education/fundamentals-mapping/history-mapping
https://www.nationalgeographic.org/media/selecting-map-projection/
http://www.icsm.gov.au/education/fundamentals-mapping/earths-coordinate-system
https://www.thoughtco.com/geography-basics-4133034