Coordinate System

[B.A. Sem. – I (Hons.)- CC2]

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What is a coordinate system?

Coordinate systems enable geographic datasets to use common locations for integration. A coordinate system is a reference system used to represent the locations of geographic features, imagery, and observations, such as Global Positioning System (GPS) locations, within a common geographic framework.

Each coordinate system is defined by the following:

Its measurement framework, which is either geographic (in which spherical coordinates are measured from the earth's center) or planimetric (in which the earth's coordinates are projected onto a two dimensional planar surface)

Units of measurement (typically feet or meters for projected coordinate systems or decimal degrees for latitude longitude)

The definition of the map projection for projected coordinate systems

Other measurement system properties such as a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the x and y directions.

Several hundred geographic coordinate systems and a few thousand projected coordinate systems are available for use. In addition, you can define a custom coordinate system.

Types of coordinate systems

The following are two common types of coordinate systems used in a geographic information system (GIS):

A global or spherical coordinate system such as latitude longitude. These are often referred to as geographic coordinate systems.

A projected coordinate system such as universal transverse Mercator (UTM), Albers Equal Area, or Robinson, all of which (along with numerous other map projection models) provide various mechanisms to project maps of the earth's spherical surface onto a two dimensional Cartesian coordinate plane. Projected coordinate systems are referred to as map projections. Coordinate systems (both geographic and projected) provide a framework for defining real world locations.

Geographic coordinate systems

A geographic coordinate system (GCS) uses a three dimensional spherical surface to define locations on the earth. A GCS is often incorrectly called a datum, but a datum is only one part of a GCS. A GCS includes an angular unit of measure, a prime meridian, and a datum (based on a spheroid). The spheroid defines the size and shape of the earth model, while the datum connects the spheroid to the earth's surface.

A point is referenced by its longitude and latitude values. Longitude and latitude are angles measured from the earth's center to a point on the earth's surface. The angles often are measured in degrees (or in grads).

Projected coordinate systems

A projected coordinate system (PCS) is defined on a flat, two-dimensional surface. Unlike a GCS, a PCS has constant lengths, angles, and areas across the two dimensions. A PCS is always based on a GCS that is based on a sphere or spheroid. In addition to the GCS, a PCS includes a map projection, a set of projection parameters that customize the map projection for a particular location, and a linear unit of measure.

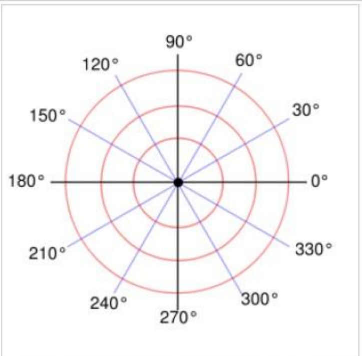
Vertical coordinate systems

A vertical coordinate system defines the origin for height or depth values. Like a horizontal coordinate system, most of the information in a vertical coordinate system is not needed unless you want to display or combine a dataset with other data that uses a different vertical coordinate system. Perhaps the most important part of a vertical coordinate system is its unit of measure. The unit of measure is always linear (for example, international feet or meters). Another important part is whether the z values represent heights (elevations) or depths. For each type, the z axis direction is positive "up" or "down," respectively.

Polar Coordinate System

In mathematics, the polar coordinate system is a two dimensional coordinate system in which each point on a plane is determined by an angle and a distance. The polar coordinate system is especially useful in situations where the relationship between two points is most easily expressed in terms of angles and distance; In the more familiar Cartesian or rectangular coordinate system, such a relationship can only be found through trigonometric formulae.

As the coordinate system is two dimensional, each point is determined by two polar coordinates: the radial coordinate and the angular coordinate. The radial coordinate (usually denoted as r) denotes the point's distance from a central point known as the *pole* (equivalent to the *origin* in the Cartesian system). The angular coordinate (also known as the polar angle or the azimuth angle, and usually denoted by θ or t) denotes the positive or anticlockwise (Counter clockwise) angle required to reach the point from the 0° ray or *polar axis* (which is equivalent to the positive x axis in the Cartesian coordinate plane).



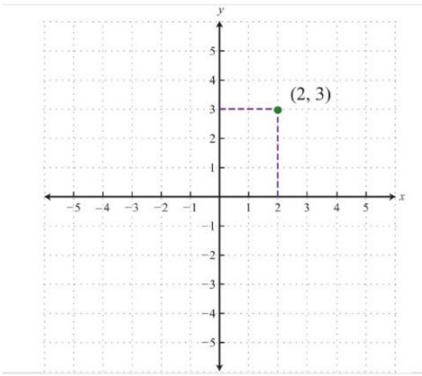
A polar grid with several angles labeled in degrees

Rectangular Coordinate System

The rectangular coordinate system consists of two real number lines that intersect at a right angle.

The horizontal number line is called the x axis, and the vertical number line is called the y axis. These two number lines define a flat surface called a plane, and each point on this plane is associated with an ordered pair of real numbers (x, y). The first number is called the x coordinate, and the second number is called the y coordinate. The intersection of the two axes is known as the origin, which corresponds to the point (0, 0).

An ordered pair (x, y) represents the position of a point relative to the origin. The x coordinate represents a position to the right of the origin if it is positive and to the left of the origin if it is negative. The y coordinate represents a position above the origin if it is positive and below the origin if it is negative. Using this system, every position (point) in the plane is uniquely identified. For example, the pair (2, 3) denotes the position relative to the origin as shown:



This system is often called the Cartesian coordinate system, named after the French mathematician René Descartes (1596–1650).

Geoid

The **geoid** is the shape that the surface of the oceans would take under the influence of Earth's gravity and rotation alone, in the absence of other influences such as winds and tides. This surface is extended through the continents (such as with very narrow hypothetical canals). All points on a geoid surface have the same effective potential (the sum of gravitational potential energy and centrifugal potential energy). The geoid can be defined at any value of gravitational potential such as within the Earth's crust or far out in space, not just at sea level. The force of gravity acts everywhere perpendicular to the geoid, meaning that plumb lines point perpendicular and water levels parallel to the geoid if only gravity and rotational acceleration were at work.

Specifically, the geoid is the equipotential surface that would coincide with the mean ocean surface of Earth if the oceans and atmosphere were in equilibrium, at rest relative to the rotating Earth,[1] and extended through the continents (such as with very narrow canals). According to Gauss, who first described it, it is the "mathematical figure of Earth", a smooth but highly irregular surface whose shape results from the uneven distribution of mass within and on the surface of Earth. It does not correspond to the actual surface of Earth's crust, but to a surface which can only be known through extensive gravitational measurements and calculations. Despite being an important concept for almost two hundred years in the history of geodesy and geophysics, it has only been defined to high precision since advances in satellite geodesy in the late 20th century. It is often described as the true physical figure of the Earth, in contrast to the idealized geometrical figure of a reference ellipsoid.

The surface of the geoid is higher than the reference ellipsoid wherever there is a positive gravity anomaly (mass excess) and lower than the reference ellipsoid wherever there is a negative gravity anomaly (mass deficit).

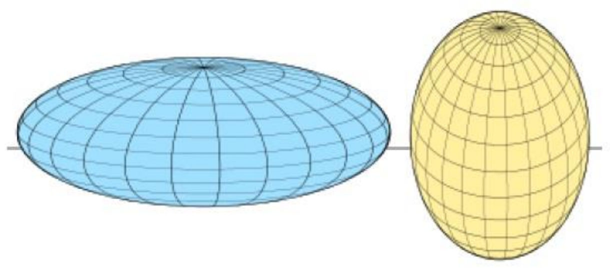
Spheroid

A **spheroid**, or **ellipsoid of revolution**, is a quadric surface obtained by rotating an ellipse about one of its principal axes; in other words, an ellipsoid with two equal semi-diameters.

If the ellipse is rotated about its major axis, the result is a **prolate** (elongated) spheroid, shaped like anA merican football or rugby ball. If the ellipse is rotated about its minor axis, the result is an **oblate** (flattened) spheroid, shaped like a lentil. If the generating ellipse is a circle, the result is a sphere. A spheroid has circular symmetry. Because of the combined effects of gravity and rotation, the shape of the Earth, and of all planets, is not quite a sphere but instead is slightly flattened in the direction of its axis of rotation. For that reason, in cartography the Earth is often approximated by an oblate spheroid instead of a sphere. The current World Geodetic System model uses a spheroid whose radius is 6,378.137 km (3,963.191 mi) at the equator and 6,356.752 km (3,949.903 mi) at thep oles.

The word "spheroid" originally meant "an approximately spherical body", admitting irregularities even beyond the bi- or tri-axial ellipsoidal shape, and that is how the term is used in some older papers on geodesy.

Example spheroids



oblate | *prolate*