

## Topic 1 - For Our Eyes Only

### Frames of Reference

A **frame of reference** is a set of axes of any kind that is used to describe positions or motions of things. The stars, the Sun and the planets do not rotate around the Earth, but seem to because the Earth is rotating on its axis. The Earth is our fixed frame of reference. To locate positions on Earth, the equator and the prime meridian (latitude and longitude) are the axes used.

Reference Frames and Coordinate Systems - <http://theory.uwinnipeg.ca/physics/intro/node9.html>

Concepts of Earth and Space - <http://nssdc.gsfc.nasa.gov/planetary/>

### What Our Ancestors Saw

Objects in the sky have fascinated humans throughout time. The explanations of how these celestial objects came to be are even more fascinating. Ancients developed their ideas of what was happening in the sky and explained it with their frame of reference. The **constellations** were patterns that seemed to tell stories about people. Stars are not always in the sky at the same time, but change positions over time – giving rise to the creation of calendars. The Sun and the Moon have their own pattern of rising and setting – the Moon also has phases. Mercury, Venus, Mars, Jupiter, and Saturn were special ‘stars’ called **planets** – meaning ‘wanderer’.

<http://www.electric-cosmos.org/ouruniverse.htm> - <http://www.uts.utoronto.ca/~shaver/ancient.htm>

### Ancient Myths

Myths, folklore and legends were used to explain what ancient people observed in the night sky.

- **First Nations people of the Pacific Northwest** – believed the night sky was a pattern on a great blanket overhead, which was held up by a spinning ‘world pole’ resting on the chest of a woman named Stone Ribs.
- **Aboriginal tribes** – Algonquin, Iroquois and Narragansett believed the constellation Ursa Major was a bear running from hunters.
- **Inuit in the high Arctic** – used a mitt to determine when seal pups would be born, by holding the mitt at arm’s length at the horizon.
- **Ancient Egyptians** - The Sun God – Ra – was carried in a sacred boat across the sky every day.

**Solstice** represents the shortest and longest periods of daylight

<http://www.equinox-and-solstice.com/>

*Winter solstice* - shortest period of daylight (Northern hemisphere - Dec. 21)

*Summer solstice* – longest period of daylight (Northern hemisphere - June 21)

- **The Ancient Celts** set up megaliths, in concentric circles, at **Stonehenge** to mark the winter and summer solstices.
- **Ancient African** cultures set large rock pillars into patterns to predict the timing of the solstices as well.

**Equinox** represents periods of equal day and night

<http://solar.physics.montana.edu/YPOP/Classroom/Lessons/Sundials/equinox.html>

*Autumnal equinox* – occurs in the fall (Northern hemisphere - Sept. 22)

*Vernal equinox* – occurs in the spring (Northern hemisphere - Mar. 21)

- The **Mayans of Central America** built an enormous cylinder shaped tower, at Chichen Itza, to celebrate the two equinoxes.
- The **Ancient Egyptians** built many pyramids and other monuments to align with the seasonal position of certain stars.
- **Aboriginal Peoples of Southwestern Alberta** used key rocks, which aligned with certain stars, in their medicine circles.

**Constellations** are the groupings of stars we see as patterns in the night sky. There are 88 constellations and many are explained in Greek Mythology.

<http://www.enchantedlearning.com/subjects/astronomy/stars/constellations.shtml>

**Asterisms** are also groupings of stars, but are not officially recognized as constellations.

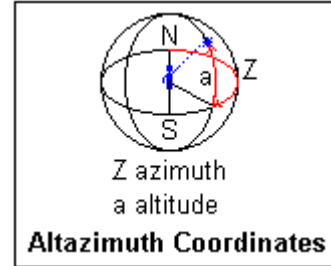
<http://www.cns.uni.edu/~morgan/astro/asterisms.html>

### Sky Co-ordinates

**Altitude** and **Azimuth** are calculated from the observer's (*the person in blue*) position:

**Altitude** tells you "*how far above the horizon the object is*"; the point straight overhead has an altitude of +90 degrees; straight underneath, an altitude of -90 degrees. Points on the horizon have 0 degree altitudes. An object halfway up in the sky has an altitude of 45 degrees.

**Azimuth** determines "*which compass direction it can be found in the sky*." An azimuth of zero degrees puts the object in the North. An azimuth of 90 degrees puts the object in the East, and one of 270 degrees puts the object in the west. Thus, if you are told that an object is at altitude 30 degrees, azimuth 80 degrees - look a little North of due East, about a third of the way from the horizon to the zenith.

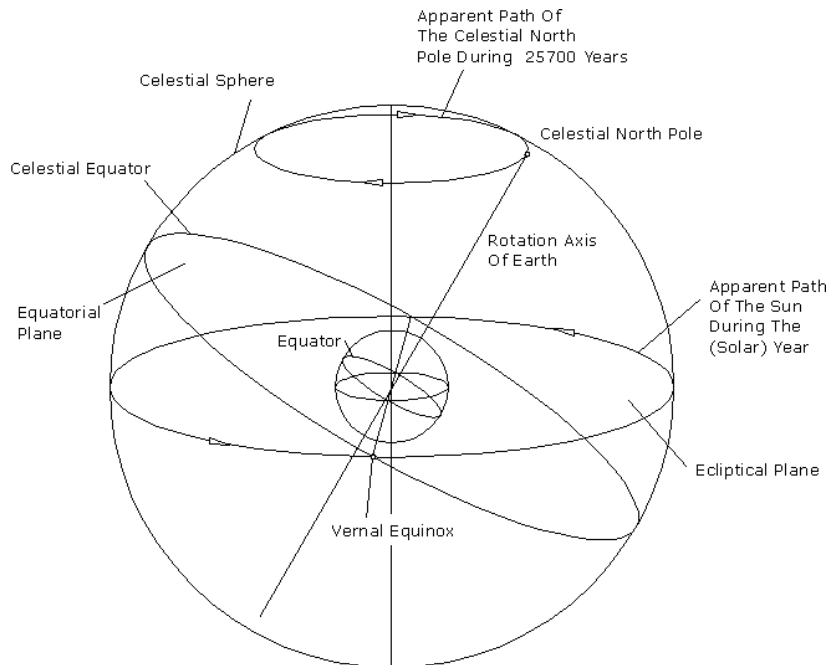


Java script applet: <http://www.kemi.fi/kk021498/Java/sunapplet.html>

**Zenith** is the position in the sky directly overhead.

The path in the sky along which the Sun takes is called the **ecliptic**.

The **Celestial Sphere** is the name given to the very large imaginary '*sphere of sky*' surrounding the Earth.



[http://www.ortelius.de/kalender/basic\\_en.php](http://www.ortelius.de/kalender/basic_en.php)

### The Stars as a Frame of Reference

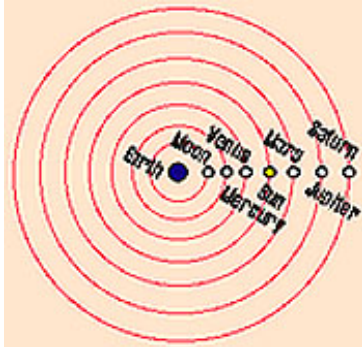
Ancient cultures tried to explain the motions of the stars and planets, with their frame of reference being the Earth. To track the actual motion of each celestial body in space, you need to use the stars as your frame of reference, instead of the Earth. To do this you would make an observation of which celestial body you are studying and include other stars in relation to it. Make subsequent observations and include those same stars. Over a period of time you would be able to determine in which direction the celestial body you are studying is moving.

**The Earth-Centred Model**

The Earth was fixed and the center of the solar system with all celestial bodies in space rotating around it.

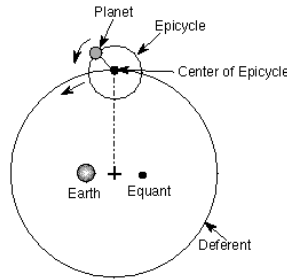
**Geocentric**

Aristotle's Model -  
Assisted by Pythagoras and Euclid

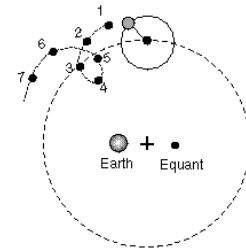


The stars were 'the firmament of fixed stars'

One of the problems this model faced was trying to explain the **retrograde motion** (reversal of direction) of Mars, Jupiter and Saturn. To account for this **Ptolemy** developed a model that gave Aristotle's planets another level of circular motion called **epicycles**.



Center of epicycle moves counter-clockwise on deferent and epicycle moves counterclockwise. Epicycle speed is uniform with respect to equant. The combined motion is shown at right.



Deferent motion is in direction of point 1 to 7 but planet's epicycle carries it on cycloid path (points 1 through 7) so that from points 3 through 5 the planet moves backward (retrograde).

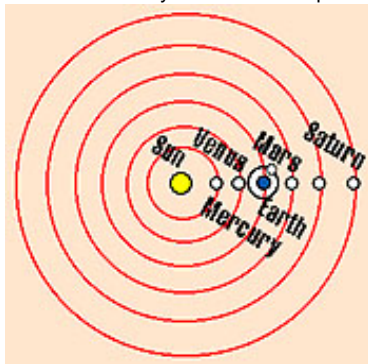
**Animation of the Heliocentric and Geocentric Models** - <http://www.astro.utoronto.ca/~zhu/ast210/both.html>

**The Sun-Centred Model**

Nicholas Copernicus developed this model, in which the Sun was fixed and a rotating Earth revolved around it.

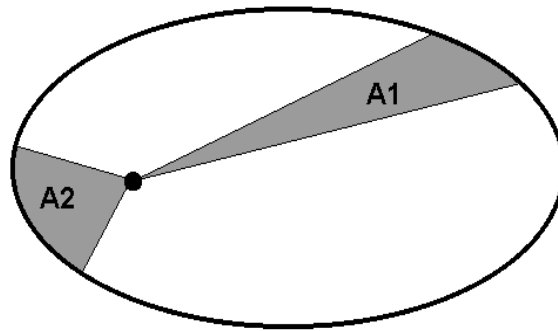
**Heliocentric**

Copernicus' Model  
- Confirmed by Galileo and Kepler



**Kepler's Laws of Planetary Motion**

1. The planets travel in ellipses with the Sun at one focus
2. The radius vector sweeps out equal areas in equal times ( $A_1 = A_2$ )
3. The square of the period of revolution,  $T$ , is proportional to the cube of the mean distance,  $R$  ( $T^2 = R^3$ )



<http://www.thetech.org/exhibits/online/satellite/4/4d/4d.1.html>

Elliptical Orbits - <http://collections.ic.gc.ca/satellites/english/anatomy/orbit/elliptic.html>