E1.1 identify different ideas about the nature of Earth and space, based on culture and science (e.g., compare geocentric and heliocentric models [Note: knowledge of epicycles is not required]; describe Aboriginal views of space and those of other cultures; describe the role of observation in guiding scientific understanding of space)

Culture and Science

Humans have always been fascinated by entities in the sky. Many ancient tribes created stories to explain the presence and movement of objects in space. The people of the First Nation saw a distinct pattern of stars they called the Great Bear. The Egyptians built the pyramids in alignment with the seasonal position of certain stars.

E1.2 investigate and illustrate the contributions of technological advances - including optical telescopes, spectral analysis and space travel - to a scientific understanding of space

Early Theories and Technological Advances

The **geocentric** model of planetary motion was proposed by Aristotle approximately 2000 years ago. This model has Earth at the centre with the sun, moon, and other planets orbiting it.

In the 1500s, Copernicus proposed the sun-centred, or **heliocentric model**. In this model, all the planets revolve around the sun in a concentric circular pattern.

Later, it was the work of Galileo and Kepler that determined the revolution around the sun to be an elliptical pattern.
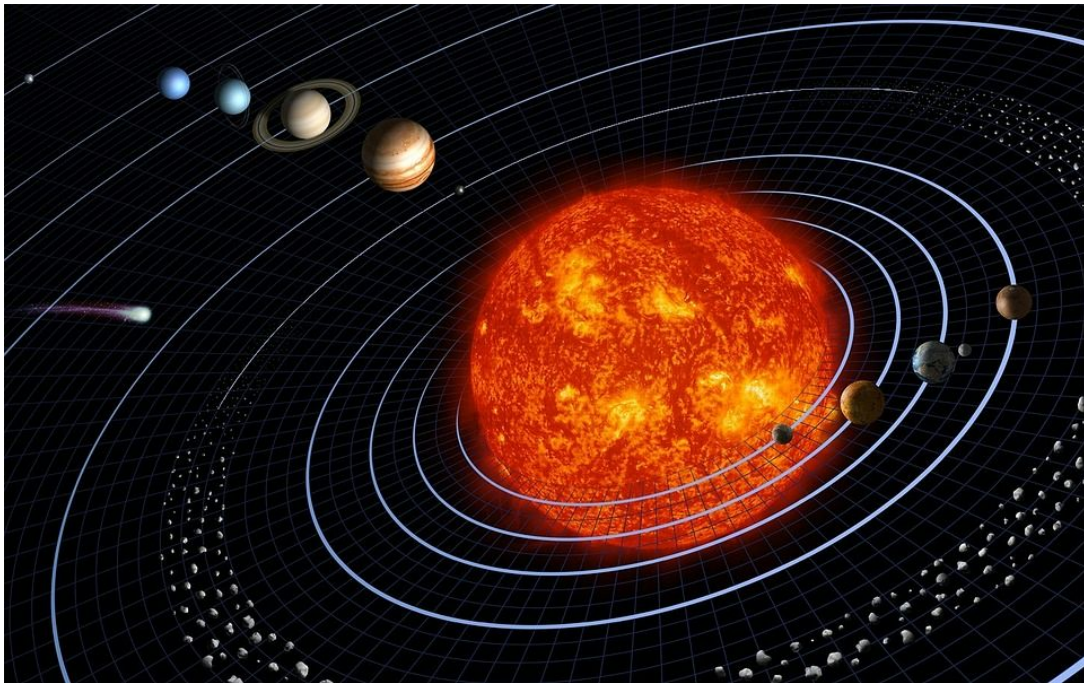
Much of the data collected by early astronomers was gathered using simple instruments such as the quadrant, cross-staff, or astrolabe. It was, however, the invention of the telescope in the early 1600s that provided the necessary tool for studying distant objects. This invention was followed by the discovery of **spectroscopy**, the breakdown of light into its spectrum of colour. The spectrum provided information about the element composition of celestial bodies.
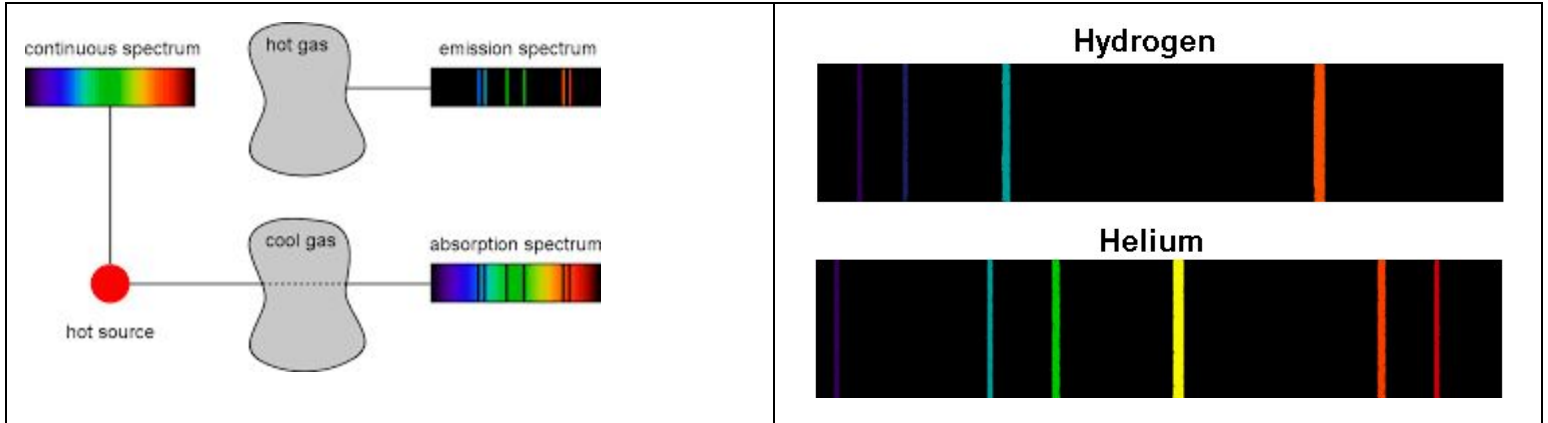
Improved optical and radio telescopes followed, and then came the age of rockets and satellites. Today, advanced computer and space technologies in the form of space stations and rovers are collecting information previously unattainable.

Scientists use the **astronomical unit** (AU) to measure distances within the solar system. The distance from the centre of Earth to the centre of the Earth to the centre of the sun is 1 AU. By comparison, the distance from Mercury to the sun is 0.39 AU and from Pluto to the sun is 39.5 AU.
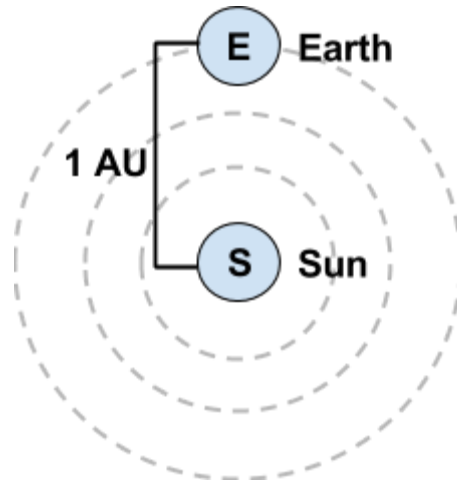
Distances beyond the solar system are measured in light-years. A **light-year** is the distance light travels in one year. After the sun, the next nearest star to Earth, Proxima Centauri, is 4.2 light-years away. The following calculation expresses the vast distance that Proxima Centauri is from Earth.

1 ly = speed of light x the time it travels
1 ly = 300 000 km/s x 1 yr x 365 days/yr x 24 hrs/day x 60 s/min x 60s/min
1 ly = 3.97 x 10^{13} km or 39.7 PM (pentameters) or about 4 with 13 zeros behind it kilometers!

There are other types of measurement in space, like a parsec which is much easier to use than a light-year. Parsecs are measured by seeing the apparent movement of stars at different times of the year.

E1.3 describe, in general terms, the distribution of matter in star systems, galaxies, nebulae and the universe as a whole

E1.4 identify evidence for, and describe characteristics of, bodies that make up the solar system; and compare their composition and characteristics with those of Earth

The Solar System

It is believed that huge accumulations of dust and gases called **nebulae** are pulled together by gravity to form stars. It appears that stars go through stages of development. They begin as red giants, become white dwarfs, and eventually evolve to supernovas and neutron stars or black holes. Scientific evidence shows they move through this progression.
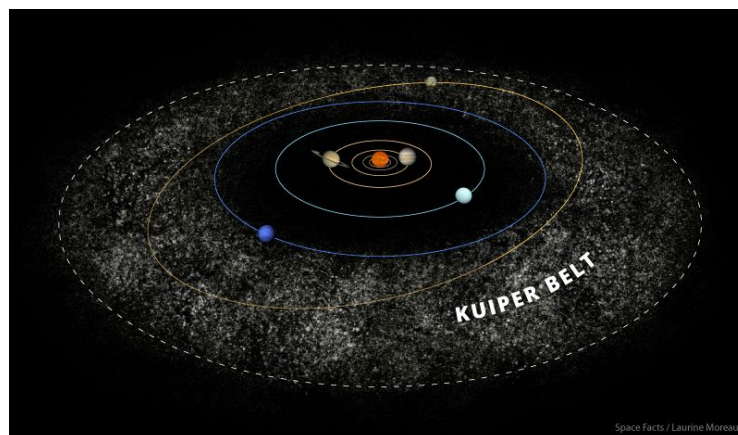
The sun is the nearest star to Earth. It is the bases of the solar system that includes eight planets and their moons. ALl the planets revolve around the sun in an elliptical orbit and rotate on their axis to produce day and night.

The **terrestrial planets** of Mercury, Venus, Earth, and Mars are closer to the sun and are made of solid material. Jupiter, Saturn, Uranus, and Neptune are much larger but less dense. These planets are made of gases, usaully hydrogen and helium and are referred to as **Jovian Planets**.
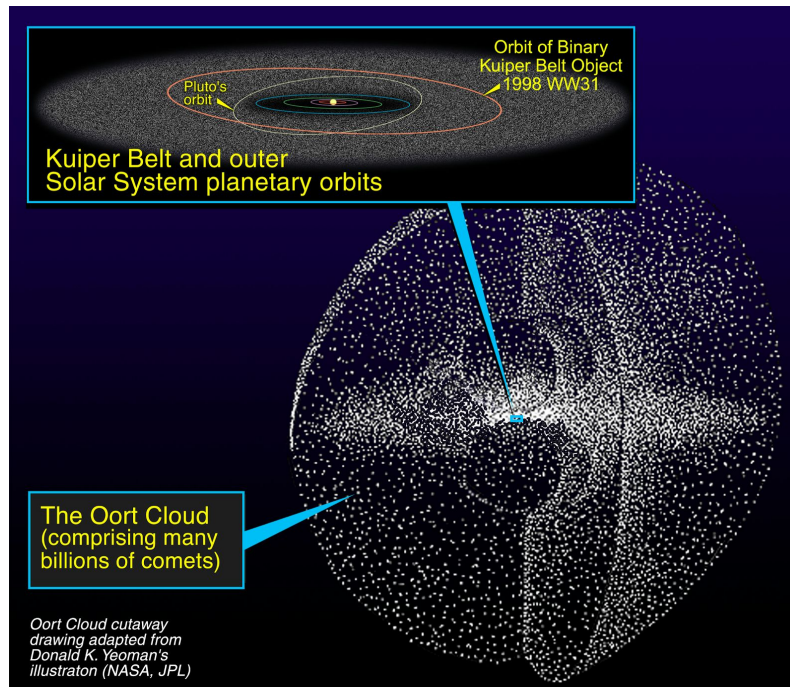
The asteroid belt is found between the orbits of Jupiter and Mars. Asteroids are rocky or metallic and revolve around the sun, as do the other planets.
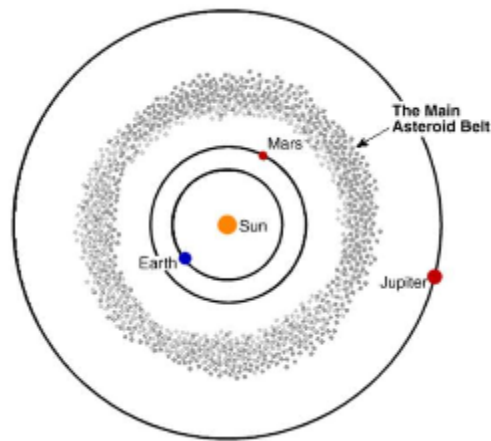
There is also another belt of objects outside of Neptune's orbit called the Kuiper belt objects

And EVEN another location beyond that called the Oort Cloud!

Kuiper Belt and outer Solar System planetary orbits

Orbit of Binary Kuiper Belt Object 1998 WW31

Pluto's orbit

The Oort Cloud (comprising many billions of comets)

Oort Cloud cutaway drawing adapted from Donald K. Yeoman's illustraton (NASA, JPL)

Fragments of rocks called **meteoroids** are often pulled toward Earth by gravity. As they enter the atmosphere, air is compressed by the force of the rock creating light and heat. These shooting stars or **meteors** frequently burn up in the atmosphere. Occasionally, a rock crashes down to Earth's surface as a **meteorite**.

Comets are also found travelling in the solar system. They are made up of dust and ice. The sun's heat causes the ice to vaporize and leave a trail of visible gases. Halley's comet orbits the sun; therefore, it has a predictable schedule and becomes visible every 76 years.

E1.5 describe and apply techniques for determining the position and motion of objects in space, including:

- *constructing and interpreting drawings and physical models that illustrate the motion of objects in space (e.g., represent the orbit of comets around the Sun, using a looped-string model)*

- *describing in general terms how parallax and the Doppler effect are used to estimate distances of objects in space and to determine their motion*

- *describing the position of objects in space, using angular coordinates (e.g., describe the location of a spot on a wall, by identifying its angle of elevation and its bearing or azimuth; describe the location of the Sun and other stars using altitude-azimuth coordinates, also referred to as horizon coordinates or local coordinates) [Note: A description of star positions based on right ascension and declination is not required.]*

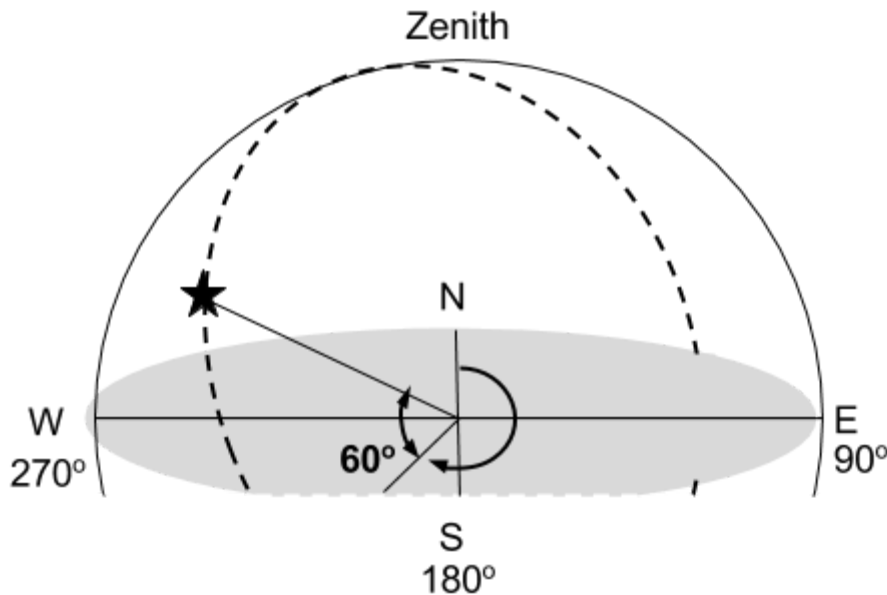# Measuring Distances in Space

To estimate the distance of an object from Earth, astronomers use the parallax of a star. **Parallax** refers to the apparent shift in position of the star when it is viewed from different places. The speed and direction of motion of an object in space are determined based on the Doppler effect.

The **Doppler effect** is the change in frequency of a wave as it moves toward or away from an observer.

Two important measurements are used to describe the position of objects in space.

1. The **azimuth** is the direction relative to due north (0 degrees).

2. The altitude is the height in the sky of the object measured in degrees from 0 to 90. Zero degrees is at the horizon, while 90 degrees is straight up (The **Zenith**).

The location of a star is recorded as a azimuth of x degrees and an altitude of y degrees.
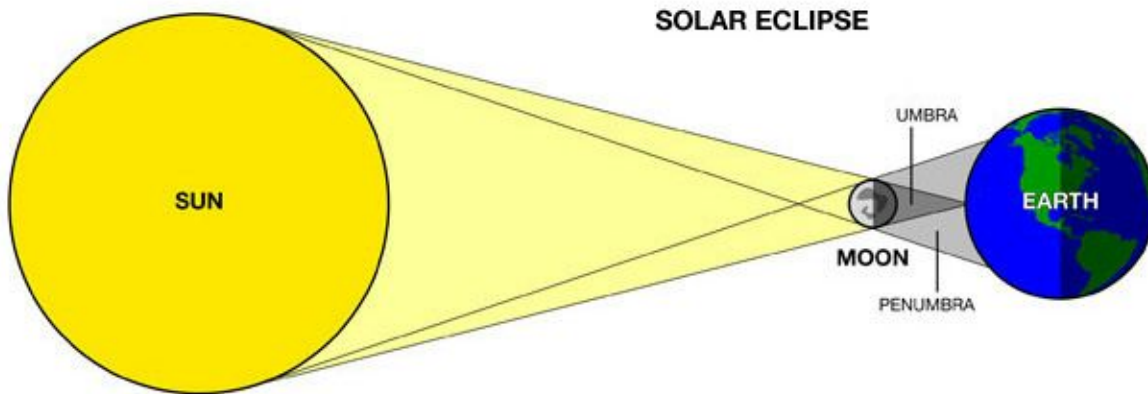
Motion and Eclipses

Because of the predictable pattern of Earth's revolution around the sun and the moon's revolution around Earth, the sun, Earth, and moon can align in a straight line relative to one another. This produces a shadow called an **eclipse**.

A solar eclipse occurs when the moon aligns itself between Earth and the sun.

SOLAR ECLIPSE

A lunar eclipse occurs when Earth aligns itself between the sun and the moon.

LUNAR ECLIPSE
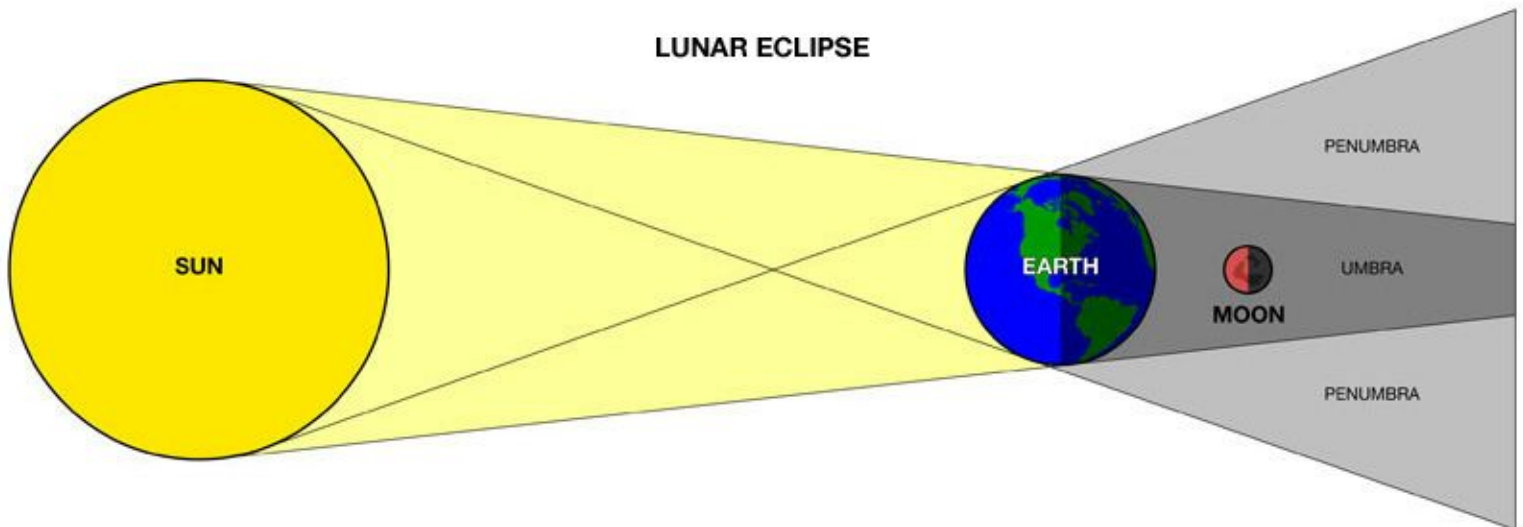
Planets, comets, asteroids, and meteoroids are in constant motion in space. Occasionally, some space matter leaves its orbit and falls to Earth. It is believed that the Barringer Crater in Arizona was formed by the impact of a meteorite that fell to Earth about 50 000 years ago. More frequent are smaller meteorite collision with Earth. Thousands of tiny meteorites hit Earth each year.