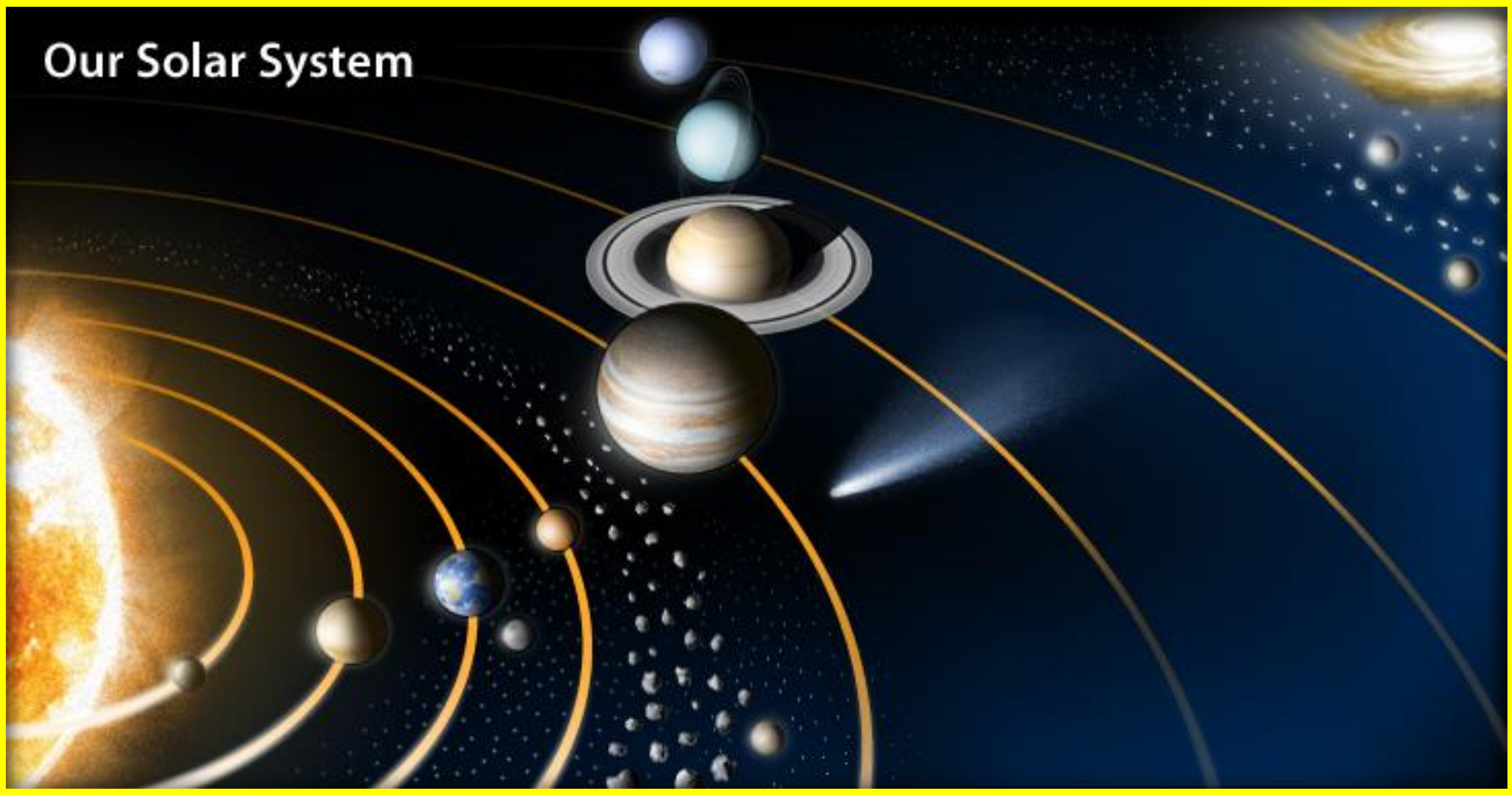
Understanding our Solar System



Essential Standard 1.1

Explain Earth’s role as a body in space.

Learning Objective 1.1.1

Explain Earth’s motion through space, including precession, nutation, the barycenter, and its path about the galaxy.

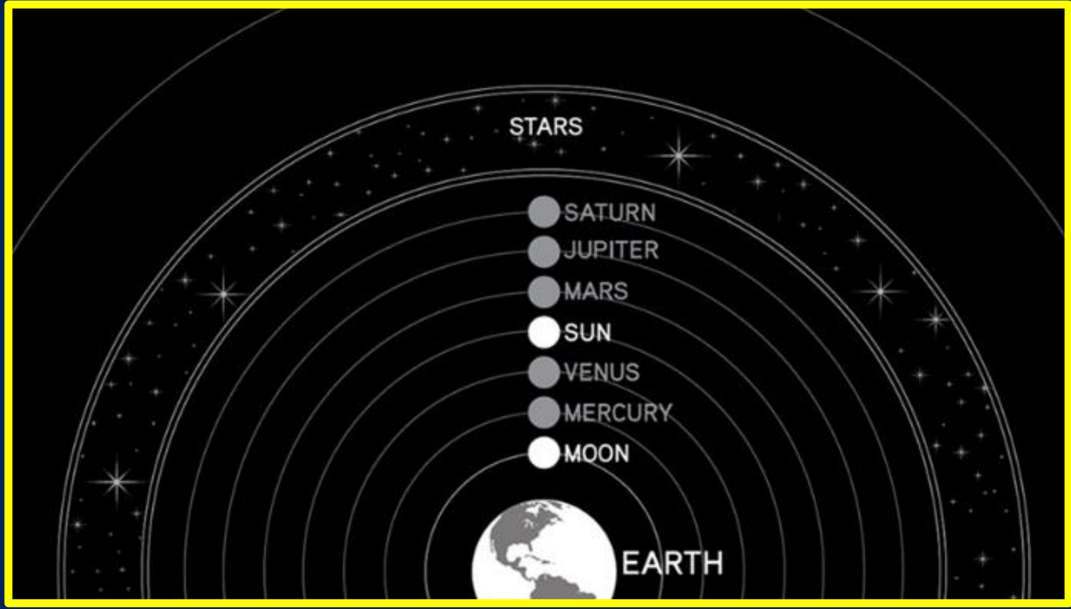
I Can Statements

At the end of this lesson, you should be able to say, with confidence:

- I can distinguish between the geocentric model for the solar system and the heliocentric model developed by Nicolaus Copernicus.
- I can explain Kepler's three laws of planetary motion in everyday language.
- Describe Galileo's contribution to our understanding of our solar system.

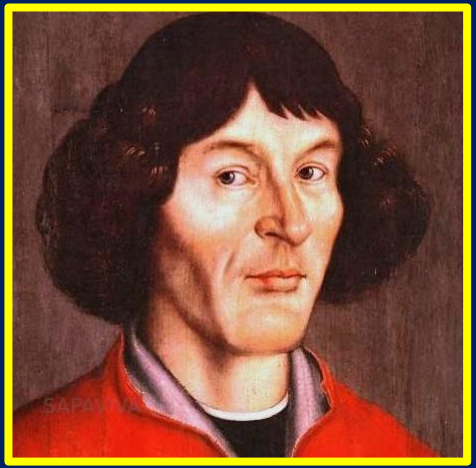
Geocentric Model

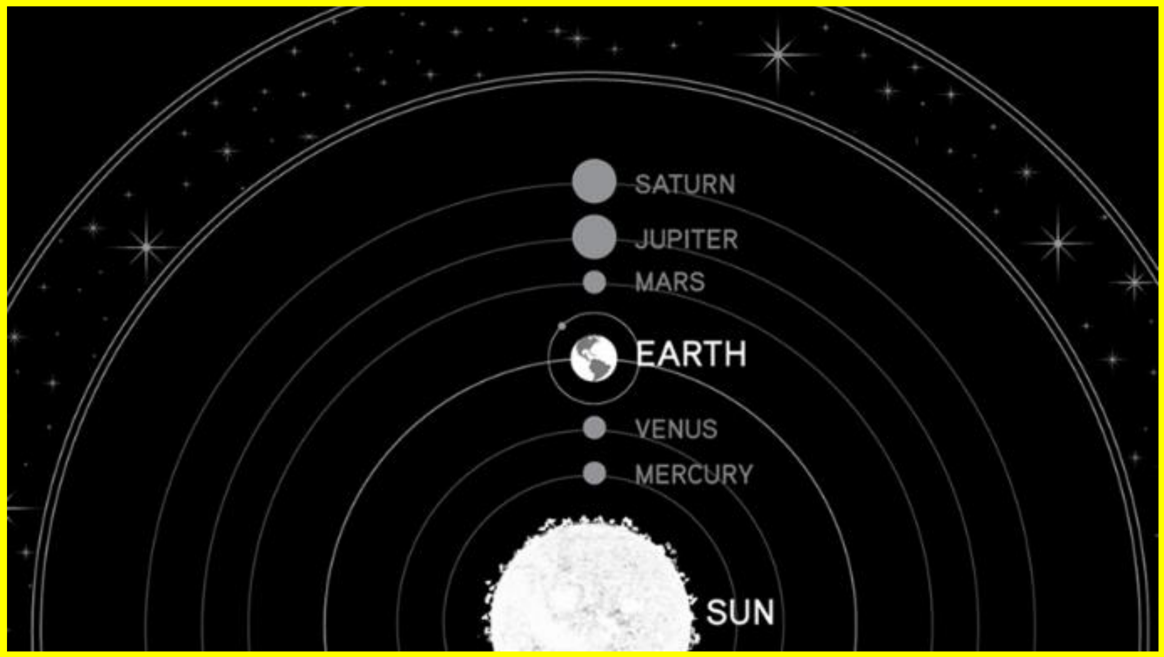
Prior to the 1500's, people believed that the Earth was the center of the universe and that everything else revolved around the Earth.



Heliocentric Model

In the early 1500's, a mathematician named Nicolaus Copernicus developed the heliocentric model with the Sun at the center and planets orbiting the Sun.





Johannes Kepler

In the early 1600's, Johannes Kepler, a German mathematician, showed mathematically that the Sun was the center of our solar system.

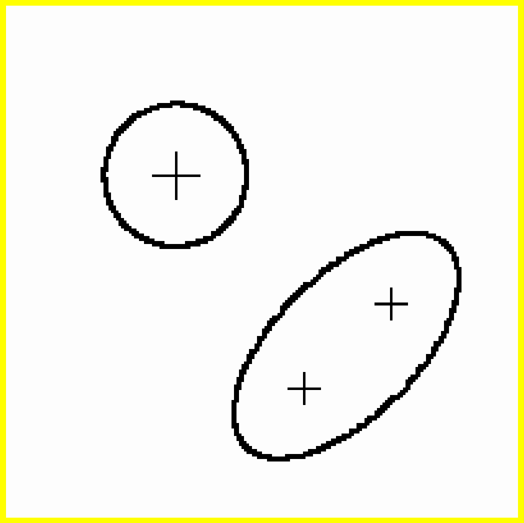
Kepler's Laws of Planetary Motion

1. The orbit of every planet is an ellipse with the sun at one focus.
2. A line joining a planet and the sun sweeps out equal areas during equal intervals of time.
3. The square of the time taken for a planet to complete one orbit is proportional to the cube of its mean distance from the Sun.

Kepler's First Law

The orbit of every planet is an ellipse with the Sun at one focus.

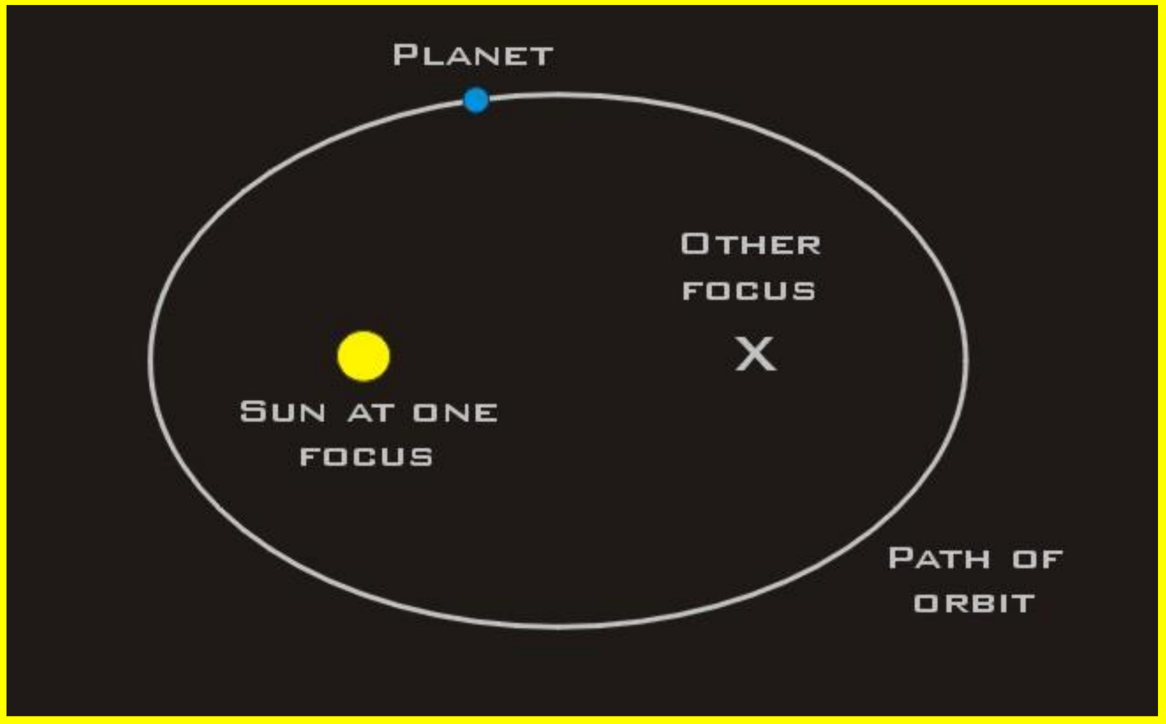
A circle has one focus and the distance between the focus and any two points on the circle will be the same.



For any point on an ellipse, the sum of the distances to both foci will be the same.

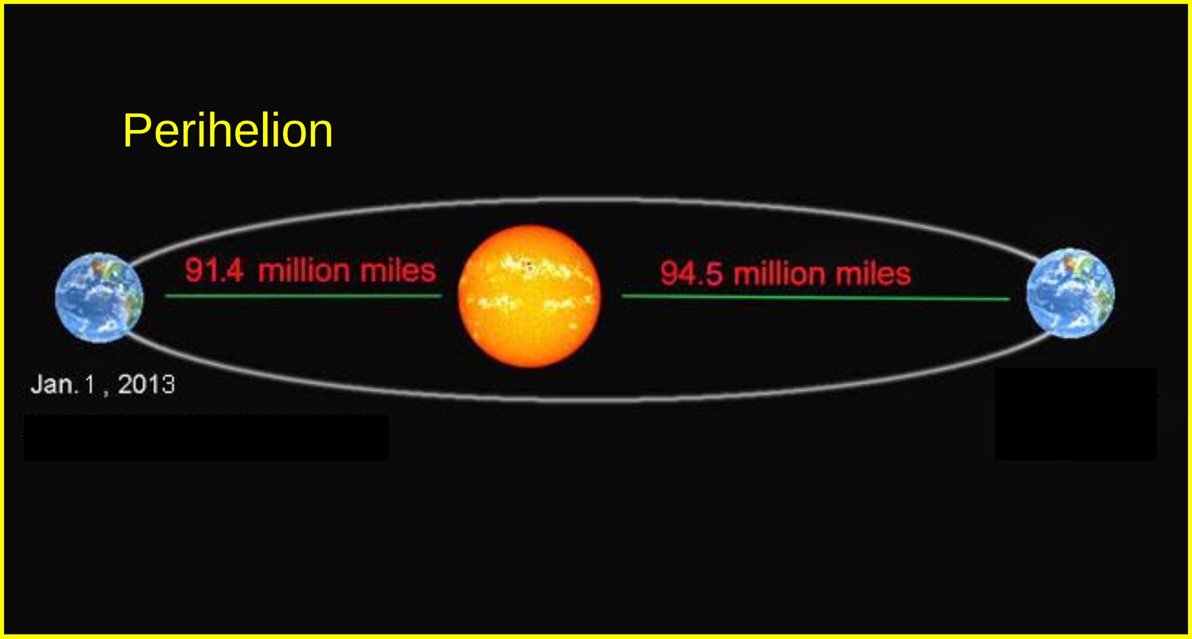
Kepler's First Law

In the case of the planets, the Sun is at one focus and nothing is at the other focus.



Kepler's First Law

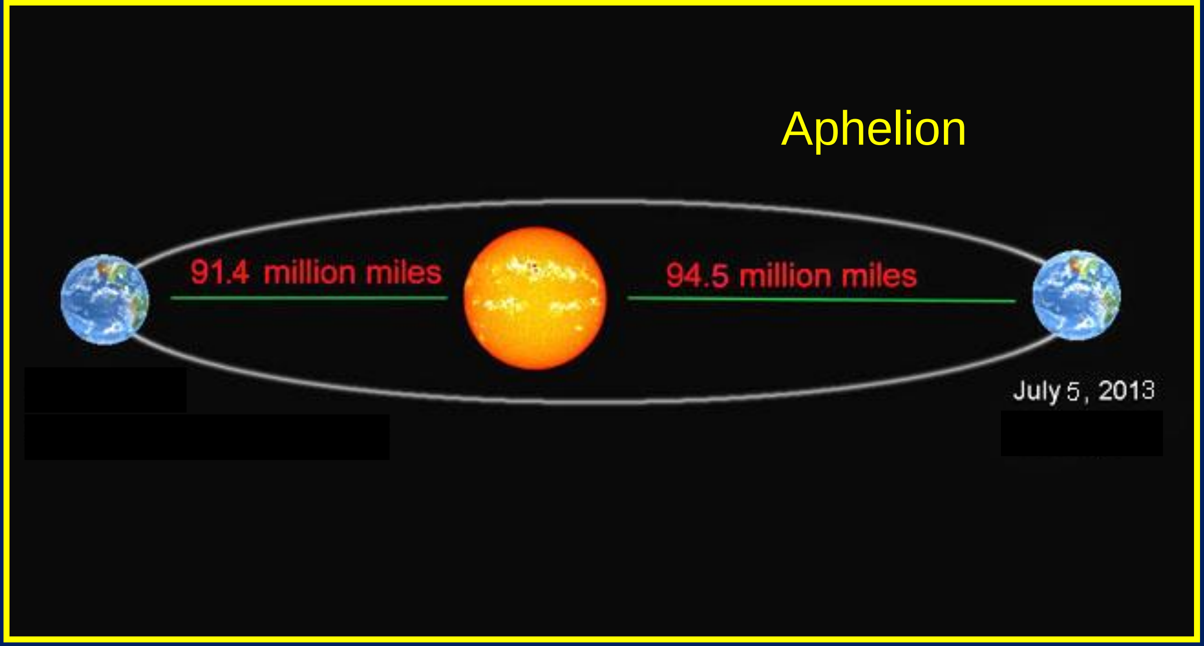
When the planet is closer to the Sun, it is said to be at perihelion.



The Earth is closer to the Sun, or at perihelion, in January of every year.

Kepler's First Law

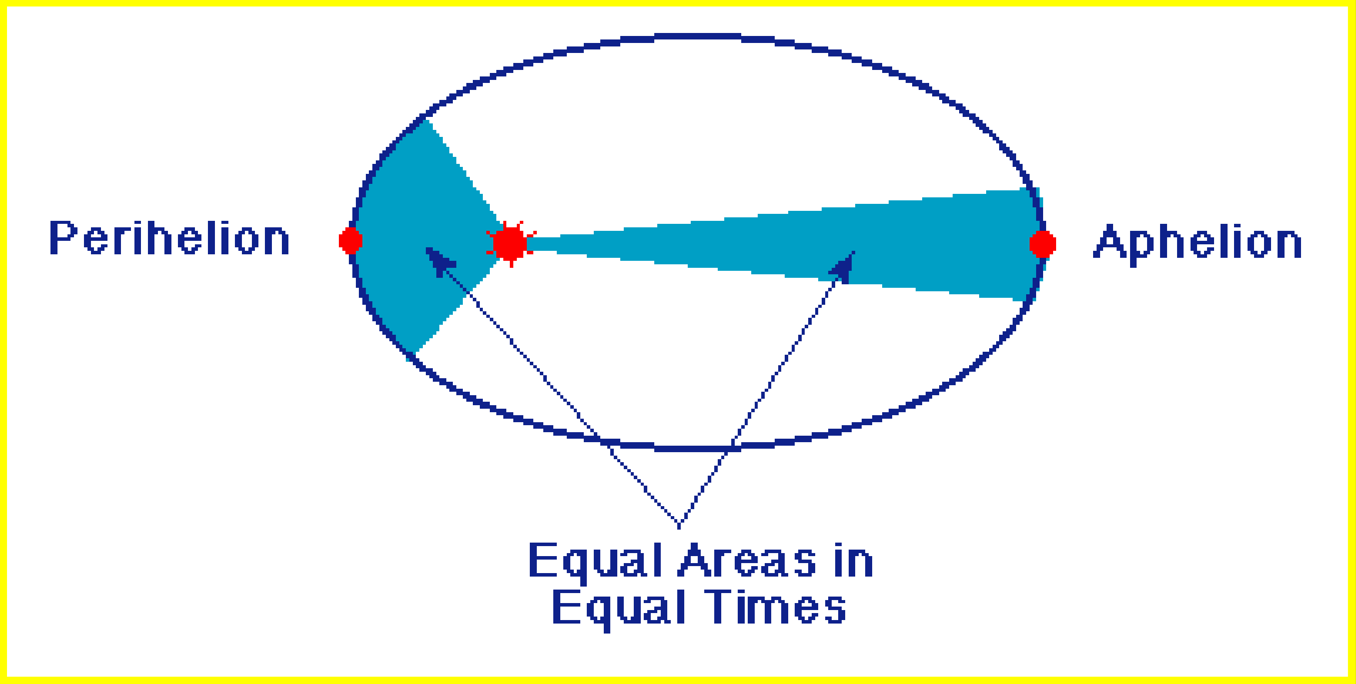
When the planet is farther from the Sun, it is said to be at aphelion.



The Earth is farther from the Sun or at aphelion in July of every year.

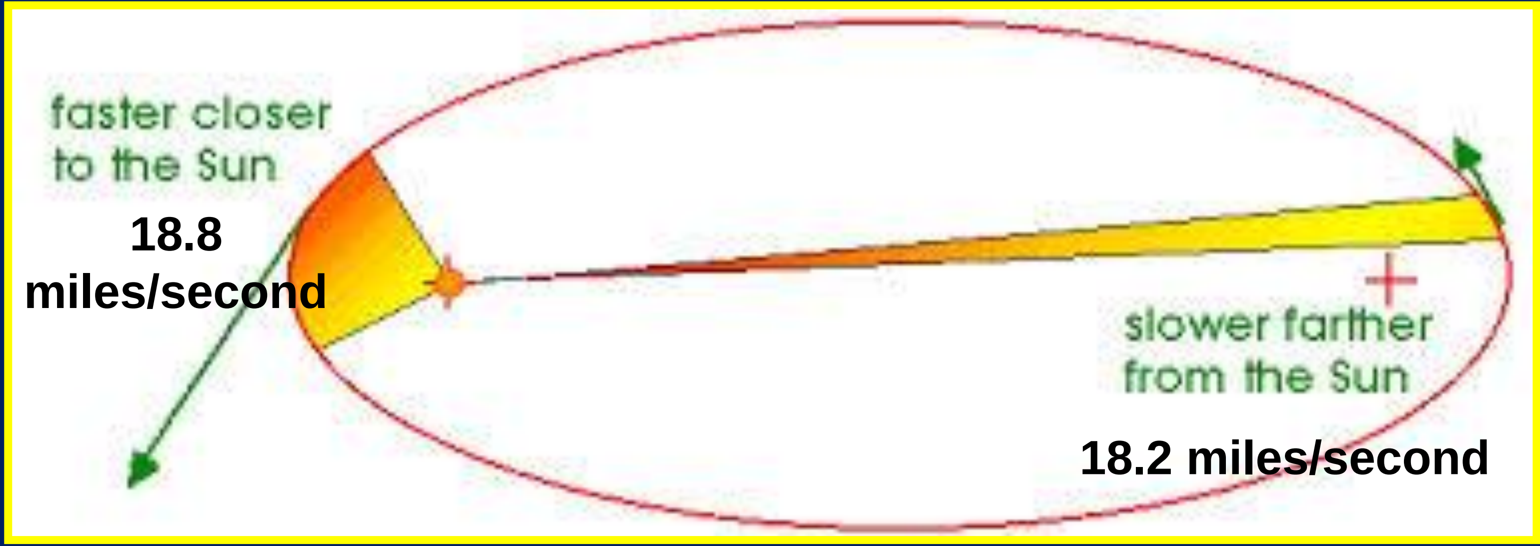
Kepler's Second Law

A line joining and a planet and the Sun sweeps out equal areas during equal areas of time.



Kepler's Second Law

In order to cover the distance of the longer bases near the Sun, in the same amount of time, the planet must travel at a faster rate.



Planets travel faster when closer to the Sun and slower when furthest from the Sun.

Kepler's Third Law

The square of the time taken for a planet to complete one orbit is proportional to the cube of its mean distance from the Sun.

$$P\ (years)^2 = R\ (AU)^3$$

P = Orbital time period R = Distance to Sun

Kepler's Third Law

Scientists have developed a unit of measurement called the astronomical unit to refer to the average distance between the Earth and Sun, 93 million miles.

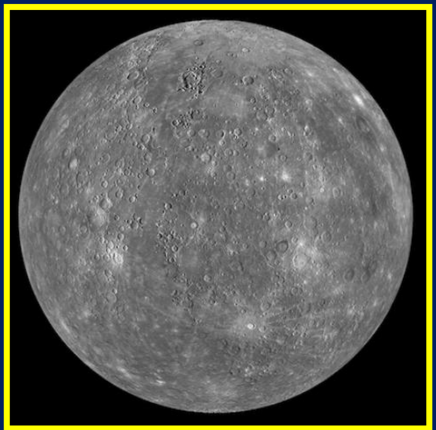
1 au = 93,000,000 miles

2 au = 2(93,000,000) miles

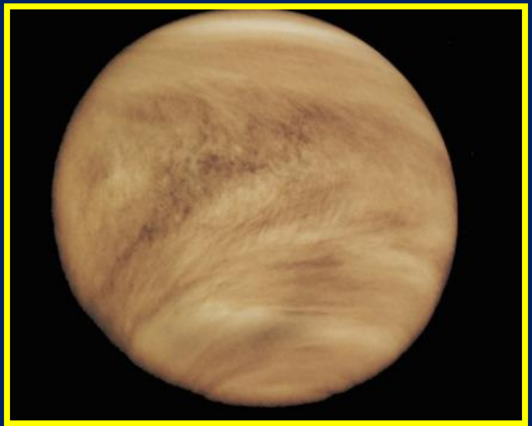
3 au = 3(93,000,000) miles

Kepler's Third Law

Planets closer to the Sun, than Earth, will have a distance to the Sun that is less than 1 AU.



Mercury 0.39 AU

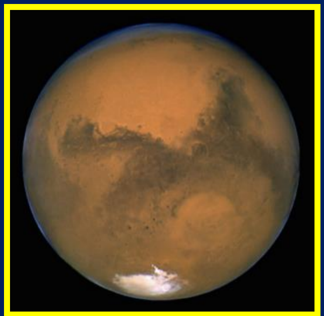


Venus 0.72 AU

Earth 1 AU

Kepler's Third Law

Planets farther from the Sun, than Earth, will have a distance to the Sun that is greater than 1 AU.

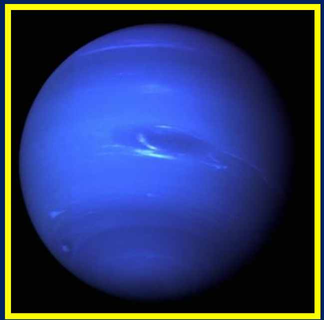


Mars
1.52 AU

Jupiter
5.2 AU

Saturn
9.54 AU

Uranus
19.8 AU



Neptune
39.44 AU

Kepler's Third Law

The square of the time taken for a planet to complete one orbit is proportional to the cube of its mean distance from the Sun.

$$P\ (\text{years})^2 = R\ (\text{AU})^3$$

P = Orbital time period

R = Distance to Sun

Earth's Orbit = 1 year
Earth's Distance = 1 AU

Saturn's Orbit = 29.5 years
Saturn's Distance = 9.54 AU

$(1.0)^2 / (1.0)^3 = 1.0$

$(29.5)^2 / (9.54)^3 = 1.0$

Proportional means that when divided, they will be equal to 1.

Kepler's Third Law

Planet	Period (Orbit)	Distance	P^2/R^3
Mercury	0.24 year	0.39 AU	0.98
Venus	0.615 year	0.72 AU	1.01
Earth	1 year	1 AU	1.00
Mars	1.88 years	1.52 AU	1.01
Jupiter	11.8 years	5.2 AU	0.99
Saturn	29.5 years	9.54 AU	1.00
Uranus	84 years	19.8 AU	1.00
Neptune	165 years	39.44	1.00

Notice how P^2/R^3 are all equal to or nearly equal to 1

Kepler's Third Law

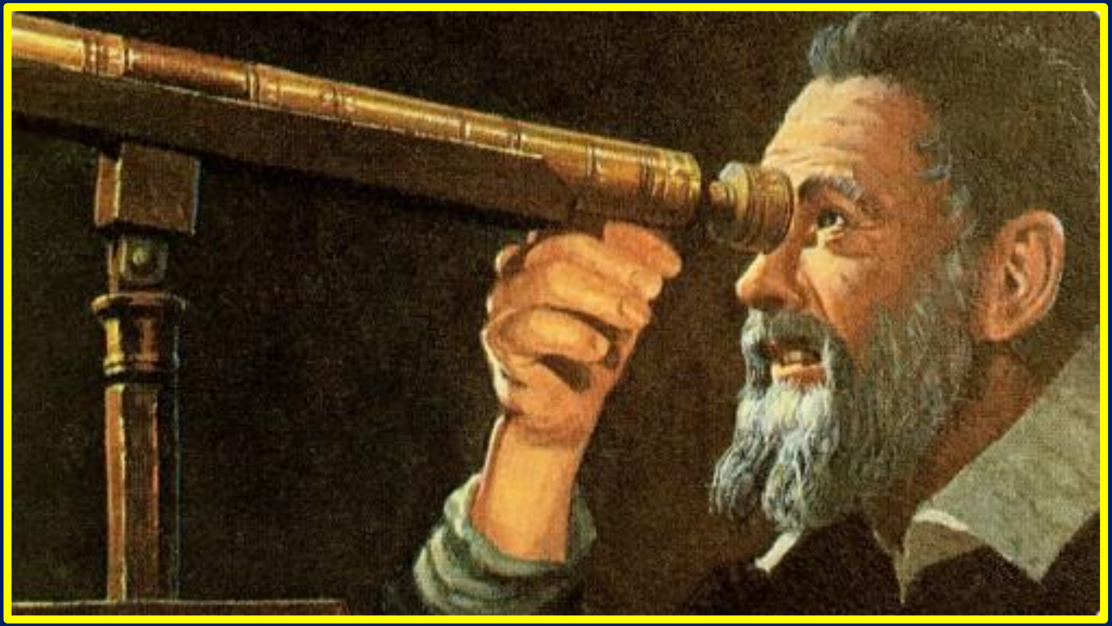
In very simple terms, the closer the planet is to the Sun, the shorter the time it takes for it to orbit the Sun.

Kepler's Laws in Everyday Language

1. Every planet's orbit is an ellipse.
2. Planets travel at different speeds as they orbit the Sun, traveling faster when they are nearer the Sun and slower when they are farther away from the Sun.
3. Planets farther from the Sun take a longer time to orbit the Sun than planets that are closer to the Sun.

Galileo Galilei

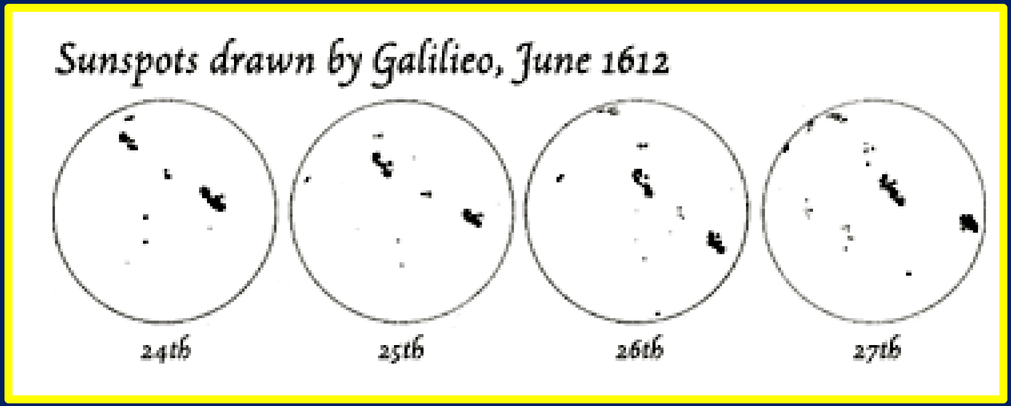
In 1610, an Italian scientist named Galileo Galilei, was the first person to use a telescope to look at the Moon, stars, planets, and the Sun.



With the use of the telescope, Galileo saw more stars than anyone had ever seen before.

Galileo Galilei

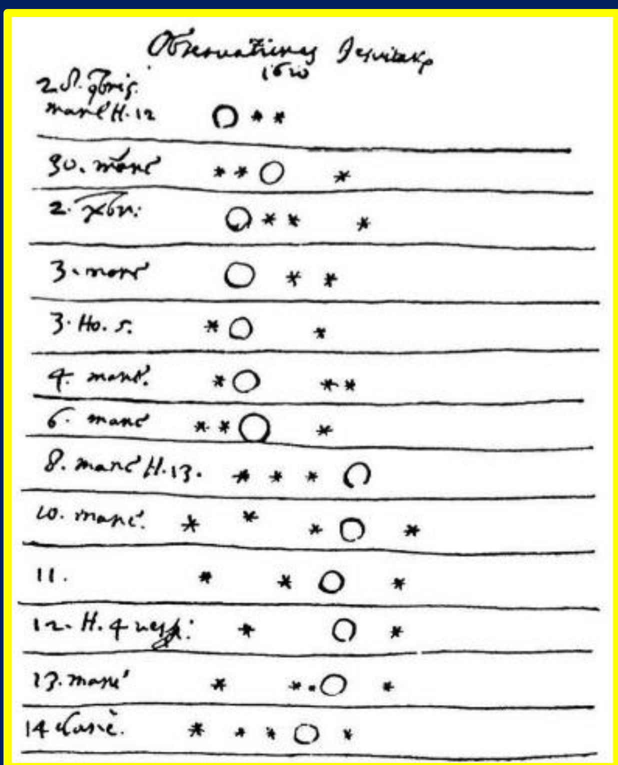
Galilei made detailed drawings of the Moon, proving the Moon had a topography similar to that of Earth.



Galilei also noticed and drew sunspots on the Sun.

Galileo Galilei

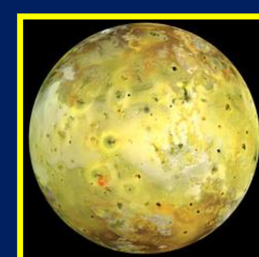
Galileo's greatest contribution to science, was finding observable proof that not everything revolved around Earth.



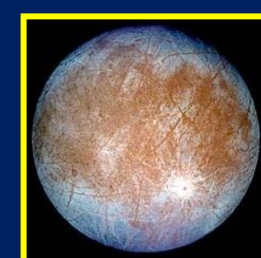
Galileo was the first to ever observe four large moons orbiting around Jupiter, thereby proving that not everything revolves around Earth.

Ganymede

Callisto



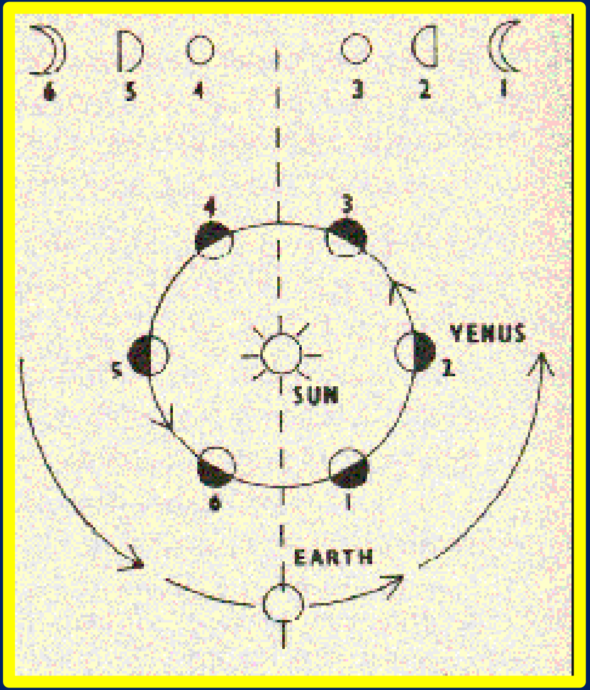
Io

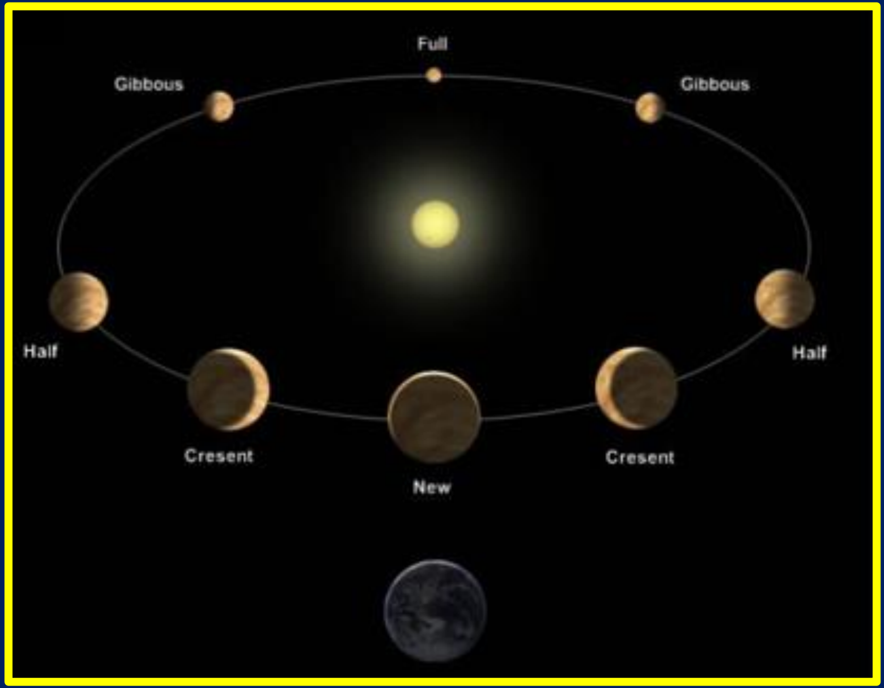


Europa

Galileo Galilei

Galileo also found direct observable evidence that Venus revolved around the Sun, by noticing the phases Venus underwent as it passed between the Earth and the Sun, and, as it passed on the other side of the Sun from the Earth.



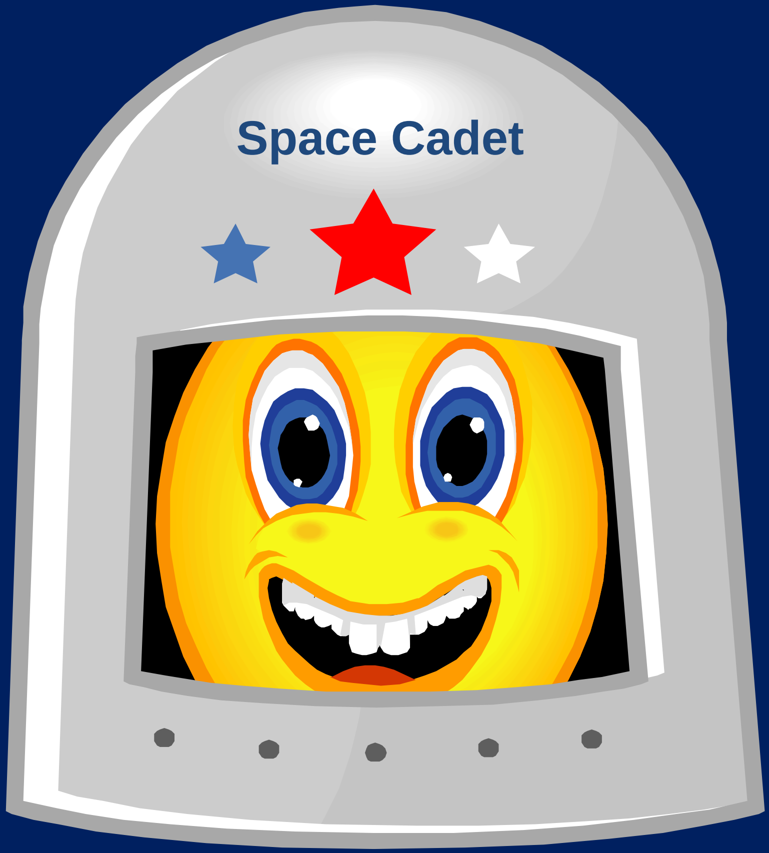


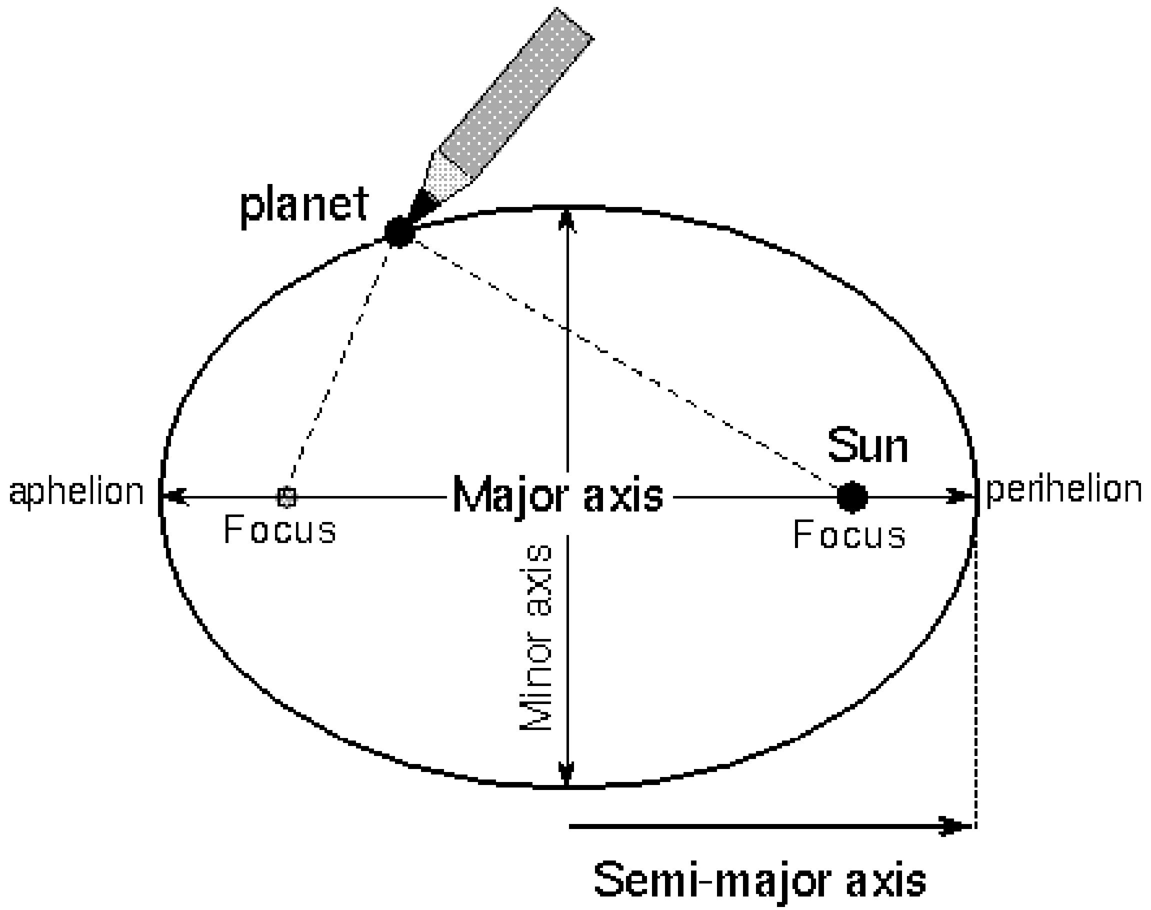
Galileo Galilei

Feeling threatened, the Catholic church arrested Galileo, tried him for heresy, and told him to recant his claim or be sentenced to death.

Galileo did recant his claim but was still sentenced to house arrest for the rest of his life.

The End





Drawing an **ellipse**: loop string around thumb tacks at each **focus** and stretch string tight with a pencil while moving the pencil around the tacks. The Sun is at one focus.