Name: _____

What do Kepler's three Laws describe? **They describe orbits!**

<u>Kepler's First Law:</u>
What does Kepler's First Law state about orbits?

Objects do not follow a circular orbit. They follow a more Oval-shaped orbit, also called an Elliptical Orbit!

What is the perihelion?

The perihelion is the orbiting objects distance from the object that it's orbiting when it's at its closest point! Example, the distance the Earth is from the Sun when it's at its closest point to the Sun in its orbit.

What is the aphelion?

The aphelion is the orbiting objects distance from the object that it's orbiting when it's at its furthest point! Example, the distance the Earth is from the Sun when it's at its furthest point to the Sun in its orbit.

What is an object's eccentricity representing and what is the equation that we use to figure it out? What units does eccentricity have?

An object's eccentricity represents the extent to how elliptical its orbit is. The equation that we use to figure out eccentricity is…

$$Eccentricity = \frac{(Aphelion\ Distance - Perihelion\ Distance)}{(Aphelion\ Distance + Perihelion\ Distance)}$$

Eccentricity is unitless!

When measuring distances in our own solar system, what is the unit of distance that astronomer's generally use?

Astronomical Units, denoted by (AU). 1 AU equals roughly 150,000,000,000 meters. We'll see where this seemingly random number comes from, but astronomer's use units of AU for distances in our solar system instead of meters, for the same reason you'd measure the distance from your house to school in miles, not centimeters.

Let's find the eccentricity for Earth.

$$Distance\ at\ Aphelion\ for\ Earth = 1.017\ AU$$

$$Distance\ at\ Perihelion\ for\ Earth = 0.983\ AU$$

$$\boldsymbol{Eccentricity = \frac{(1.017\ AU - 0.983\ AU)}{(1.017\ AU + 0.983\ AU)} = \frac{0.034\ AU}{2\ AU} = 0.017}$$

What is the Earth's major axis?

$$\boldsymbol{Major\ Axis = Aphelion\ Distance + Perihelion\ Distance}$$

$$\boldsymbol{Major\ Axis = 1.017\ AU + 0.983\ AU = 2\ AU}$$

What is the Earth's semimajor axis?

$$\boldsymbol{Semimajor\ axis = Major\ Axis \div 2}$$

$$\boldsymbol{Semimajor\ axis = 2\ AU \div 2 = 1\ AU}$$

What does the distance "Astronomical Units" represent?

1 Astronomical Unit is the semimajor axis (or average distance) from the Earth to the Sun.

Now, let's use the aphelion and perihelion to calculate the eccentricity, major axis, and semimajor axis for all the planets in our solar system.

Mercury:	**Venus:**
$Distance\ at\ Aphelion = 0.467\ AU$	$Distance\ at\ Aphelion = 0.728\ AU$
$Distance\ at\ Perihelion = 0.307\ AU$	$Distance\ at\ Perihelion = 0.718\ AU$
Eccentricity =	Eccentricity =
Major axis =	Major axis =
Semimajor axis =	Semimajor axis =

Mars:

Distance at Aphelion = 1.659 AU

Distance at Perihelion = 1.381 AU

Eccentricity =

Major axis =

Semimajor axis =

Jupiter:

Distance at Aphelion = 5.459 AU

Distance at Perihelion = 4.950 AU

Eccentricity =

Major axis =

Semimajor axis =

Saturn:

Distance at Aphelion = 10.123 AU

Distance at Perihelion = 8.957 AU

Eccentricity =

Major axis =

Semimajor axis =

Uranus:

Distance at Aphelion = 20.078 AU

Distance at Perihelion = 18.324 AU

Eccentricity =

Major axis =

Semimajor axis =

Neptune:

Distance at Aphelion = 30.385 AU

Distance at Perihelion = 29.709 AU

Eccentricity =

Major axis =

Semimajor axis =

- What numbers can the eccentricity range from?
Zero to one!

- How can you determine the extent to how Oval-shaped a planet's orbit is?
Eccentricity closer to 1 means MORE elliptical. Eccentricity closer to 0, means LESS elliptical

Kepler's First Law

From the eccentricities that you calculated, and Earth, rank the planet's orbits from MOST Elliptical to LEAST Elliptical. Or, LEAST Circular to MOST Circular

Least Circular		Most Elliptical
↓		↓
Most Circular		Least Elliptical

Kepler's First Law

Answers:

Mercury:
Eccentricity = 0.207
Major Axis = 0.774 AU
Semimajor Axis = 0.387 AU

Venus:
Eccentricity = 0.007
Major Axis = 1.446 AU
Semimajor Axis = 0.723 AU

Mars:
Eccentricity = 0.091
Major Axis = 3.04 AU
Semimajor Axis = 1.52 AU

Jupiter:
Eccentricity = 0.049
Major Axis = 10.409 AU
Semimajor Axis = 5.20 AU

Saturn:
Eccentricity = 0.061
Major Axis = 19.08 AU
Semimajor Axis = 9.54 AU

Uranus:
Eccentricity = 0.046
Major Axis = 38.4 AU
Semimajor Axis = 19.2 AU

Neptune:
Eccentricity = 0.011
Major Axis = 60.1 AU
Semimajor Axis = 30.0 AU

Kepler's First Law

Mercury
Mars
Saturn
Jupiter
Uranus
Earth
Neptune
Venus

Most Circular

Least Elliptical