Name ______________________________ Date _________________ Period ______________

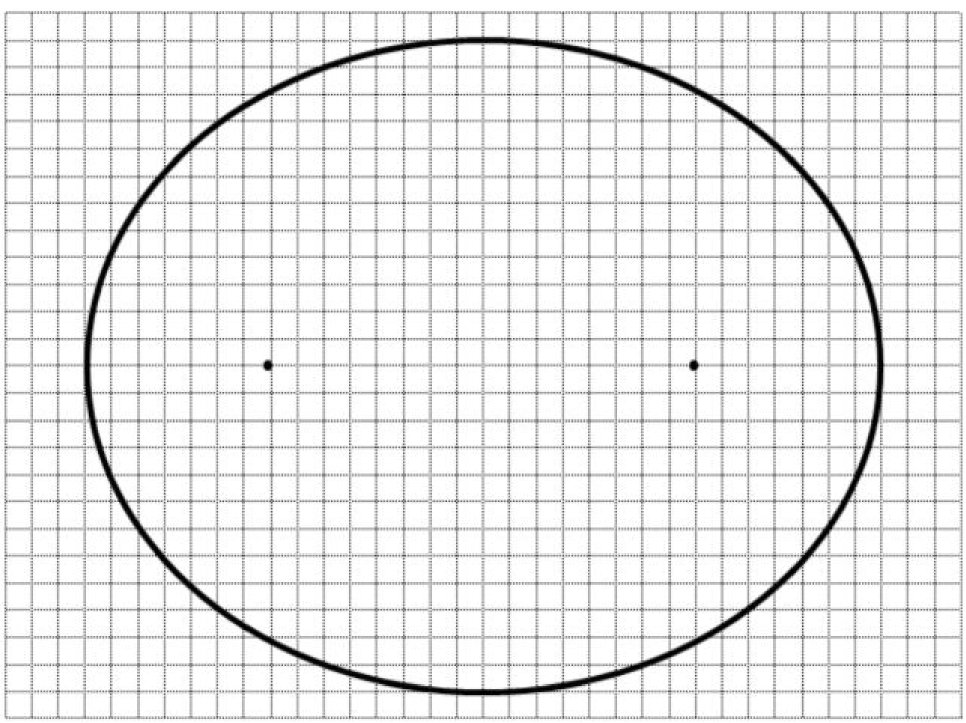
Kepler's Laws and Planetary Motion

This activity has been modified from Mr. Traeger who modified the Genesis Mission *Search for Origins* Education Series and Museums Teaching Planet Earth.

Part 1: Kepler's First Law of Planetary Motion (Orbital Shape) Use the ellipse below to label and determine its eccentricity.

1) Label the two foci "Focus 1" and "Focus 2." Choose one of these foci and label it "Sun"
2) Choose a place on the outline of your ellipse and place a small circle there. Label the dot "Planet" 3) Find the point on the outline of the ellipse that is closest to the dot that you made the Sun. Label this point "Perihelion."
4) Find the point on the outline of the ellipse that is farthest from the dot that you made the Sun. Label this point "Aphelion."
5) Put an "X" directly in the center of your ellipse exactly half way between the two foci.
6) Draw a line from the "X" to the dot that you denoted as the Sun. Label this line as "c."
7) Draw another line from the "X" through the focus that does not denote the Sun and all the way to the point that you denoted "Aphelion." Label this line as "a." In math, we call this line the "semi-major axis." It is similar to the radius of a circle.
8) Eccentricity is the measurement of how stretched out an ellipse is. It ranges from zero to one. Zero is the eccentricity of a circle and one is the eccentricity of a straight line. Calculate the value of the eccentricity for the ellipse you drew by measuring the length of line "c" and measuring the length of line "a." Calculate the eccentricity of the ellipse by taking "c" and dividing it by "a." Put your data below.

Length of line "c" in centimeters	Length of line "a" in centimeters	Eccentricity of the ellipse you drew (c/a)



Calculating Aphelion and Perihelion:

The maximum distance of a planet (or comet) from the sun is its *aphelion* distance, generally written as r_a. We say that the planet is "at aphelion".

The minimum distance of a planet (or comet) from the sun is called is *perihelion*, and is written as r_p.

Looking at the graph of the ellipse on the previous page, we see that the minimum distance r_p is equal to (a - c), and the maximum distance r_a is equal to (a + c).

Calculate the eccentricity, the minimum and maximum distance from the Sun for each of the planets and Pluto.

	Semi-major Axis (a) in AU	Length from Focus to Center (c) in AU	Eccentricity (c/a)	Minimum Distance in AU (a-c)	Maximum Distance in AU (a+c)
Mercury	0.387	0.080			
Venus	0.723	0.005			
Earth	1.000	0.017			
Mars	1.524	0.142			
Jupiter	5.203	0.252			
Saturn	9.537	0.517			
Uranus	19.191	0.906			
Neptune	30.069	0.267			
Pluto (Dwarf Planet)	39.482	9.823			

Questions:

1) Which of the planet's orbits is the most eccentric? Assume that Pluto is still a planet for this question.

2) Which of the planet's orbits is the least eccentric (closest to a circle's eccentricity of zero)? Assume that Pluto is still a planet for this question.

3) Which two planets have the most similar eccentricity?

4) Which planet has an eccentricity most similar to Earth's eccentricity?

5) The average eccentricity of the Moon's orbit around the Earth is 0.054900489. Would you say the eccentricity of the Moon's orbit is low, medium, or high with respect to most of the planets' orbits around the Sun?

6) How could the eccentricity of a planet's orbit affect the amount of solar radiation it receives from the Sun? (Think about the planets distance from the Sun at aphelion and perihelion.)

Part 2: Kepler's Second Law of Planetary Motion (Orbital Speed) 1) How does the speed of a planet's orbit at perihelion compare to the speed of a planet's orbit at aphelion?

Explain why is there a difference in
speed?

2) Look at the diagram below. **Count** the number of squares in sector 1 and in sector 2. Record the number
of squares
below.

Squares in Sector 1:
____

Squares in Sector 2:
____

3) How does the number of squares in Sector 1 compared to the number of squares in Sector 2?

4) What does the number of squares imply about each sector's area?

5) If it takes the same amount of time for a planet to move from point A to point B as it does for a planet to move from point C to point D, then what must a planet do in terms of its speed in each sector? Speed equals distance over time. Note that the distance between A and B is shorter than the distance between C and D.

Speed from A to B (Faster or Slower?) Speed from C to D (Faster or Slower?)

Part 3: Kepler's Third Law of Planetary Motion (Mean Orbital Velocity and Mean Distance)

Mean Orbital Velocity and Mean Distance to the Sun **Mercury Venus**

Earth Mars Jupiter Saturn Uranus Neptune Pluto Mean Orbital Velocity in (km/s)

47.87 35.02 29.79 24.13 13.07 9.67 6.84 5.48 4.75

Mean Distance to the Sun in (AU)

0.39 0.72 1.00 1.52 5.20 9.54 19.19 30.07 39.48

1) How does the distance from the Sun of a planet affect the planet's orbital velocity? (In other words, do planets that are farther from the Sun travel faster or do they travel slower?)

2) Based on your response to number 1, what does Kepler's Third Law of Planetary Motion say?