Name ________________________________ Date __________ Section______

ACTIVITY 6

Working with Kepler's Laws

Learning Goals

In this activity, you will learn about Kepler's geometric model of planetary orbits and learn to:

1. Determine the properties of an ellipse.
2. Apply these properties to planetary orbits.

Step 1—Kepler's First Law

Kepler's first law states that the orbits of the planets are ellipses with the Sun at one of the foci.

1. On **Figure 6.1**, clearly label the following parts of an ellipse:
   a. focus
   b. semimajor axis
   c. minor axis
   d. center

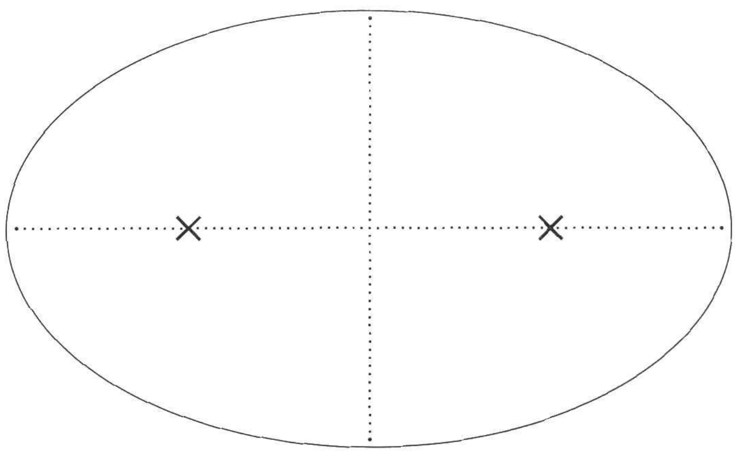

FIGURE 6.1

2. Eccentricity is a measure of the degree of "flattening" of the ellipse. Mathematically, the eccentricity of an ellipse is defined as the distance from a focus to the center of the ellipse divided by the length of the semimajor axis. Calculate the eccentricity of the ellipse in Figure 6.1. (Hint: Use the dotted lines and the number of "dots" as the units.)

3. A circle is a special ellipse, one with both foci at the same point. The eccentricity of a circle is 0. The value of the eccentricity of an orbit may run from 0 to almost 1. Estimate the eccentricities for the ellipses in **Figure 6.2**.

   a. ______________________

   b. ______________________

   c. ______________________

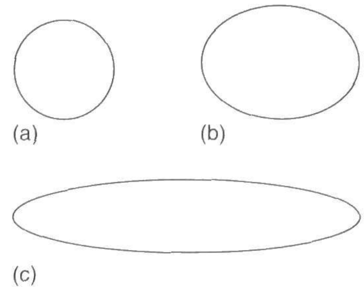

FIGURE 6.2

4. In your own words, state how to determine the eccentricity of an ellipse. If you'd like, you may use a figure to express your thoughts.

Step 2—Kepler's Second Law

Kepler's second law, which states that as a planet moves around its orbit it sweeps out equal areas in equal times, can be difficult to visualize. It may be easier to consider this simpler version:

> **A planet travels faster when nearer to the Sun and slower when farther from the Sun.**

Examine **Figure 6.3**, which shows a planet, D, orbiting the Sun, A, in a counterclockwise direction. Match the following terms with the letter that identifies the location in the figure:

5. focus ______
6. aphelion ______
7. perihelion _____
8. increasing speed: ____ to ____
9. decreasing speed: ____ to ____
10. planet has greatest speed ____
11. planet has lowest speed ______

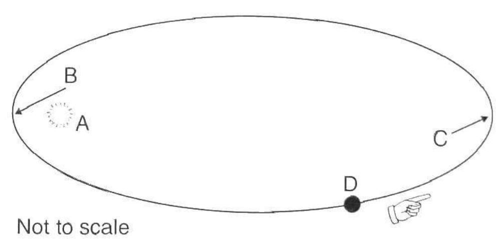

FIGURE 6.3

12. Now, state Kepler's second law in your own words, and give your reasoning for why planets behave this way.

Step 3—Kepler's Third Law

Kepler's third law relates the time it takes a planet to go around the Sun (the period, P) to the semimajor axis, a, of the orbit. If we assume that the mass of the Sun is much greater than any of the planets (which it is), and measure P in years and a in astronomical units (AU), the simplified relationship (formula) is

$$P^2 = a^3$$

13. According to Kepler's third law, all orbits with the same semimajor axis have the same period. The two orbits in **Figure 6.4** have the same value for a. How do their values of P compare?

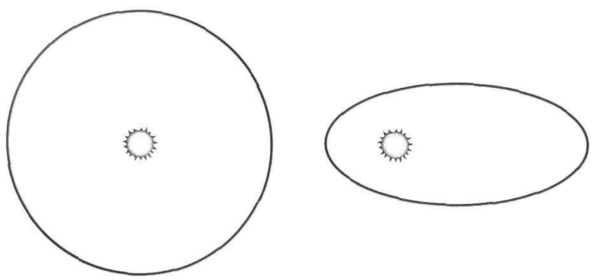

FIGURE 6.4

14. Explain how this is possible when the orbits look so different.

15. Fill in **Table 6.1** by calculating the missing data for the planets of our own Solar System. Be sure to include only the correct number of significant figures.

TABLE 6.1

The semimajor axes and periods of the planets of the Solar System.

PLANET	SEMIMAJOR AXIS (AU)	PERIOD (YEARS)
Mercury	0.39	
Venus		0.62
Earth	1.0	
Mars		1.9
Jupiter	5.2	
Saturn		29
Uranus	19	
Neptune		165

Suppose a planet is discovered around a star like the Sun, with a period of 0.2 year.

16. What is the semimajor axis of its orbit? ________

17. How does this compare to the orbits of the planets in our Solar System?