

An Introduction to Kepler's Laws

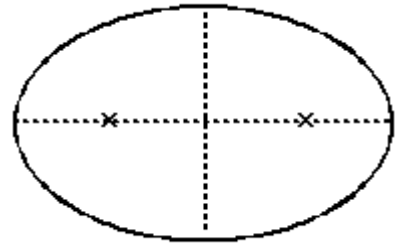
Objective

To review Kepler's three laws; to determine the properties of an ellipse; to relate these properties to the orbits of planets.

Procedure

01. Clearly label the parts on the following diagram of an ellipse:

- Focus
- Semi-Major axis
- Major axis
- Center



02. 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 semi-major axis. Calculate the eccentricity of this ellipse: _____

03. A circle is a special ellipse: one with the foci at one point. The eccentricity of a circle is 0. The value of the eccentricity of an orbit may run from 0 to 1, with 1 being basically a straight line. Estimate the eccentricities for the following ellipses:

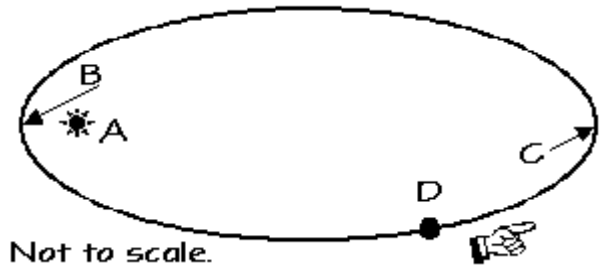
- a) $e =$
- b) $e =$
- c) $e =$



04. 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.

Kepler's second law, which states that as a planet moves around its orbit it sweeps out equal areas in equal times, is often a difficult, totally confusing concept to picture, let alone understand. It is a description; what the second law really means: that a planet travels faster when it is nearer to the Sun and slower when it is farther from the Sun.

05. Examine the next figure of the "Planet D" orbiting the Sun "A" in a counter-clockwise direction and fill in the blanks with the correct letter:



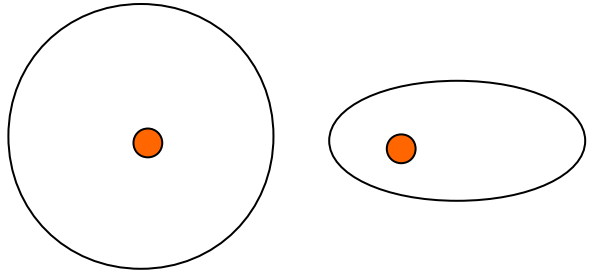
- Focus _____
- Aphelion _____
- Perihelion _____
- Increasing speed: ____ to ____
- Decreasing speed: ____ to ____
- Planet has greatest speed ____
- Planet has lowest speed _____

06. Now, state Kepler's Second Law in your own words and give your reasoning as to why planets "behave" this way:

07. Kepler's Third Law relates the period (P) it takes a planet to go around the Sun in an orbit of a given semi-major axis (a). Assume that the mass of the Sun is much, much greater than any of the planets (which it is), and measure P in years and a in astronomical units. The simplified relationship (formula) is:

$$P^2 = a^3$$

08. The following two orbits have the same value for a . How do their values of P compare?



09. Kepler's Third Law means that all orbits with the same semi-major axis have the same period. Explain how this can be when the orbits look so different, and why this makes sense.