Dowling College

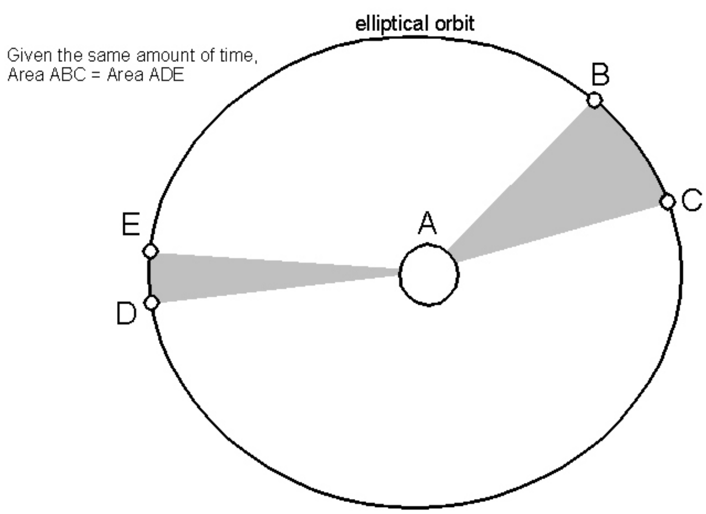
Student name: ______________________________________

Lab 2: Kepler's Three Laws of Planetary Motion

In the 16th century, the Polish astronomer Nicolas Copernicus replaced the traditional Earth-centered view of planetary motion with one in which the Sun is at the center and the planets move around it in circles. Although the Copernican model came quite close to correctly predicting planetary motion, discrepancies existed. This became particularly evident in the case of the planet Mars, whose orbit was very accurately measured by the Danish astronomer Tycho Brahe.

The problem was solved by the German mathematician Johannes Kepler, who found that planetary orbits are not circles, but ellipses. Kepler described planetary motion according to three laws.

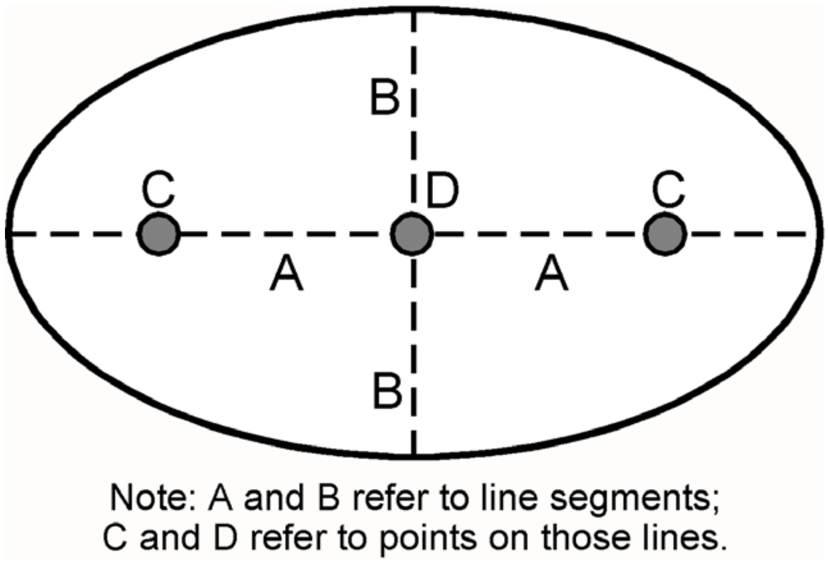
- Law I: Each planet revolves around the Sun in an elliptical path, with the Sun occupying one of the foci of the ellipse.
- Law II: The straight line joining the Sun and a planet sweeps out equal areas in equal intervals of time.
- Law III: The squares of the planets' orbital periods are proportional to the cubes of the semimajor axes of their orbits.



Kepler's laws apply not just to planets orbiting the Sun, but to all cases in which one celestial body orbits another under the influence of gravitation -- moons orbiting planets, artificial satellites orbiting the Earth and other solar system bodies, and stars orbiting each other.

Exercise:

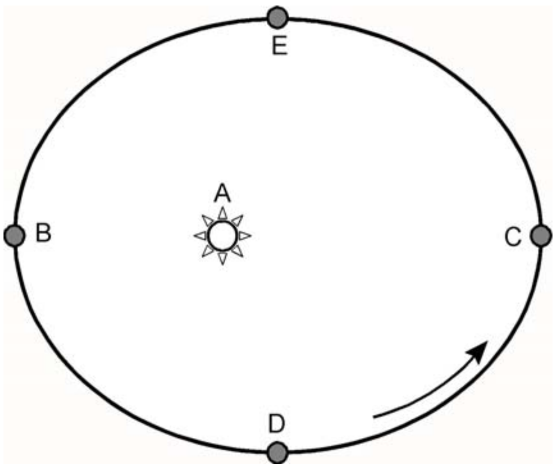
1. Refer to your lecture notes and clearly label the parts (focus, semimajor axis, semiminor axis, center) on the following diagram of an ellipse:



2. 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 this ellipse: ___________

3. State Kepler's First Law in your own words:

4. Examine this figure of a planet orbiting the Sun and fill in the blanks with the correct letter of the various points shown in the drawing:



a. Focus ____

b. Aphelion ____

c. Perihelion ____

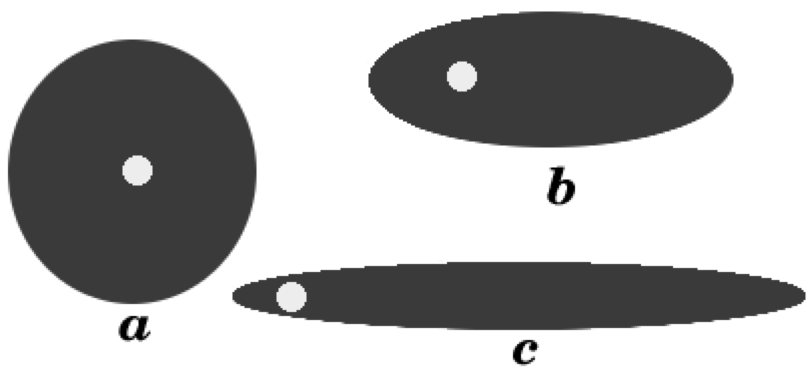
d. The planet is *increasing* in orbital speed from points ____ to ____

e. The planet is *decreasing* in orbital speed from points ____ to ____

f. The planet has the greatest orbital speed at point ____

g. The planet has the lowest orbital speed at point ______

5. Calculate the approximate eccentricities for the following ellipses:



a. ***e* =**

b. ***e* =**

c. ***e* =**

6. State Kepler's Second Law in your own words:

7. Kepler's Third Law relates the ______________ **(P)** it takes a planet to go around the Sun in an orbit of a given ___________________________ **(D)**.

8. The simplified relationship (formula) is: __________________

9. Using the formula above from Kepler's 3rd law, complete the following table of planetary orbital data.

Planet	P (years)	A (astronomical units)
A	4	
B	10	
C		64
D		1,000
E	1	
F	16	

10. Following the steps given below for drawing ellipses, fill in the following table with your results.

Ellipse	Major Axis	Distance from foci to center	Eccentricity
1			
2			
3			

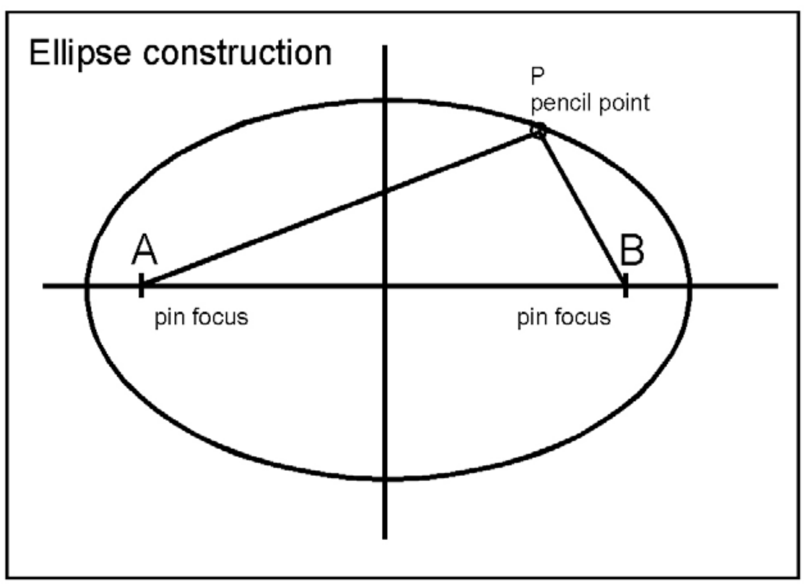
Needed: 2 tacks (or thick straight pins), cardboard, 6-inch length of string, pencil

a. Tack the next page to a piece of thick cardboard, placing the tacks through the points marked "1".

b. Tie the ends of the string together and loop it around the tacks.

c. Using the string as a guide (i.e., place the pencil inside the string loop and pull the loop taut), draw an ellipse.

d. Repeat steps a. and b. with the tacks through points marked "2" (one tack through the "top" 2, the other through the "bottom" 2. Finally, use just one tack through point "3." (You may need to change the length of the string to keep the ellipse on the sheet of paper and adjust your methods accordingly!)



e. Measure the major axis of each ellipse. Measure the distance between the foci. Record these numbers in the above table.

f. Calculate the eccentricity of each ellipse. Record the eccentricities in the table.

Drawing Ellipses