Name: _____ Date: _____

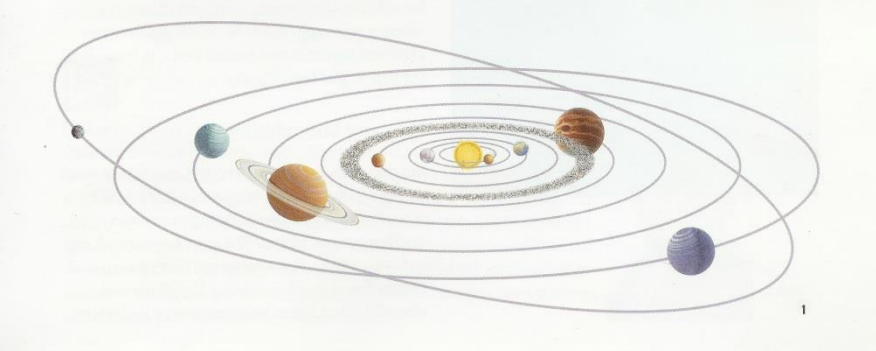
LAB: Orbits & Ellipses

As you know, each planet in the Solar System revolves around the sun. The shape of each planet's orbit is an **ellipse** (or **elliptical**). Unlike a circle, which is a curved shape drawn around a central point, an ellipse is a curved shape that is drawn around two points. Each of these points is called a **focus**, and together, they are called the **foci** of the ellipse. When comparing the shapes of planetary orbits, it is most helpful to describe the **eccentricity** (degree of flattening) of each ellipse. A perfect circle has an eccentricity of 0 because there is a no flattening. An ellipse that is completely flat has an eccentricity of 1.

In this investigation you will draw several ellipses, calculate their eccentricity, and explore the relationships between the shape of each orbit and the motion of its planet.

MATERIALS

pencil
1 sheet of unlined paper
2 thumbtacks or pushpins
piece of strong approximately 15 cm long
piece of cardboard at least as large as the sheet of paper
metric ruler
calculator



PROCEDURE

1. Fold the piece of paper the long way (hot dog style). Without opening it, fold it in half the short way (hamburger style). Open the paper and locate the center of the paper.

2. Make one point 4 cm from each side of the center point. Place a pushpin at each of these points. The pins should be 8 cm apart.

3. Place your string around the pins, not too tightly.

4. Use a pencil to gently pull the string away from the pins, and in a smooth motion, draw an ellipse. Remove the string and write "8 cm" along the top of the ellipse.

5. You will now draw a second ellipse. Make one point 2 cm from each side of the center point, so that the pins are 4 cm apart. Label the top of this ellipse as "4 cm."

6. Draw a third ellipse with the pins a total of 2 cm apart (each one should be 1 cm from the center point). Label this "2 cm."

7. Because an ellipse is not a circle, it is said to be eccentric. The eccentricity can be calculated and expressed as a number using the following equation:

$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of the major axis}}$$

Use the formula above to calculate the eccentricities (**rounded to the nearest 0.001**) of each ellipse that you have drawn. Enter your data in the table below. Be sure to use either mm or cm – do not alternate between the two!

Ellipse you drew	Distance between the foci (cm or mm)	Length of the major axis (cm or mm)	Eccentricity
First			
Second			
Third			

QUESTIONS

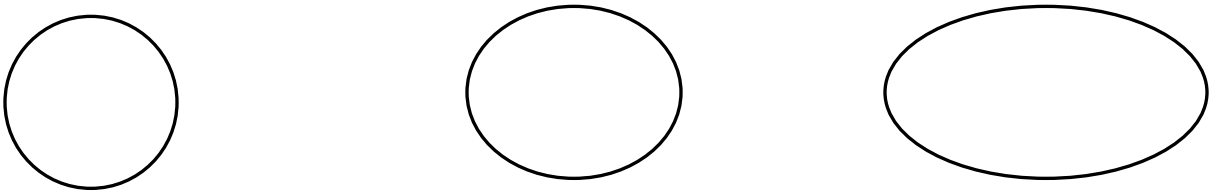
1. If you were drawing an ellipse, what would happen to its shape (NOT its size!!) if you used the same size string but moved the foci farther apart?

2. Does the eccentricity of an ellipse increase, decrease, or remain the same if its shape becomes more circular? Why?

3. What is the relationship between the eccentricity of an ellipse and how round it appears to be?

4. Does the earth's orbit look more or less eccentric than the three ellipses you drew?

5. Which diagram most accurately shows the shape of the earth's orbit drawn to scale?



A B C

6. Rank each planet's orbit in order from least eccentric (1) to most eccentric (8):

Mercury _____ Mars _____ Uranus _____

Venus _____ Jupiter _____ Neptune _____

Earth _____ Saturn _____

7. The figure below represents the orbit of a planet drawn to scale. The sun is located at one of the foci; there is nothing at the other focus.

a) Calculate the eccentricity of this planet's orbit to the **nearest thousandth**. _____

b) How does the eccentricity of Earth's orbit compare to this planet's?

c) At which lettered position would each of the following occur:

Fastest orbital velocity _____

Slowest orbital velocity _____

Strongest gravitational attraction _____

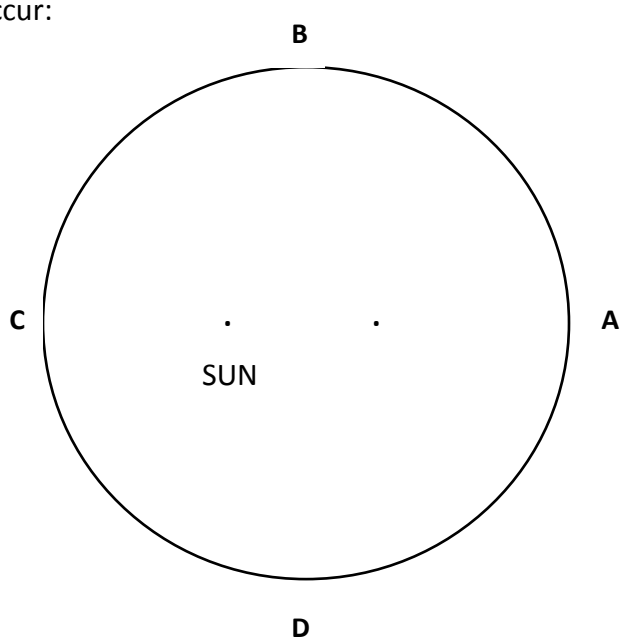
Weakest gravitational attraction _____

Perihelion _____

Aphelion _____

Largest apparent diameter of the sun _____

Smallest apparent diameter of the sun _____



8. The shape of Earth's orbit is a(n) _____ with the sun located at one _____.

9. Earth is a satellite of the sun. What is Earth's major satellite? _____

10. Earth is closest to the sun (perihelion) in the month of _____.

11. Earth travels in its orbit most slowly in the month of _____.

12. Which planets travel faster in their obits, the inner planets or outer planets? _____

13. Label each of the following as a cyclical or noncyclical change:

    a) the changing distance between Earth and the sun _____

    b) the changing speed of Earth in its orbit _____

    c) the changing apparent diameter of the sun _____

14. What length of time is required for one complete cycle of the changes listed above?
    _____

15. Which planets are the **terrestrial** planets? _____

16. Which planets are the **gas giants**? _____

17. a. Which of the gas giants has the greatest density? _____

    b. What is its density? _____

    c. Which of the terrestrial planets has the lowest density? _____

    d. What is its density? _____

18. Which two planets have almost circular orbits? _____ and _____