Kepler's First Law of Planetary Motion: The orbit of every planet is an ellipse with the sun at one of the foci

Purpose: The purpose of this lab is to demonstrate Kepler's First Law of Planetary Motion by calculating the eccentricity of ellipses.

Vocabulary:

eccentricity ____

ellipse ____

foci ____

Materials:

ruler	cotton string (at least 25cm)	push pins (2)	pencil
calculator	styrofoam board	paper (4)	tape

Objectives: Upon completion of this laboratory exercise, students will be able to:

(1) Define the words: eccentricity, ellipse, and foci

(2) Calculate the eccentricity of an ellipse.

(3) Describe how eccentricity changes as the distance between foci changes.

(4) Explain Kepler's First Law of Planetary Motion.

(5) Describe how Earth's orbit compares to any given eccentrical orbit

(6) Describe the shape of an ellipse with an eccentricity of 0.00 or 1.00

(7) Give an example of a celestial object with a highly eccentric orbit.

(8) Describe Earth's orbital shape.

Procedure Part A:

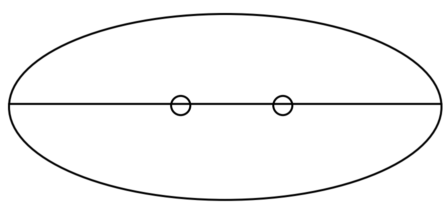
In this part of the laboratory exercise you will construct several ellipses.

(1) Tie the piece of string into a loop of approximately 10 cm.
(2) Place a piece of white paper on the Styrofoam board and fix it into place with a small piece of tape.
(3) Label the piece of paper in the top right hand corner "#1" (for other ellipses, number them #2, #3, #4).
(4) In the center of the piece of paper, place the two pushpins approximately 2.0 cm apart.
(5) Take the loop of string and place it over the two pushpins.
(6) Using one hand, place a finger on top of each pushpin.
(7) Using the other hand, take the pencil and stretch the cotton string out as far as it will go.
(8) Slowly move the pencil around the two pushpins keeping the string tight at all times. Only move your fingers that are on top of the pushpins when necessary.
(9) When done drawing your ellipse, take the pushpins out and mark one of the holes "F_1" and the other "F_2".
(10) Take the piece of paper off from the Styrofoam and repeat this procedure three more times substituting the following distances in step #4: 5.0 cm, 7.0 cm, 9.0 cm

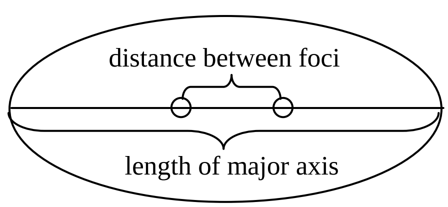
Procedure Part B:

In this part of the laboratory exercise you will calculate the eccentricity of each of the four ellipses that you constructed.

(1) For each of the four ellipses you have drawn, use the ruler to draw a line that runs from the outside of the ellipse through the two foci as shown below.



(2) ***For each of the four ellipses***, label the distance between foci and the major axis as shown below.



(3) For each of the four ellipses, measure the distance between foci and the length of the major axis ***to the nearest tenth*** of a centimeter and record your results in the data table below.

Ellipse Number	**Distance Between Foci (cm)**	**Length of the Major Axis (cm)**
1		
2		
3		
4		

(4) Using your ***Earth Science Reference Tables***, write the formula used to calculate the eccentricity of an ellipse below.

(5) Using the formula above and your data, calculate the eccentricity of each of the ellipses. Record your results to the ***nearest thousandth***. **Show all work!**

Ellipse 1	**Ellipse 2**	**Ellipse 3**	**Ellipse 4**

Questions for Procedure Part B:

(1) Describe the relationship that exists between the distance between foci and the eccentricity of the ellipse.

____

____

(2) a. What is the maximum value that an eccentricity can be? ______________________

b. What shape would this be? ________________

c. What is the minimum value an eccentricity can be? __________________________

d. What shape would this be? ________________

e. If there were only one pushpin used, what would be the shape of the ellipse? __________________

f. What would its eccentricity be? _____________

(3) Which of the four ellipses you drew do you believe is most similar in eccentricity to the Earth's orbit? ____________ Why? ____
____

(4) Using the data below, calculate the eccentricity of Earth's orbit to the ***nearest thousandth*.**

Length of Major Axis	299,000,000 km
Distance Between Foci	5,083,000 km

Show all work!

(5) How does the eccentricity of Earth's orbit compare with the eccentricity of the ellipses you drew?

____

(6) Which is more round---the ellipses you drew or Earth's orbit? ____________________
Explain how you know. ____

____

____

(7) Compared to the other planets in our solar system. Which planet has an eccentricity most similar to the ellipses you drew? ____________________

(8) In step #9 of Procedure A you labeled one foci "F_1" and the other "F_2". If you were to draw the Earth's orbit, what celestial object would be one of the foci? ____________________

(9) The diagram below represents an object's orbit around the Sun. Draw where the other foci would be located.