Earth Science Regents
The Ellipse

Name_____

Period _____

The ellipse is the geometric shape of most orbits. In this lab, you'll construct 2 ellipses, and examine and measure them to determine some of the fundamental properties of ellipses.

Follow the directions below, making sure you draw and measure carefully along the way. When you have completed the construction and measurement of your ellipses, carefully and thoughtfully answer the questions posted at the end of this lab.

1. Gather up the materials you need to complete this lab (See Fig. 1):

   ❑ A piece of cardboard
   ❑ 2 sheets of clean white paper
   ❑ 2 push pins
   ❑ A 30 cm (or so) length of string
   ❑ A metric ruler/straight edge
   ❑ A pen or sharp pencil

Fig. 1

Fig. 2

2. Tie your string into a loop. The loop, when stretched tight, should be 12 cm or so long (anything between 10 and 13 cm will work fine) (See Fig. 2)

2A. Place one sheet of paper on the cardboard, and place the 2 push pins horizontally about 6 cm apart near the center of your paper as shown in Fig. 2.

3. Place your loop of string around the 2 push pins, and, keeping the string tight, use the string as a guide to carefully draw an ellipse around the push pins. (See Fig 3.) Be patient - you may have to try it a few times before you get the hang of it!

Fig. 3

Fig. 4

4. After you've drawn your ellipse, remove the push pins (it's probably a good idea to stick them in the margin of cardboard so they don't roll away). The 2 pinholes are called the *foci* of the ellipse (each one is called a *focus*). Label the 2 foci F_1 and F_2 as indicated in Fig.4.

5. Carefully draw a straight line across the ellipse so that it passes **exactly** through the foci. That line, which is the longest one you can draw in the ellipse, is called the *major axis* of the ellipse. Label it on your diagram. (See Fig. 5)

Fig. 5

Fig. 6

6. Select and make a mark at 3 randomly located points on the ellipse. Label the points A, B, and C as indicated in Fig. 6. The black arrows point to 3 possible locations for points - but yours can be anywhere on the ellipse.

7. Draw a line from each point (A,B, and C) to each of the foci as indicated in Fig. 7. When you've done that, you're done with your first ellipse!

Fig. 7

8. Make all the measurements listed below to the nearest 1/10 of a cm. Record them on this sheet **and** label them on your diagram. Don't forget to include the units of your measurement as well.

Length of the major axis = _____

Distance between the foci = _____

Length of line A F_1 = _____

Length of line A F_2 = _____

Length of line B F_1 = _____

Length of line B F_2 = _____

Length of line C F_1 = _____

Length of line C F_2 = _____

9. Calculate and record your answers to the following sums:

Length of A F_1 + length of A F_2 = _____

Length of B F_1 + length of B F_2 = _____

Length of C F_1 + length of C F_2 = _____

What do you notice about those sums? _____

Think of how you drew the ellipse, and explain why the sums are equal to each other.

_____

_____

_____

_____

10. The eccentricity of an ellipse tells us how "out of round" it is. Use this formula:

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

to calculate the eccentricity of your ellipse. Round your answer to the nearest tenth, and record it on this sheet **and** record and label it on your ellipse drawing as well. (Notice what happens to the units when you do your division!)

Eccentricity =   _____

11. Using a second sheet of white paper, repeat steps 2 through 6 of this lab, ***only this time place the push pins 9 or so cm apart.***

12. On your new ellipse, make all the measurements listed below. Record them to the nearest tenth of a cm. on this sheet **and** label them on your diagram. Don't forget to record the units of measurement as well.

Length of the major axis =   _____

Distance between the foci =   _____

13. Recall the formula for calculating the eccentricity of an ellipse:

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

and calculate the eccentricity of your new ellipse. Round your answer to the nearest tenth, and record it on this sheet **and** record and label it on your ellipse drawing as well. (Remember to think about what happens to the units when you do your division!)

Eccentricity =   _____

14. Carefully and thoughtfully do/answer the following:

a. Place your 2 ellipses on your desk in front of you so you can see them both. Which one looks more nearly circular?

_____

Which one has the greater eccentricity?

_____

b. Complete this statement in a way that indicates that you know what eccentricity measures:

"The greater the eccentricity of an ellipse, the _____

_____

_____

c. Imagine drawing ellipse after ellipse, each time moving the push pins closer and closer together, until they are both in a single hole at the center of your page. What shape would that ellipse be?

_____

What would the eccentricity of that ellipse be? _____. Explain how you know that:

_____

_____

d. Now imagine drawing ellipse after ellipse again, but this time moving the push pins farther and farther apart, until the string is stretched as tightly as possible between the pins. What shape would *that* ellipse be?

_____

What would the eccentricity of that ellipse be? _____. Explain how you know that:

_____

_____

e. What is the maximum eccentricity that an ellipse can have? _____ What is the shape of an ellipse with that eccentricity?

_____

f. What is the minimum eccentricity that an ellipse can have? _____ What is the shape of an ellipse with that eccentricity?

_____

g. Compare the eccentricities of your 2 ellipses with the eccentricity of Earth's orbit (ESRT p. 15). Which of the 3 is more nearly circular?

_____

How do you know that?

_____

_____

h. Which planet in the solar system has the most eccentric orbit? _____

How does the eccentricity of that orbit compare with the eccentricities of your ellipses?

_____

_____

i. Use the internet or an astronomy book or encyclopedia to find the eccentricity of Comet Halley's orbit.

_____

If the major axis of Comet Halley's orbit were scaled down to 15 cm, how far apart would the foci of that elliptical orbit be?

_____

Describe what the shape of that orbit would look like: _____

_____

Challenge !